THE WATER WHEEL

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Building starts at Braamhoek

Water Institute of Southern Africa
Membrane Technology Division (MTD)
http://www.wisa.org.za/Divisions/membrane/mtd_index.htm

7th WISA-MTD Symposium and Workshop
18 – 20 March 2007

Mabalingwe Nature Reserve
Limpopo Province, South Africa

Limited to 150 delegates
Register early (before 15 February 2007)

INVITATION

Membranes are an important technology employed in a variety of processes. They play important roles in water treatment, chemical separation and environmental management. The continued development and application of membrane processes are taking place at an ever-increasing rate. The Committee of the WISA Membrane Technology Division is pleased to invite those with an interest in membranes to the 7th Biennial Symposium and Workshop, to take place from 18 - 20 March 2007.

PROGRAM OF EVENTS

Sunday 18 March 2007

16:30 – 18:00	Early Registration
18:00 – 19:30	Icebreaker Snacks and Cocktails
19:30	Meet & Greet Dinner

Monday 19 March 2007

7:30	Registration
8:30	Welcome and Opening Address
8:45 – 9:30	Plenary Lecture: International Speaker
9:40 – 10:40:	Session 1
10:40 – 11:00	Short break
11:00 – 12:00	Session 2
12:00 – 13:00	LUNCH
13:00 – 15:00	Workshop1
15:00 – 15:30	AGM/Tea Break
15:30 – 16:30	Poster Presentations
16:30 – 18:30	Game Drive
18:30	Symposium Dinner and Entertainment

Tuesday 20 March 2007

5:00 – 7:00	Game Drive
8:30 – 8:45	Start of day's proceedings
8:45 – 9:30	Plenary Lecture: International Speaker
9:40 – 10:40:	Session 3
10:40 – 11:00	Tea Break
11:00 – 13:00	Session4
13:00 – 14:00	LUNCH
14:00 – 16:00	Session 5

MORE INFORMATION

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REGISTRATION FORM – WISA MTD 2007

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Registration (please tick)

Non-WISA Member	R1450	❑	WISA Member	R1250	❑
Student	R300	❑	Spouse	R850	❑

Late Registration add R200 (after 15 Feb)

Payment to be made directly to WISA

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Branch:	BOULDERS BRANCH
Branch Code:	250 856
Acc No:	620 4455 2710
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Signature .....Date .....

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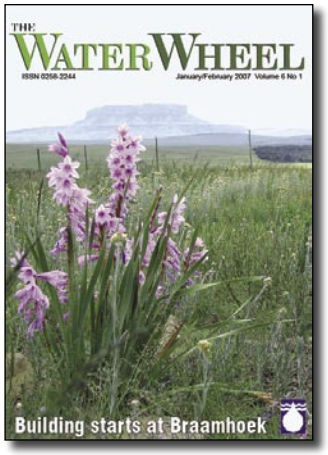

***Cover**: Engineers face tremendous environmental challenges at the construction of Eskom's Braamhoek Pumped Storage Scheme. See page 14.*

THE WATER WHEEL is a two-monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source.

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Editor's Letter
Bottled vs. tap debate rages on

The Water Wheel received both praise and criticism for its article on bottled water in the September/October 2006 issue.

One specific reader (who did not want her letter published) went so far as accusing the magazine and its publisher, the Water Research Commission of the "uncritical promotion of a commercial product, one which is hardly environmentally-friendly". The reader specifically mentioned the issues around the environmental impact of the sector.

While the debate over the merits and disadvantages of bottled water rages on internationally, the sector keeps on expanding in almost every country, even in South Africa, which has always been thought to have some of the highest-quality tap water. Even the country's largest tap water supplier, Rand Water, is now entering the bottled water market in a bid to tap into new markets and diversify its income streams.

The Water Wheel asked John Weaver, Chair of the South African Bottled Water Association) to respond to some of the criticisms against bottled water. He writes:

"The original 'highly controversial issue' around the bottled water industry was sparked off by a discussion paper titled *Bottled Water: Understanding a Social Phenomenon* by Catherine Ferrier of the University of Geneva (www.panda.org/livingwaters/pubs/bottled_waterpdf). From this reasonable, balanced article a number of points made by Ferrier have been taken and expanded upon to become various website and newspaper articles. Of these, the most prominent one did the e-mail rounds a year back (www.earth-policy.org/Updates/2006/Updates51.htm). The latter article picked out and expanded on just the two negative aspects of bottled water from the Ferrier article, namely that bottled water is up to 10 000 times more expensive than tap water, and the energy cost associated with making the containers and transporting the finished product. The rest of the Ferrier article was ignored.

There are various reasons why people consume bottled water, as noted in Ferrier's article. Taste is high on the list. Tap water with high chlorine levels, while being safe (bacteriologically) to drink, is not nearly as pleasant as bottled water.

In a bottled water tasting organised by *Men's Health* magazine 16 waters were presented to three tasters, including myself. These were presented blind and one stood out as having an off smell and taste, and we correctly identified it as tap water.

The next reason is for personal safety. Bad quality water has given rise to many quaint phrases in the English language, such as 'Delhi belly' and 'Gyppo guts'. The traveller who has paid lots of money for air tickets and accommodation should never drink tap water, even in supposedly safe countries. Risking a few days being sick in order to save the price of a bottle of water is a silly choice.

One of my brothers was in West Africa, and being confronted by a US$10 cost for bottled water in a five-star hotel, opted for tap water. The result: ten days down with 'rumble in the jungle'. In fact, bottled water is often advertised as a positive selling point for tourist destinations, even WWF's Eco-Safaris.

A third reason is that bottled water is a healthy alternative to other beverages such as sodas, drinks with high sugar levels and beverages containing artificial sweeteners or colouring. It is a calorie-free thirst quencher and now freely available in South Africa. Indeed, the huge rise in bottled water consumption over the last 20 years is closely linked to the way consumers face their nutrition, i.e. the current trends for healthier eating.

Lastly, it is the convenience factor. Cruising down the highway, or lying on the beach, having a bottle of water at hand is far more convenient than having to look for a tap. A sign of modern times is the bottle of water on the desk next to the computer. Our estimate is that more than half of those bottles will be tap water re-fills: Our view – great, so long as it is water and not sugary cooldrink.

Bottled water versus tap water: we have no argument with the tap water industry. These are two very different water markets, with a small overlap. It would be a wonderful world if the tap water industry could provide safe water to all, but the overwhelming reality is that the combination of inadequate personal primary health training, human behaviour and social customs will continue to result in human deaths, despite the best efforts of water engineers, social workers and water people. The bottled water industry does not pretend to be able to solve these enormous problems. In emergencies, bottled water can be called upon, e.g. the *Cryptosporidium* outbreak in Sydney, Australia, but it is not a long-term solution to the provision of safe drinking water.

An aspect of bottled water that was highlighted is the energy cost associated with making the containers and transporting the finished product. Packaging is one of the unfortunate aspects of modern life, and is not something for which the bottled water

industry should shoulder all the blame, and also cannot solve by itself. Yes, in South Africa we really do need plastic recycling policy and legislation that will apply to all plastic used in our daily lives, not just bottled water containers.

The energy cost of transportation also adds to our energy cost. The Ferrier articles notes that 75% of bottled water is consumed locally, and advocates that this should be increased. We have no argument with this. Indeed the sight of Italian bottled water on the shelves of some of our supermarket chains at prices lower than local water can be bottled for, is startling and a reflection of the craziness of export subsidies.

An important item in *the Water Wheel* article is that South Africa now has legislation governing bottled water. This legislation which has been approved by the Minister of Health will come into operation in July. The legislation covers both quality standards, and also the wording on the label so that the origin, and treatment applied, and mineral content must be clearly stated. This legislation is in line with the international standards of the Codex Alimentarius Commission.

My final image I present is one of an obese junk-foodie driving a fuel-guzzling suburban SUV sucking a can of sweet cooldrink, versus a gym-fit person driving a fuel-litre car with a bottle of water in the pop-out tray. It is all about choices."

Ancient knowledge forgotten

The twelfth century king of Sri Lanka, Parakramabahu I, officially decreed that not one drop of water should reach the sea without first serving humanity. And his regulations of how water should serve humanity (and humanity serve water) were far ahead of his time.

Many of his wewas have since been rendered inoperable by encroaching jungle. Why have we, in Southern Africa, who have followed western and scientific approaches to water usage have to deal with an encroaching jungle instead?

Ben Dekker, Port St Johns

Praise for the Water Wheel

It is high time to say a word of hallo to you all. I have been a subscriber of *the Water Wheel* for many years since you enrolled me in your *Water Wheel.*

I found your *Water Wheel* to be the most interesting and educative, and well managed. It is relevant in water technology and environmental aspects and very informative. It is also keeping up to date with the modern world and with the future vision of water co-ordination of both rural and urban centres, highlighting and creating awareness on waterborne diseases. Since I started receiving the journals I am meeting with points tip with stakeholder meeting with our small town in Kenya called Nanyuki. Keep up the good work. I would like to continue receiving your journal and conference invitations.

John Sikote, Water Technologist, Kenya

Bring back reservoir limnology

I have read with great interest the September 2006 issue of *Water Wheel* which contains an article on South African reservoirs and the message of expectation that an extinct science might be "*revived through a report*".

For someone who was trained in South African reservoir limnology, and who experienced the indignities of the "extinction" of reservoir science, it would be remiss to not pass comment on this article and the implications it conveys to the leaders of South Africa's water resource institutions.

The pool of South African reservoir expertise in the 1970s and 1980s was indeed internationally renowned, as were the institutions that housed the teams of scientists. Today, those scientists have moved on, either through a process of retirement, to other topics, or to greener pastures elsewhere in the world. It took more than two decades to attract and build up those teams, a process that was achieved through a network of stakeholder-based cooperative scientific programs with high-level governmental and institutional support. The decline began in the mid 1980s and was largely associated with the demise of eutrophication as a Department of Water Affairs priority issue, coupled to the quest for assessing ecological water requirements (Ecological Reserve).

With an arid landscape, reservoirs will always be the backbone of the country's water supply and therefore we need to ask the questions of how, and why, the leadership of our water resource and research institutions committed the cardinal sin of collectively, and progressively, allowing reservoir expertise to degenerate to the extinction level. Perhaps these questions will always remain largely unanswered, as the decision-making players of the day have passed on, and the topic does not merit a national commission of enquiry. I could offer a lengthy personal analysis which would cover themes such as politics, economics, institutional reorganisations, culture, personalities, the rise of the river scientists – all of which contributed. This however is another subject.

It was predicted many years ago that the focussed romance with river science would eventually play out, and at some stage South Africa would resuscitate its reservoir science base. Hopefully, the University of KwaZulu-Natal, my alma mater where I received my early training, has produced a report that leads to a revitalization of this science.

However, it will take more than a report to reconstruct the pool of expertise that has the necessary intellectual capacity to serve South Africa's reservoir science requirements. It will require the development of a similar type of stakeholder-based reservoir science program that was initiated more than 30 years ago. The support and leadership of the WRC is critical on this, as it should have been when the science was becoming extinct.

One final word of caution – beware of letting the pool of river science expertise follow the same extinction process – in what seems to be an eternal global cycle of casualties in expertise – as managers and institutions chase the next "flavour of the month".

Danny Walmsley (Former Coordinator of the CSIR Inland Water Ecosystems Program 1985-1990) Dartmouth, Nova Scotia, Canada

Bottled water article 'fascinating'

This is an appreciative note to congratulate you on your outstanding editorship of *the Water Wheel* and your significant personal contribution to its wide-ranging water-related articles.

You have raised the content and range of the reporting to a new plateau of excellence. Your article on bottled water in the issue of November/December 2006 is both timely and fascinating. Rand Water has recently joined the band wagon.

AH Charnaud, Howick

Lifestyle costing made easy with new software

Engineers and designers of bulk water pipelines now have a tool available to them to determine the most economical solution for the complete design life of their system.

The software, named AQUA Hydraulic Utilities, is described in a new report available from the Water Research Commission, entitled *Lifecycle Costing Analyses for Pipeline Design and Supporting Software.* The report, authored by Prof Fanie van Vuuren and Marco van Dijk, both from the University of Pretoria's Department of Civil and Biosystems, is a guide to lifecycle costing analysis, limited to the design/analyses of bulk pipelines.

The guide introduces different lifecycle cost elements to the design engineer, and indicates how these cost elements will affect the final decision. It also explains the functionality of the AQUA Hydraulic Utilities program.

The program requires the user to enter the demands, design life, pipeline profile, pipeline characteristics, laying details, rates and costs of the proposed pipeline. It will then determine the initial capital requirements, the annual maintenance and operational costs and, in the case of a pumping system, the energy costs. The program also provides a graphical representation of these costs, as well as the hydraulic capacity of the ageing system.

- *The **AQUA Hydraulic Utilities** program can be downloaded from www.wrc.org.za or www.sinotechcc.co.za.*
- *To order the report, **WRC Report No 278/06**, contact Publications at Tel: (012) 330-0340 or E-mail: orders@wrc.org.za*

More bulk infrastructure planned for SA

Development of bulk infrastructure remains top of mind for the Department of Water Affairs & Forestry (DWAF), at least in the short term.

While this may be good news for the construction industry it could concern ecologists and conservationists, especially since the department's latest annual report reveals that only 28,2% of the rivers surveyed under the River Health Programme to date remain in natural or good condition. Already 29% of the rivers surveyed are in poor condition.

Construction of bulk infrastructure projects such as the Berg River Dam and the Vaal River Eastern Sub-System Project are continuing at full steam. Pre-feasibility and feasibility studies were completed for a number of proposed developments. This includes the feasibility reports for the Mooi-Mngeni Transfer Scheme Phase II, which proposes the construction of the Spring Grove Dam on the Mooi River as well as the De Hoop Dam on the Steelpoort River.

Investigations into the construction of a dam on the Lower Orange river close to the border between South Africa and Namibia are also going ahead.

In addition, pre-feasibility study reports were completed for the use of low-level storage at Vanderkloof Dam and viability of irrigation schemes for resource-poor farmers in the Eastern Cape. The refurbishment of 20 dams has also been initiated across the country.

Choose loos carefully, says expert

Municipalities should carefully weigh all the options before selecting a sanitation technology.

So said David Still of Partners in Development at the Water Institute of Southern Africa's Appropriate Technologies conference, held in Umhlanga towards the end of last year. Still, who has been investigating the cost of sanitation in a project funded by the Water Research Commission, reported that many local municipalities were still set on implementing full waterborne sanitation, even though at times neither the authority nor the users could afford it.

Compared to ventilated improved pit toilets or urine diversion toilets, which cost about R4 000 per unit, waterborne toilets could cost about up to R30 000 per unit to install, including bulk sewer and wastewater treatment costs. "This is only construction costs, but what about long-term operation and maintenance?", Still asked.

The costs of on-site sanitation systems fall well within local government finance allocations, such as the Municipal Infrastructure Grant and the Equitable Share. Moreover, these systems often did not require much operation and maintenance compared to waterborne sanitation.

"When waterborne sanitation does not function properly, it cannot be considered an improvement in service. Unmaintained systems can be extremely hazardous to the health of communities, and have far-reaching environmental consequences," noted Still. He advised local authorities not to even consider waterborne sanitation if they did not have the necessary skills or financial capacity to operate and maintain such a system.

In addition, the cost to the household had to be borne in mind. "A household with waterborne sanitation will use about 10 kℓ more water per month than a family without," noted Still. "This means having a flush toilet could cost that family about R100 more per month in water bills."

Give private sector a chance

South Africa needs the private sector now more than ever to assist in rapid services delivery.

So said Laila Horton, senior project advisor in the National Treasury's Public-Private Partnership (PPP) Unit. She was speaking at the Africa Water Congress, held in Gauteng, in November.

The cumbersome legislative framework, opposition from labour and the persistent preference of public sector provision have led to a decline in PPPs in the South African water sector since the 1990s. Other constraints include the limited capacity within the public sector as well as the historically poor bankability of these projects.

According to Horton, current efforts to meet the 2008 target for basic water services and 2010 target for sanitation services would have to quadruple. "Private sector investment can go a long way in assisting municipalities to meet these deadlines for delivery."

At the time of writing, National Treasury was in consultation with the Department of Provincial and Local Government to find ways of simplifying and streamlining present PPP legislation.

The PPP Unit is also offering local authorities financial assistance for Section 78 assessment and feasibility studies into possible involvement of private companies in water projects through its Project Development Facility. "Many a time, local authorities only consider public delivery options, without even considering the potential of a PPP," noted Horton.

Possible suitable projects for PPP involvement include those in areas with high-income users (for example, mining companies and resort towns); as well as projects in water scarce areas which require sophisticated technologies such as the establishment of desalination plants along the West Coast. Horton said cost saving endeavours (leakage reduction, improved billing and collection) also offered significant potential for private sector investment.

Maguga Wins

Rob Fraser of Ninham Shand won this year's photographic award presented by the South African Institution of Civil Engineering for his photograph of the Maguga Dam, situated in the Komati River in Swaziland.

Water Diary

WATER & SANITATION
FEBRUARY 12-24
International company Bushproof is offering an introductory course on water and sanitation technologies for development situations and emergencies in Fort Dauphin, Madagascar. *Enquiries: Eric Fewster; Tel: +44 (7814) 788 846; E-mail:* ericfewster@bushproof.com*; Visit:* www.bushproof.com

NUTRIENT REMOVAL
MARCH 4-7
The Water Environment Federation, in cooperation with the IWA Nutrient Removal and Recovery Group, US EPA and the Chesapeake Water Environment Federation will be hosting a Speciality Conference covering the latest research and experience in the design and operation of nutrient removal systems at municipal and industrial wastewater treatment plants. The conference will be held in Maryland, US. *Enquiries: Tel: +1 708-684-2400 ext 7010 or E-mail:* Nutrients2007@wef.org

SANITATION
MARCH 12-13
The International Water Association and the Institute of Environmental Engineering of RWTH Aachen University are hosting an Advanced Sanitation conference in Aachen, Germany. Topics include decentralised wastewater systems, non-conventional wastewater treatment systems, economics, social aspects and case studies, among others. *Enquiries: Peter Lambertz; Tel: 0049-(0)241-8026821; E-mail:* lambertz@advancedsanitation.de

TECHNOLOGY
MARCH 14-16
LabAfrica 2007, a showcase for suppliers of laboratory equipment and analytical instrumentation will be held at the Coca-Cola Dome, in Johannesburg. *Enquiries: Tel: (011) 460-0247; Visit:* www.labafricaonline.co.za

DESALINATION
MARCH 18-20
The Seventh WISA Membrane Technology Division Workshop will be held at Mabalingwe Nature Reserve, in Limpopo. *Enquiries: Marshall Sheldon, Tel: (021) 460-3160; Fax: (021) 460-3282; E-mail:* sheldonm@cput.ac.za

WATER IN PROTECTED AREAS
APRIL 25-27
The IWA & UNESCO are hosting a the Second International Conference on Water in Protected Areas in Dubrovnik, Croatia.
E-mail: hdzv@voda.hr *or Visit:* www.hdzv.hr

Sanitation falls short of the grade

South Africa's public sanitation assets only managed an overall E grade in the first *Infrastructure Report Card for South Africa*, published by the South African Institution of Civil Engineering (SAICE).

The report, a reflection of the present state of the country's built environment, including water, sanitation, solid waste, roads, rail, ports, airport, electricity, hospitals and clinics, is based on the expert perception of eminent professionals in the civil engineering field, backed by existing research. "While the South African government has made significant strides in addressing backlogs of the past, and continues to invest at a rapid pace in infrastructure to the previously disadvantaged, significant challenges remain which are threatening our nation's support systems," noted SAICE President Sam Amod.

SAICE President Sam Amod at the launch of the Infrastructure Report Card.

Two key themes emerged from the report. The first is the extreme shortage of skills and the terrible impact this is having on planning, procurement, design, construction and care of infrastructure. The second is the lack of adequate funding for the maintenance of the existing asset base and the new assets that come on stream each day. "It is imperative that we do not continue to build only to permit decay. Neither can we continue the culture of 'patch and pray' that typifies too many of our maintenance activities," Amod said.

The challenges of skills and maintenance are most acute in the sanitation sector, which scored the lowest ranking of the public infrastructure graded. The report pointed out that, while South Africa has some very adequate sanitation infrastructure and service delivery, it has an increasing proportion of deteriorating infrastructure together with poor and often unacceptable quality services.

A nationwide sanitation sustainability audit in 2004/5 to ascertain the functionality of sanitation projects completed since 1994 revealed that 28% of households' sanitation facilities have failed or are in the process of failing, and only 53% of municipalities have adequate operations and maintenance capacity. Another survey of 51 micro, small and medium-sized wastewater treatment plants undertaken in 2005/6 found that "immediate intervention" was required at about 30% of the works to avoid crisis situations such as an outbreak of waterborne diseases.

Bulk water infrastructure scored a D+. The report noted with concern that some 150 of the Department of Water Affairs & Forestry's (DWAF's) 350 dams have significant dam safety shortcomings. On a positive note, a dam refurbishment programme is starting during the 2006/7 financial year.

A further assessment of water supply infrastructure owned by water services authorities (mostly municipalities) and water boards showed that while some water services institutions have exemplary practices in place with respect to many of the aspects of infrastructure management, gross shortfalls in management policies and practices exist in many others. Most non-metro water services authorities are failing in their compliance with the compulsory national standards for the quality of potable water.

"Government should not change its focus from providing the new infrastructure to address backlogs from the past," said Dr Kevin Wall, past President of SAICE, and the main author of the report. "The challenge is to do this and at the same time also maintain both old and new infrastructure, as well as upgrade or replace infrastructure that is overloaded or has become obsolete."

Commenting on the findings of the report, Fred van Zyl, DWAF Director: Planning & Infrastructure, said it came as no surprise, as most of the findings were based on surveys carried out by the national department itself. "Government faces massive infrastructure challenges, not the least being meeting the water and sanitation targets of 2008 and 2010 respectively. It is estimated that a 350% increase in the present rate of delivery is required to meet the water target. We also need to increase present sanitation delivery from the estimated 100 000 units a year to 900 000 units a year."

Investigations also showed that in many local authorities, present infrastructure was not able to meet the increased demand. According to Van Zyl, a series of intervention strategies have been launched by the national department to aid municipalities in improving the management of new and existing infrastructure.

- *The report is available from SAICE's website:* www.civils.org.za

Sewage threatens world's oceans

Nearly 90% of sewage entering coastal zones in many developing countries are estimated to be raw and untreated, according to a new study by the United Nations Environment Programme (UNEP).

This rising tide of sewage is threatening the world's seas and oceans, endangering human health, wildlife and livelihoods, the *State of the Marine Environment* report warns. It is estimated that an additional US$56-billion a year is required to address the global sewage problem.

With regards to South Africa the report notes that untreated sewage does enter the marine environment via informal settlements, and is cause for concern in larger coastal cities such as Cape Town, Port Elizabeth and Durban. Contaminated stormwater runoff is considered the major cause of any non-compliance to bathing quality standards.

Other areas in need of attention are the declining flows in many of the world's rivers as a result of dams, over-abstraction and global warming; new streams of chemicals; the state of coastal and freshwater wetlands and sea-level rise linked with climate change. Meanwhile, around 700 delegates from 15 countries attended an international conference in Beijing, China, to combat sewage, pesticides and other forms of pollution coming from the land into the seas and oceans.

World population running out of resources

Humans are consuming natural resources faster than they can be replaced, according to the 2006 *Living Planet Report* by world conservation organisation WWF.

The report notes that on current projections humanity will be using two planets' worth of natural resources by 2050 – if those resources have not run out by then. It also confirms the trend of biodiversity loss seen in previous *Living Planet* reports, produced biennially. "We are in serious ecological overshoot, consuming resources faster than the Earth can replace them," said WWF DG James Leape. "The consequences of this are predictable and dire."

With regards to water resources, the report shows that freshwater species have declined by 28%. The main drivers are habitat destruction, over fishing, invasive species, pollution and the disruption of river systems for water supplies. It is reported that the alteration and damming of river systems for industrial and domestic use, irrigation and hydroelectric power have fragmented more than half of the world's large river systems. Water withdrawals worldwide amount to about 4 000 km^3 per year, equivalent to about 10% of global freshwater runoff.

Fragmentation and alteration of natural river flows affect the productivity of wetlands, flood plains, and deltas, disrupt the migration and dispersal of fish, and cause decline in freshwater species. Some 83% of rivers' total annual flow is affected – 52% moderately, 31% severely – with Europe's river flow being the most regulated and Australasia's the least. Worldwide, the amount of water stored in reservoirs behind dams is three to six times the quantity contained in rivers.

According to the report, worldwide Mediterranean woodlands, deserts and xeric shrublands, temperate broadleaved forests, and temperate, flooded and montane grassland biomes all have more than 70% (by catchment area) of their large river systems severely disrupted, primarily for irrigation.

Credit: WWF-Canon/Martin Harvey

School girls filling water bottles at a water tap in Nairobi, Kenya. Water is a threatened resource and with population growth and expanding urbanisation the pressure can only increase.

Killer spinach found in US

E. coli tainted spinach caused the deaths of at least three people and sickened nearly 200 others in the US.

It was the twentieth such outbreak in lettuce or spinach since 1995, reports Associated Press. At the time of writing, investigators had found the same strain of bacteria at a cattle ranch in California's Salinas Valley within a mile of spinach fields, but were unsure how the bacteria made its way on to the spinach. Agricultural runoff, irrigation water and the hygiene of farm workers as potential sources were being investigated.

The produce company that processed and packaged the spinach at the centre of the outbreak investigation has repeatedly asserted its factories are blameless, and pointed to the fields where the greens are grown as the potential source of the problem.

Most Polluted Places Named

Courtesy of Wikipedia

The encapsulated Chernobyl reactor.

The world's ten most polluted places have been named by independent environmental action group, the Blacksmith Institute.

Sites in eight countries affecting a total of more than ten million people were identified as the areas where environmental degradation presents the worst long-term health threats and, at the same time, an opportunity to reverse the problems. "A key criterion in the selection process was the nature of the pollutant," said Richard Fuller, Director of the Blacksmith Institute. "The biggest culprits are heavy metals – such as lead, chromium and mercury – and long-lasting chemicals, such as persistent organic pollutants."

Living in a town with serious pollution is like living under a death sentence, according to the report. "If the damage does not come from immediate poisoning, then cancers, lung infections and mental retardation are likely outcomes." The selected polluted places listed bear testimony to the severe impact man has on his environment.

While it has been 20 years since the world's worst nuclear disaster, Chernobyl, in the Ukraine, remains arguably the most polluted place on earth. The 19-mile exclusion zone around the plant remains uninhabitable to this day. The reactor was enclosed in a concrete casing after the accident to contain radioactivity within the plant. There are concerns, however, that leaks in the structure have caused rainwater and fuel dust to form a toxic liquid that may be contaminating the groundwater.

In Dzershinsk, Russia, a significant centre of the Russian chemical manufacturing industry, the average life expectancy is 42 years for men and 47 for women. Until the end of the Cold War, the city was among Russia's principal production sites of chemical weapons. It is reported that from 1930 to 1998, almost 300 000 t of chemicals waste were improperly disposed of. The city draws its drinking water from the same aquifers into which these old wastes and unused products were pumped.

The effects of tannery waste, containing hexavalent chromium and azodyes, potentially affects 3,4 million people in Ranipet, India. The contamination of the soil and groundwater with wastewater, as well as runoff from solid wastes has affected the health, resources and livelihood of thousands of people.

There are 23 tailings dumps and 13 waste rock dumps scattered throughout Mailuu-Suu, Kyrgyzstan, home to a former Soviet uranium plant. An estimated 1,96 million m^3 of radioactive mining waste threatens the Ferghana valley, one of the most fertile and densely populated areas in Central Asia. Due to the high rates of seismic activity in the area, million of people are potentially at risk from a failure of the waste containment. In April last year, about 300 000 m^3 of material fell into the Mailuu-Suu River.

To access the report go to www.blacksmithinstitute.org/top10/10worst1.pdf

New report on world water

The World's Water 2006-2007, published by the Pacific Institute, is now available. Produced biennially, the report identifies and explains pertinent trends, and offers some of the best data available on a variety of water-related topics. Present worldwide water issues covered include water and terrorism, preserving and restoring instream water allocations, desalination, growing risks of floods and droughts, environment justice of water, water risks facing industry, and bottled water.

According to Editor Peter Gleick, there have been some positive changes in the world regarding water. There seems to be a growing public interest in water, and increased involvement of communities. In addition, there are new efforts at ecosystems restoration.

The World's Water describes more than 50 incidents of water-related terrorism, starting in the 1700s. Other interesting numbers include the fact that there are more than 10 000 desalination plants worldwide.

The bottled water sector is expanding fast, and is now a US$400-500 billion a year business. Despite its tremendous growth worldwide, it remains 1 000 times more expensive than high-quality tap water. Interestingly, the publication also notes that there have been more than 100 official 'recalls' of bottled water in recent years.

The report underlines the fact that science is crucial to water policy. "The integrity of science is key. We live in an increasingly polarised, critical, cynical world: efforts to diminish respect for media, government, academics and science will diminish the chances of solving the remaining water problems," noted Gleick.

To purchase the report go to www.worldwater.org *or* www.pacinst.org

The world in brief

- Trees that live in an odd forest in Oman, in the Middle East, have found an unusual way to water themselves by extracting moisture from low-lying clouds. According to researchers from the Massachusetts Institute of Technology the trees have preserved an ecological niche despite being surrounded by desert by exploiting a wispy-thin source of water that only occurs seasonally.

- The US government has partnered with two large non-profit organisations, the Case Foundation and the MCJ Foundation, to help bring clean drinking water to millions of people in sub-Saharan Africa. The so-called Playpump Alliance hopes to install 4 000 pumps in schools and communities over the next few years.

- Members of the G-77 backed plans for the establishment of the Consortium on Science, Technology & Innovation for the South (COSTIS). COSTIS will focus on organising South-South forums on developing appropriate and affordable technologies in sectors such as energy and water.

- Ghana has finalised a US$600-million deal with a Chinese corporation to build a 400 MW hydro-electric dam in the north of the country.

- Australia's worst drought in known history has sparked an increase in the number of water bandits who use crowbars to crack open water tanks and steal the contents. Farmers have been advised to lock their water stores.

- US scientists have identified a 'new generation' of byproducts of the disinfection processes used to purify drinking water at municipal water treatment plants. They reportedly identified 28 previously unreported so-called disinfection by-products (DBPs), however toxicity studies are still to be conducted to determine the health implications of these DBPs.

More plants, more rain

A statistical study of satellite images has indicated that more plants make for more rain.

The study, published in *Geophysical Research Letters*, concludes that vegetation effects account for about 30% of annual rainfall variation in Africa's Sahel region. This should assist scientists in understanding rainfall patterns in the area, which is threatened with increasing desertification and periods of drought. "It gives us an additional element of predictability: a bit of an edge in knowing where it might rain," reports study co-author Peter Cox, Director of the Climate and Land Surface Interactions Centre.

US scientists score big by thinking small

Researchers at the University of California, in the US, have designed nanoparticles to create a membrane that does not clog easily, allowing water to be pumped through using less energy.

Sci-Dev.Net reports that in the new membrane, used in reverse osmosis, nanoparticles are designed to attract water, soaking it up like a sponge, while repelling nearly all contaminants that might ordinarily stick to the surface. This creates a water purification process that is as effective as present methods, but may use half the energy, reducing the total cost of water desalination by 25%.

Water by Numbers

- **8,3 km** – The length of the new pipeline being constructed from the Crocodile River in Nelspruit to White River, via Rocky Drift. The pipeline is expected to be completed by mid-2007.
- **R112-million** – The Water Research Commission's planned research funding for 2006/07.
- **R154-million** – The profit posted by Umgeni Water for the 2005/6 financial year. The previous year's profit was R40-million.
- **59%** – The estimated proportion of people in the world that have access to basic sanitation. Only 37% of people in sub-Saharan Africa have access, according to the UN.
- **R2,5-billion**– The money to be spent by Rand Water over the next five years on upgrading and refurbishing its distribution infrastructure. The company reportedly spent R607-million on refurbishing and upgrading its infrastructure in the 2006 fiscal year.
- **25 million** – The estimated number of 'environmental refugees' – people forced to leave their homes due to increased water insecurity – according to international NGO Tearfund. For example, in Nigeria, thousands of square kilometres of land are converted to desert each year, forcing farmers and herdsmen to move to the cities.
- **3 600** – The estimated number of international treaties signed since the last water war between two Sumerian city-states 4 500 years ago.
- **US$81,8-million** – The funds loaned to Tanzania by the African Development Bank for water and sanitation projects in rural areas. The funds will be channelled through the Tanzania Rural Water & Sanitation Programme.
- **R27-million** – The value of the tender issued by the Limpopo government for the repair of sewerage systems in the Elias Motswaledi District Municipality.
- **93%** – The percentage of the South African population who have access to basic water supply, according to the Department of Water Affairs & Forestry.

Two successes for turnkey firm

VWS Envig has completed two large projects involving the construction of water recycling plants for SAPREF and ImproChem at the Chevron Refinery.

The SAPREF reverse osmosis (RO) plant was designed, built and commissioned by VWS Envig. Water from the Durban Water Recycling Plant is directed to the RO plant where it undergoes carbon filtration to remove impurities such as odours and organic compounds. The water then goes through two stages of RO followed by a final stage where the water is polished with a mixed bed to meet the required specifications. The company supplies all the chemical requirements to the automated plant, and has a service contract to maintain a smooth operation.

In turn, the Chevron/Improchem project in Milnerton involved the design, construction and commissioning of an ultrafiltration/RO plant. Domestic and industrial effluent from a nearby wastewater treatment plant is directed to the water recycling plant.

Software helps water demand planning

Civil Designer's Water Module allows users to establish water demands accurately and efficiently.

In residential areas, demands can be established according to stand areas, while reticulation pipelines are fairly evenly distributed along the area. When demands are distributed in the Water Module, it is only necessary to establish total demand in the network using a number of people and per capita demand, or measured consumption for existing networks using the menu option 'Adjust Demands' in the Data menu.

Choose the option 'Demand to Distribute (ℓ/s)' and enter the appropriate amount. The program will now automatically assign demands for each node proportionally to the lengths of the adjoining pipes.

In certain cases, certain parts of the network can have different per area demands. This is the case with low-income suburbs located next to a high-income area. In these instances, total demands should be established individually for each part of the network and the appropriate pipes and nodes should be selected.

For more information, contact Knowledge Base at Tel: (021) 701-1850

Leak-free toilet saves water

Toilet leaks, which often go undetected, can waste large volumes of potable water.

The Akuvuzi leak-free cistern, supplied by Ray Mitchley, is one solution to frequent toilet leaks. The Akuvuzi can hold between 6 ℓ and 11 ℓ of water. The mechanism keeps the cistern dry until needed. When it is flushed, a pilot-operated diaphragm valve opens and lets water flow into the cistern quickly. When the water reaches the level of the height-adjustable float, the flush valve is automatically operated and the cistern flushes. On flushing, the inlet valve is closed so that, once the water empties the cistern remains empty until the next time it is needed.

According to Mitchley, conventional toilets can easily be retrofitted with the leak-free cistern. Local plumbers can also be trained to fit the cisterns, creating valuable employment.

More than 1 000 of these cisterns have already been fitted in the Mangaung municipal area, in the Free State, with positive results.

For more information, contact Ray Mitchley at Tel: (031) 701-3185 or e-mail: bobcat@intekom.co.za

CSIR part of EU solar project

CSIR is representing South Africa in an international, multi-partner programme aimed at demonstrating the solar disinfection (SODIS) of drinking water as an appropriate intervention against waterborne diseases.

The programme, which has been awarded a €1,9-million research grant from the European Union, is being undertaken under the auspices of the EU Sixth Framework Programme. SODIS is reportedly a low-tech, affordable method of improving water quality. It involves placing contaminated water in transparent bottles, then placing it in direct sunlight for six hours. The method has been approved by the World Health Organisation.

The three-year SODISWATER programme will be carried out by nine research groups in Ireland, Spain, UK, Switzerland, South Africa, Zimbabwe and Kenya. The multidisciplinary team will investigate the health benefits of using solar-disinfected drinking water in developing countries, the factors which influence communities to adopt or reject SODIS, whether the basic technique can be improved or whether there are any major waterborne diseases that are not susceptible to the technique.

New nozzles for CT plant

The City of Cape Town has purchased 55 000 nozzles and 10 000 sockets to replace the nozzles in the rapid gravity sand filters at the Wemmershoek Water Treatment Plant.

The filtration plant was commissioned in the late 1960s, and has a design capacity of 318 Mℓ/day. The original nozzles were reportedly supplied by Jeffrey Manufacturing and had a 1'' BSP thread.

The new polypropylene nozzles were manufactured locally by Isekeni Trading. To match the thread and the municipality's design requirements, which included a detachable head with 0,45 mm, new tooling was required.

In brief

- **Rand Water** has reportedly established a bottled water unit to explore ways of entering this lucrative market.
- Dr Shadrack Ralekeno Moephuli has been appointed the new President and CEO of the **Agricultural Research Council** (ARC). He joined the ARC from the Department of Agriculture where he was the Chief Director responsible for Agricultural Production.
- **Johannesburg Water** is working with the City of Johannesburg to provide 20 households in informal settlements with ventilated improved pit toilets and improved water supplies through communal standpipes through Project Thonifho.
- International company **Coca Cola** has signed an agreement with UNESCO-IHE for a four-year co-operation aimed at improving the water and environmental sectors. It includes training programmes for Coca Cola staff members, with the first group of 40 receiving training on advanced water treatment technologies, groundwater treatment and risk management in Johannesburg earlier this year.

New magflow meter introduced

The new Safmag Beta Meter is the latest edition in the Safmag range. The meter is reportedly cost-effective, easy to use, and install, while providing accurate and reliable flow measurement. According to supplier, Flowmetrix SA, the product is available with wetted parts to suit all potable water and effluent applications.

The meter delivers accuracy of about 0,5% using the non-intrusive principle of electro-magnetic induction, has no moving parts and introduces zero head loss. Readings are independent of density.

For more information, contact Flowmetrix SA E-mail: enquiries@flowmetrix.co.za or Visit: www.flowmetrix.co.za

Water on the Web

http://www.fao.org/landandwater/iptrid/index.html
This is the official website of the International Programme for Technology and Research in Irrigation and Drainage (IPTRID), an independent multi-donor trust-fund programme hosted by the United Nations Food and Agriculture Organisation. This website contains information about IPTRID's strategy, projects, publications, database and news.

www.personal.leeds.ac.uk/~cen6ddm/
This is the personal website of Prof Duncan Mara from the School of Civil Engineering, University of Leeds, UK. It contains free-to-use video and audio PowerPoint mini-lectures and supporting material on sanitation and water supply topics.

www.unisdr.org
This is the website for the International Strategy for Disaster Reduction, which aims to build disaster resilient communities by promoting an increased awareness of the importance of disaster reduction as an integral component of sustainable development.

www.worldwatercouncil.org/index.php?id=705
This is the website of the World Water Council to promote international reflection to enhance the effectiveness of the right to water. A project has been initiated to analyse how several countries are dealing with the right to water. This site provides information on the project, among others.

www.blacksmithinstitute.org
This is the website of the US-based Blacksmith Institute whose objectives are aimed at developing and implementing solutions for pollution-related problems in the developing world. The NGO is most well known for its Polluted Places Initiative to address most severely polluted sites around the world.

Balancing Power and Water at Braamhoek

It might be situated in the Little Drakensberg Escarpment, but the R8,9-billion Eskom Braamhoek Pumped Storage Scheme is certainly not a small project. In addition to economic and social considerations, the project faces tremendous environmental challenges. Lani van Vuuren visited to site to see how the needs of power generation and water are being balanced.

It has been almost 20 years since the construction of South Africa's last pumped storage scheme, Palmiet, near Grabouw in the Western Cape. Braamhoek will not only be the most modern pumped storage facility in South Africa but, with a capacity of 1 332 MW, also certainly the largest. Pumped storage schemes are said to be desirable, as they reportedly do not require much water, as the water is being continuously recycled. The main water losses stem from evaporation from the reservoirs.

The site straddles the Klein Drakensberg escarpment and spans over the farms Braamhoek and Zaaifontein, some 40 km north-west of Ladysmith in KwaZulu-Natal, and Bedford farm, located some 23 km east-north-east of Van Reenen, in the Free State. The pumped storage station itself will be located in KwaZulu-Natal.

MAIN FEATURES

Development of the Braamhoek Pumped Storage Scheme started in earnest following the Record of Decision in 2002. Main consultants, Braamhoek Consultants Joint Venture (BCJV), comprising Knight Piésold, Stewart Scott International and Arcus Gibb, started basic design in 2004. Various other local and international specialist sub-consultants are assisting in the project, especially with regards to implementing the latest pumped-storage technology.

BCJV Resident Engineer Michael Neumann explains that the scheme basically comprises two reservoirs situated about 6 km apart, with an elevation difference of 470 m between them. Unlike the Drakensberg Pumped Storage Scheme, Braamhoek is designed solely for the purpose of generating peak-time electricity, and will not be used for the inter-basin transfer of water. Therefore, the dams will be relatively small, with an active capacity of approximately 22 million cubic metres each. Water will only be drawn from the rivers to top up the reservoirs.

The reservoirs will be connected by underground waterway tunnels, an underground powerhouse complex, and access tunnels. Access roads and a new substation also form part of the project.

RESPECT FOR THE ENVIRONMENT

Conservation organisations initially opposed the construction of Eskom's latest pumped storage scheme at Braamhoek. Sparsely populated, the 8 500 ha site features mainly grasslands with wooded gulleys along the mountain streams. Yellowwood forest predominate in the ravines of the escarpment (none of which will be affected by this project). This is reported to be the third-largest complex of this forest type in KwaZulu-Natal.

However, closer inspection revealed that while the area offers huge conservation potential, overgrazing and historically poor land management have resulted in severe erosion and a loss of biodiversity in the surrounding veld. Invading alien plants, most notably black wattle, are widespread in the area.

The biggest bone of contention was the 240 ha peat wetland situated in the Bedford catchment. This wetland is home to a number of bird species that are either critically endangered, near endangered or at risk, including the elusive white-winged flufftail. About 5% of the total wetland area will be covered by the upper reservoir.

Following negotiations, leading to an amended Record of Decision, Eskom and various conservation organisations are now working together to improve biodiversity in the area. As BirdLife SA Executive Director Prof Gerhard Verdoorn points out, much of the land in the area of the marsh was degraded and in poor condition prior to the start of the project. The non-governmental organisation (NGO) first opposed the pumped storage scheme, but later withdrew its objection. "As a conservation organisation we could see that intervention was required to prevent it from degrading even further."

The Middelpunt Wetland Trust, which was created a few years ago with the sole aim of protecting the white-winged flufftail, confirms this.

"Without focused attention brought about through the Braamhoek project, the area would never have received the attention it requires," the NGO states on its website.

Three years ago, the Braamhoek Partnership was established between Eskom, Birdlife South Africa and the Middelpunt Wetland Trust. This is reportedly the first time in the power

All water from the tunnel is pumped to a holding dam before being treated and released back into the river system. Solid waste is also strictly controlled.

An aerial view of the present construction site. The entrance to the exploration tunnel is on the left. Unlike the Drakensberg Pumped Storage Scheme, no permanent construction village is planned for the site.

generator's history that conservation NGOs have been brought on board long before construction of a power plant is due to start.

Eskom is compelled by the Record of Decision to turn the entire site into a conservation area. This will increase the present extent of 'conserved grasslands' by about 81%. Eskom has committed itself to, among others, rehabilitating eroded areas, and halting alien plant encroachment. All areas affected by construction, including all quarries, will be fully rehabilitated.

Peter Nelson was appointed Reserve Environmental Manager a few months ago, and he will inherit any development that takes place on site. "There is no reason why this project cannot be a world-class example of responsible infrastructure development. Crucial to this, however, is a respect for the land on which the development is taking place, a respect that has to be instilled in every single employee from the lowest worker to the project manager."

Rivers and streams in the area have been found to be in a good to excellent condition. Nelson explains the importance of finding a balance between power generation and water. "Eskom realises the importance of infrastructure development that is sustainable, from an economic, social and environmental point of view. South Africa needs more power but, at the same time, we are a water-scarce country, thus we must protect the water resources that we have. We cannot ignore the fact that this project is being constructed in the headwaters of two strategically important river systems."

UPPER RESERVOIR

Situated in the top catchment, the Bedford Dam will be located in the headwater tributary of the Wilge River, which flows into the Vaal River system. The concrete-faced rockfill dam will have a length of 810 m and a height of 40,9 m, with a 100 m-long emergency spillway. The dam crest elevation will be 1 740,6 m while the crest width will be 8 m. All the rockfill material will be sourced on site, and the main quarry will be located within the reservoir basin.

It is reported that the outlets works will be capable of a range of discharges at all impounded water levels to meet the strict release requirements to accommodate the conditions set out in the Record of Decision. The outlet works will comprise a tower in the reservoir with radial gate and maintenance stoplogs. The tower will be accessed by a bridge from the dam. This high-flow bottom outlet system will have a maximum discharge capacity of 70 m^3/s at fully supply level, and 52 m^3/s at minimum operating level.

A flow distributing weir will also be constructed downstream of the dam to distribute reservoir outflows across the wetland. This is crucial, as a disregard for the instream flow requirements would have a significant impact on the wetlands downstream of the dam.

It is interesting to note that the presence of an isolated population of an unidentified *Barbus* species has been found in a stream draining the eastern section of the Bedford catchment. To prevent hybridisation of fish species in the different river systems, fish barriers will be constructed at the headrace and tailrace tunnels.

Important plant species that will be inundated by the two reservoirs, such as the Red Data *Kniphofia flammula*, will be identified and relocated. A nursery will be established to house endemic and rare plants.

LOWER RESERVOIR

In turn, 38,6 m-high roller-compacted concrete Braamhoek Dam will be located in a very distinct poort in the headwater of the Klip River (Braamhoek Spruit), which flows south-eastwards into the Thukela River.

Design selection is based mainly on the presence of underlying dolerite. The spillway will be a stepped chute on the downstream face of the dam, with a 40 m-long crest featuring a stilling basin with baffles. The

Many of the soils found in the area are highly leached and strongly acidic. The presence of light textured, silty subsoils underlain by slaking mudrock renders many of these soils susceptible to erosion.

Entrance to the 5 m x 5 m exploration tunnel. The 6 m³ dump trucks used at present will later make way for articulated dump trucks once construction of the main machine hall starts. Passing bays are being excavated every 100 m along the tunnel to permit empty trucks give way to fully laden trucks hauling uphill.

Braamhoek Dam will have a length of 331 m and a crest width of 5 m.

The dam will have a high-flow outlet with a maximum discharge capacity of 74 m³/s and a low-flow outlet capacity of about 2,3 m³/s. Neumann notes that the dam wall height has been selected to provide a 0,5 m freeboard to accommodate flood inflows, such that a 1:200-year flood will not cause the dam to spill.

Nonetheless, flood inflows will normally be released downstream through the outlet works to mimic the natural flow of the stream. The dam therefore attenuates the effects of natural floods.

POWER GENERATION

Similar to the Drakensberg Pumped Storage Scheme, power generation will be conducted entirely underground. The machine hall, housing four 333 MW single-stage reversible Francis pump-turbine units, will have a length of 172 m, a height of 40 m, and an average width of 23 m. The adjoining transformer hall will be of similar length or longer (depending on the equipment needed), with a span of 18 m and a height of 17 m.

The waterways will include an intake structure for twin 6,6 m-diameter concrete-lined headrace tunnels, each with a length of 1 030 m, to the surge shafts (the main headrace surge shaft will have a diameter of 15 m). Twin inclined steel-lined pressure shafts of 5,1 m-diameter will lead into steel-lined penstocks of varying diameter. In turn, these bifurcate to two smaller penstocks leading to the inlet valves and the machine hall. They will have an overall length of just over 1 200 m to the main inlet valves, which are housed in the machine hall.

In addition, there will be four 4,7 m-diameter draft tube tunnels with a length of 135 m each, to reach the twin 20 m-diameter tailrace surge chambers. Two short 6,6-m diameter tailrace tunnels will lead to a single 9,4 m-diameter tailrace tunnel, in turn, leading to an outlet structure. This will be situated 2 530 m downstream of the surge chambers.

The main access tunnel will be 9 m x 9 m with a gradient of 1:10 and a length of 1 250 m. Tenders for this tunnel closed in November. Construction on the tunnel is scheduled to start in March, with completion expected by December 2009.

Spoil and waste rock material resulting from the tunnelling process is being stockpiled temporarily for use as fill to the access roads, to create temporary terraced working platforms for the power station contractor, and for rehabilitation of erosion features within the project boundaries. All excess waste rock will be disposed of below the minimum operating levels of the two reservoirs.

EXPLORATION TUNNEL

The first construction contract was awarded to Concor-Ukhozi Joint Venture in August 2005 for the construction of the 873 m-long exploration tunnel. The 5 m x 5 m

The Braamhoek Spruit will be dammed by a roller-compacted concrete wall. Compensation flows will, however, ensure uninterruoted flow to downstream users.

horseshoe-shaped tunnel has a gradient of 1:8 and leads to the underground powrhouse complex. As the name implies, the exploratory tunnel was initially planned for investigating different types of support materials, exploratory drilling and for the installation and monitoring of instrumentation (incorporating convergence stations, extensometers, instrumented rockbolts, and rock anchors) to provide geotechnical data for design purposes.

Since construction of the machine hall will start prior to the completion of the main access tunnel, the exploration tunnel will initially form the only access for the excavation of the underground works. It will later house the 400 kV transmission cables leading to the surface switchyard, and provide a second means of egress from the underground power station. In addition, it will be used as a ventilation tunnel.

Construction of the exploration tunnel is taking place in three shifts working 24 hours, six days a week. Neumann reports that more than 600 m of tunnelling has been completed to date. The projected completion of the tunnel is June.

The geology of the area has proven quite challenging. The area is underlain by sedimentary rocks (mostly sandstone and mudrock) of the Ecca and Beaufort Groups of the Karoo Supergroup, intruded by dolerite dykes and sills, with some faulting occurring. Approximately 137 boreholes have been drilled around the site to explore the underlying rock formations in the dam foundations, along the various tunnel alignments, potential quarry sites and cuttings of the access roads.

"By studying this core material, we believe we have gained important insight into what lies where," BCJV geologist John Reid tells *the Water Wheel.* This knowledge is crucial as the dolerite will require less support than mudrock, which typically of many Karoo mudrocks, experience rapid disintegration when exposed. For this reason, Neumann emphasises the importance the immediate installation of support following blasting, comprising roof bolting and shotcrete.

The present minimal water ingress into the tunnel is being pumped out to a holding dam outside the portal. While the water was mainly used for dust suppression in winter, it is now being treated at a 44 m^3/day water treatment plant on site before being released back into the river system. Water samples are tested weekly by an independent laboratory in Winterton.

SOCIAL ASPECTS

About 30 families remain in the upper and lower catchments of the Braamhoek Pumped Storage Scheme. It is understood that all the homesteads in the area will be relocated, and alternate tracts of land has been purchased for this process.

Nelson reports that the power generator does not want to merely move these communities, but wants to equip them with sustainable land management practices for the long term.

ENVIRONMENTAL RESEARCH AND DEVELOPMENT

Prof Verdoorn is happy to report that Eskom is diligently following the stipulations of the Record of Decision. BirdLife South Africa has performed extensive surveys on birds and plants on the Braamhoek site, and a monitoring programme on habitats and birds has been established.

In addition, the NGO participates actively in monitoring the construction work, advising on environmental management and mitigating impacts. Field officer David Maphisa was appointed to conduct all the biological work. A formal conservation project on the southern bald ibis, which has been found nesting in the area, has also been launched.

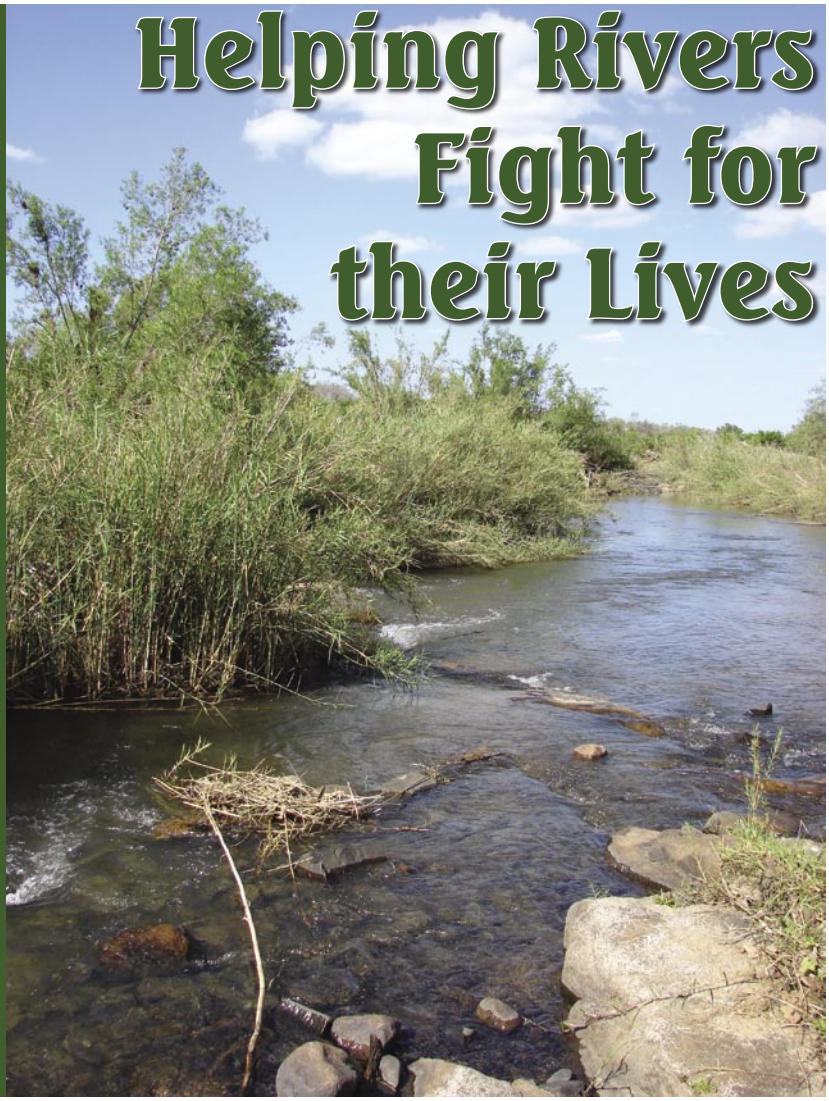
Middelpunt Wetland Trust has established links with the Ethiopian Natural History Society (Ethiopia being the only other country where the white-winged flufftail has been recorded). With funding from Eskom, the NGO established an education centre at the main breeding site of Berga, in Ethiopia.

Eskom is also a trustee of the Ekangala Grassland Trust, which is driving a pilot study to conserve high-altitude grassland in South Africa at present.

A number of neighbouring farms have expressed interest in joining the conservation area, and it is hoped that more will follow as the project progresses. "This is going to be the best example of how industry and NGOs can collaborate to improve environmental conditions for a natural area" concludes Prof Verdoorn.

Helping Rivers Fight for their Lives

Buckling under the pressures of growing water demand and pollution, the world's freshwater biodiversity and habitats are being lost at an unprecedented rate. International freshwater experts from as far afield as the US and Australia gathered at Skukuza, in the Kruger National Park, to identify solutions for freshwater conservation. Lani van Vuuren reports.



With large infrastructure developments threatening the flow of the Olifants River, the Sabie River is the last remaining perennial river in the Kruger National Park.

Although freshwater ecosystems occupy less than 1% of the world's surface, they make some of the largest contributions to human welfare. Historically, the world has taken a utilitarian view of rivers (if water is left flowing into the sea it is being wasted). Everyday, more rivers, wetlands, estuaries and groundwater resources are threatened by over-abstraction, damming, urbanisation, industrial and agricultural pollution. In fact, global trends indicate that freshwater biodiversity is declining faster than that of terrestrial and marine biomes.

Most governments afford low priority to improved freshwater ecosystem management, with decision makers and communities often being unaware of the threats and opportunities to conserve freshwater ecosystems. "Conserving river ecosystems depend on whole catchment management, where land and water is managed in an integrated manner aimed at achieving ecological and socio-economic sustainability," noted Jeanne Nel of CSIR's Natural Resources & the Environment Unit. "This requires the development of integrative assessment and planning approaches that proactively consider the needs of both terrestrial and freshwater ecosystems."

SAVING WATER FOR SOCIETY

"Conservation of freshwater ecosystems is crucial for providing reliable and clean water supplies needed to sustain people and nature," noted Jamie Pittock, Director of WWF's Global Freshwater Programme. An example of the extent of the problem is the fact that two thirds of the world's large rivers (longer than 1 000 km) have already been diverted

for human use. In Africa, there are 23 rivers longer than 1 000 km of which 35% remains free-flowing.

Many of the last remaining free-flowing rivers have been earmarked for future development. WWF estimates that of the world's remaining 64 large free-flowing rivers, at least 17 are in danger of being dammed by 2020, most of these in developing countries.

Global pressures to reduce poverty are conflicting with demands to sustain biodiversity. "The United Nations Millennium Development Goals call for countries to halve the number of those without access to basic water and sanitation, increase food production and use alternative sources of energy (including hydropower) on the one hand, and to protect biodiversity on the other hand," Pittock told delegates. "International donor aid for water is shrinking, and remains largely focused on development of infrastructure. "The environment always ends up at the bottom of the to-do list."

TOO LITTLE, NOT TOO LATE

In South Africa, such as elsewhere in the world, the focus has historically fallen on the protection of terrestrial ecosystems, with river ecosystems being in a much poorer state overall. A study undertaken of South Africa's 112 main rivers as part of the National Spatial Biodiversity Assessment in 2004/05 emphasised how hard most of the country's rivers are working to meet its economic and social development needs.

The country's main rivers are heavily utilised and regulated to improve water security for socio-economic use, and there are widespread water transfer schemes across the country to cater for areas where water requirements exceed the natural water availability. About 84% of the ecosystems of main rivers are threatened, 44% of them critical.

In addition, the analysis of the data collected on South Africa's River Health Programme, which measures rivers' ecological conditions, shows that only 1,6% of the 13 river systems that have thus far been studied are in a natural condition, 26,6% are in a good condition, 42,8% are in a fair condition and 29% are in a poor state.

By threatening freshwater habitats we also threaten the species reliant on them. About 30% of South Africa's indigenous fish species are considered threatened, of which seven are critically endangered, six are endangered and nine are vulnerable. A major threat is the introduction of alien aquatic animals. All of South Africa's main rivers are inhabited by alien fish species.

At least 33 species of introduced alien aquatic animals and 25 species of translocated indigenous species have been recorded in natural water bodies in South Africa. It is reported that introduced freshwater fish such as trout and bass threaten rare indigenous fish, such as redfin minnows in the Western Cape, and have led to the near extinction of Treur River barbs.

The introduction of trout in neighbouring streams in Lesotho 70 years ago have also nearly eradicated the Maloti minnow, the country's only known endemic fish species, explained Dr Ernst Swartz, an aquatic biologist at the Institute of Aquatic Biodiversity. The fish has already become extinct in South Africa.

Furthermore, the Mohale reservoir, constructed as part of the first phase of the Lesotho Highlands Water Project (LHWP), flooded 77% and 99% of the existing habitat of the

Courtesy of SA Tourism

All over the world, freshwater biodiversity is disappearing faster than terrestrial and marine biomes.

population in the Jordane and Bokoaneng rivers respectively. Fish in these rivers were translocated to four sanctuary streams in an effort to save the Maloti minnow from extinction. While reports from LHWP developer TCTA indicate that the translocated minnows are thriving, conservationists remain concerned as no barriers have been constructed to date to keep predator alien fish out of the sanctuary streams.

According to Dr Swartz, translocated species, indigenous fish that have been translocated either intentionally or unintentionally into catchments in which they were not naturally distributed, can be just as threatening if not more so than alien fish. "This often leads to hybridisation (genetic mixing) between species of which the outcome is unpredictable. Different species have their own genetic makeup that has been influenced by its adaptation to specific habitats. Resultant hybrids can be sterile or could be viable causing one species to dominate the other."

Great engineering feats, such as the Orange-Fish tunnel, have been considered an environmental disaster as they became enormous conduits for fish species to translocate from one catchment area to another. While alien plant control programmes are well spread within South Africa, there are no known national or even catchment-level control programmes to eradicate alien fish yet. However, the Cape Action for People and Environment is leading a project to clear some priority rivers in the Cape Floristic Region of invasive alien species.

SAVING WHAT IS LEFT

There is no doubt that efforts to reverse declining trends need to increase. But how to effect that positive change is far from obvious. One possible solution debated by Skukuza symposium delegates was the improved establishment and management of protected areas.

While large areas of freshwater habitats are incorporated into protected areas already, for example, Ramsar sites (such as St Lucia Lake), these have been found not to be properly representative of the diversity of habitats. Most existing protected areas have neither been designated nor managed for freshwater conservation. In South Africa, 90% of the country's main rivers fall outside protected areas, while an additional 5% serve as boundaries of these areas, leaving them effectively unprotected.

While it is recognised that conserving whole river systems in protected areas is seldom a practical management option, changing the way in which future protected areas are designated or expanded could help improve the representation of freshwater ecosystems within protected area systems. For example, by delineating protected areas to coincide with catchment boundaries, as opposed to using rivers themselves to mark protected areas.

"Integrated protected areas need not stop at a river's mouth. For instance, a combined terrestrial-freshwater-marine protected area might be built around meeting the linked goals of maintaining water quality in freshwater and marine systems by protecting both critical management zones and catchment management zones on the terrestrial landscape," reported Dr Robin Abell of WWF-US.

Freshwater ecosystems that do fall within protected areas are often viewed and managed as a necessary resource for conserving terrestrial biodiversity rather than for their intrinsic biodiversity value. Due to the linear characteristic of rivers, freshwater ecosystems inside protected areas are especially vulnerable to exogenous threats. For example, the Olifants River flowing through the Kruger National Park stopped flowing for the

The analysis of the data collected on South Africa's River Health Programme shows that only 1,6% of the 13 river systems that have thus far been studied are in a natural condition.

Courtesy of SA Tourism

We hold the future of our aquatic ecosystems in our hands.

Courtesy of SA Tourism

Freshwater ecosystems that fall within protected areas are often viewed and managed as a necessary resource for conserving terrestrial biodiversity rather than for their intrinsic biodiversity value.

first time on record for 78 days in 2005 due to drought and growing demands on its water. Planned upstream infrastructure developments, such as the De Hoop Dam, on the Steelpoort River and the rehabilitation of the Massingir Dam in Mozambique, further threaten the park's freshwater.

According to Dr Harry Biggs of the Kruger National Parks' scientific services, it is important for managers to take cognisance of the influences of upstream activities on freshwater within their protected area. "Conserving freshwater ecosystems within the fence often means spending more time outside the park taking part in catchment management decisions." Integrated catchment management as well as the provision of adequate water flows are critical, delegates concurred.

Symposium participants committed themselves to several actions, including preparing and distributing guidelines and case studies on management guidelines for optimal conservation of freshwater biodiversity in protected areas; and supporting governments to implement national protected area systems to conserve freshwater biodiversity.

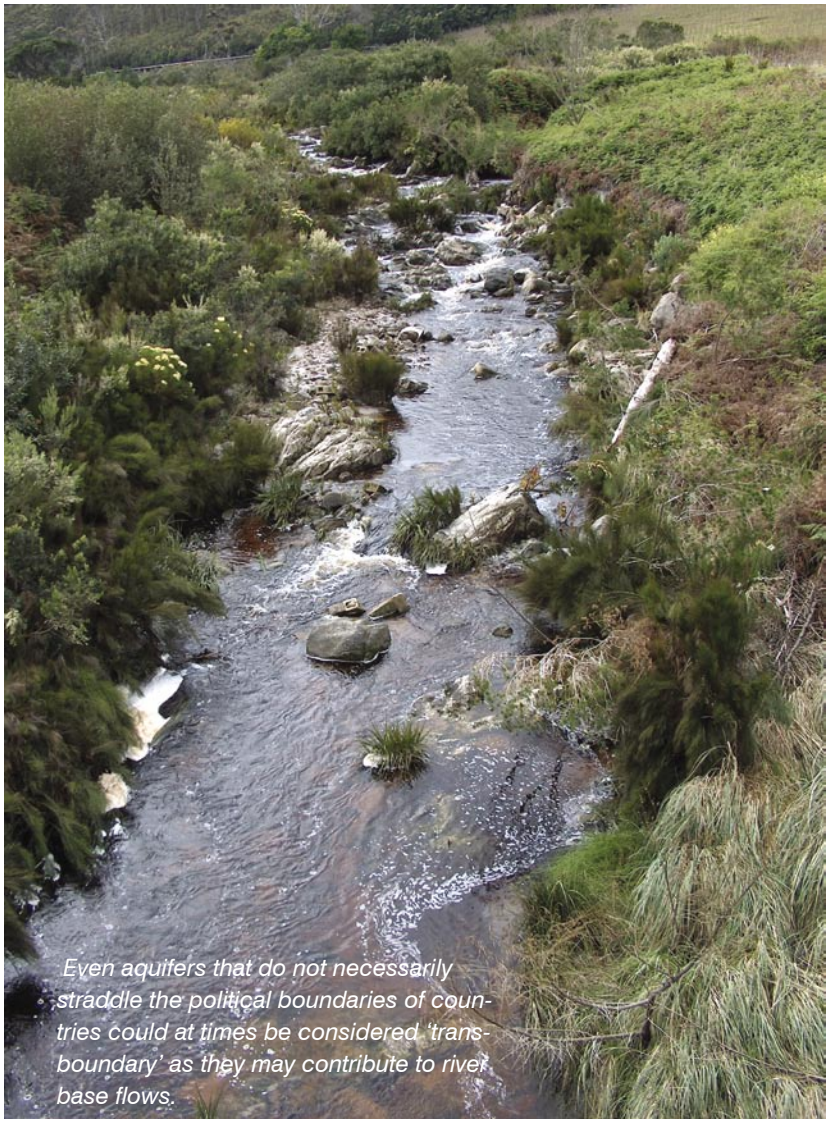
KEEPING FLOWING RIVERS FREE

Another concept that received much attention at the symposium was that of free-flowing rivers. These are rivers, or distinct sections of rivers, that flow undisturbed without encountering any dams, weirs or barrages. A free-flowing river should have sufficient flows to sustain the full range of freshwater ecological attributes. Also known as 'wild' or 'heritage' rivers, the concept has taken off in countries such as Canada, the US and parts of Australia where these free-flowing rivers are important new conservation icons and tourist attractions.

South Africa has very few free-flowing rivers left. Most of these rivers are situated in the Eastern Cape and KwaZulu-Natal, and have already been earmarked for future infrastructure development. The largest of these is reported to be the Mzimvubu River, which only has a few small farm dams on its tributaries.

From the symposium it is hoped to develop criteria, guidelines and case studies and to develop a place where rivers that are protected as free-flowing rivers can be registered and celebrated.

Freshwater protection is for many countries still a novel concept. However, it is hoped that by working together across boundaries and disciplines, that a sustainable solution might be found before it is too late.



Even aquifers that do not necessarily straddle the political boundaries of countries could at times be considered 'transboundary' as they may contribute to river base flows.

Managing Southern Africa's Shared Aquifers

During the last 50 years, more than 200 international treaties for transboundary watercourses have been signed across the globe. Unfortunately, the same cannot be said for transboundary groundwater resources. Lani van Vuuren reports.

The world's aquifers have been described as 'secretive', 'hidden', and 'mysterious'. All indications are that we just do not know enough about them. Transboundary aquifers, i.e. those underground resources which cross the border between two or more countries; are an estimated three times greater in volume than internationally shared surface waters. However, they are generally not well understood by decision makers and policy developers, in some cases being blatantly ignored.

There is still no comprehensive worldwide inventory of transboundary aquifers, and very little experience worldwide in the joint management of these resources, even though some of them contain huge quantities of water.

Today's best practice in sustainable water management – Integrated Water Resources Management (IWRM) – focuses on river basins as the unit of management, explains Dr Anthony Turton, Head of the African Water Issues Research Unit at the University of Pretoria. "However, this overlooks two fundamental realities; one, that groundwater aquifer systems, while being an integral part of the overall water resource, seldom correspond with the surface water management unit, i.e. the river basin. Two, in almost all cases, groundwater systems are, by their very nature, transboundary."

Even aquifers that do not necessarily straddle the political boundaries of countries could at times be considered 'transboundary' as they may contribute to river base flows. Groundwater use in such aquifers therefore may have an impact downstream across international boundaries. Aquifers may also receive most of their recharge in one country, but discharge in another.

Internationally, there is a trend to increasingly address groundwater in international agreements,

non-binding instruments and interstate compacts, from a resource management as well as an environmental perspective. Unfortunately, many of these agreements only contain a passing reference to the subject.

"Aquifer characteristics need to be adequately considered when formulating groundwater law and policy," maintains Chusei Yamada, Special Rapporteur on shared natural resources to the United Nations International Law Commission. For example, groundwater flows though small pores in rock material and can thus move at a snail's pace of around a few millimetres a day. This slow movement of groundwater does not allow for much mixing of its constituents. Therefore, pollutants are concentrated and move slowly. On the other hand, surface water can flow at a rate of several metres per second. The turbulent flow of the water allows pollutants to mix and distribute more evenly throughout the water system."

"An understanding of basic hydrogeology, including the proper use of scientific terminology, is thus necessary for law and science to agree on groundwater issues. Factors that determine groundwater quantity and flow should be taken into account when determining how to apply international law principles to groundwater," notes Yamada.

The complex characteristics of groundwater place increased pressure on the scientific community to provide the necessary data and information for the formulation of adequate policies and laws concerning transboundary aquifers. This includes the quantification of aquifer potential, recharge calculations, defining compartment boundaries, determining recharge 'episodes', and defining recharge zones. Most groundwater investigations undertaken by individual countries still tend to stop at the border.

TRANSBOUNDARY AQUIFERS IN SOUTHERN AFRICA

Within the Southern African Development Community (SADC) it is estimated that 37% of the population rely on formal or improved groundwater supplies, while another 40% rely on unimproved resources (both surface and groundwater resources). With about a third of the regional population living in drought-prone areas, groundwater will undoubtedly play an increasing role in socio-economic development in the future.

As it is elsewhere in the world, there are more transboundary aquifers in the region than there are transboundary river basins, with South Africa and Botswana both having the greatest number of known shared groundwater systems. The UNESCO-led ISARM (Internationally Shared Aquifer Resources Management) Initiative has identified 19 transboundary aquifers in southern Africa to date. While the extent of these transboundary aquifers is relatively known, the resources have not been properly quantified to take the transboundary conditions into account. Moreover, there are no formal structures (if any) to govern these shared resources.

Fundamental tools for transboundary groundwater management, such as hydrogeological maps and maps of groundwater vulnerability and water scarcity, are not available in the SADC region, with existing information mostly limited to the country concerned. The most arid countries such as Botswana, South Africa and Namibia have devoted understandably the most attention to groundwater resources exploration, assessment, developing and monitoring.

There seems to be little regional consensus on the measurement and management of transboundary groundwater resources, resulting in the lack of regional monitoring networks, for example. The international arena offers little guidance in this respect, notes Dr Turton.

The responsibility for management of groundwater resources is often fragmented between different authorities and at different scales. This issue has been exacerbated in recent years with the move towards decentralisation of management responsibility. Typically, local government, water departments, planning departments

Irrigated agriculture is a large user of groundwater, especially in countries such as South Africa.

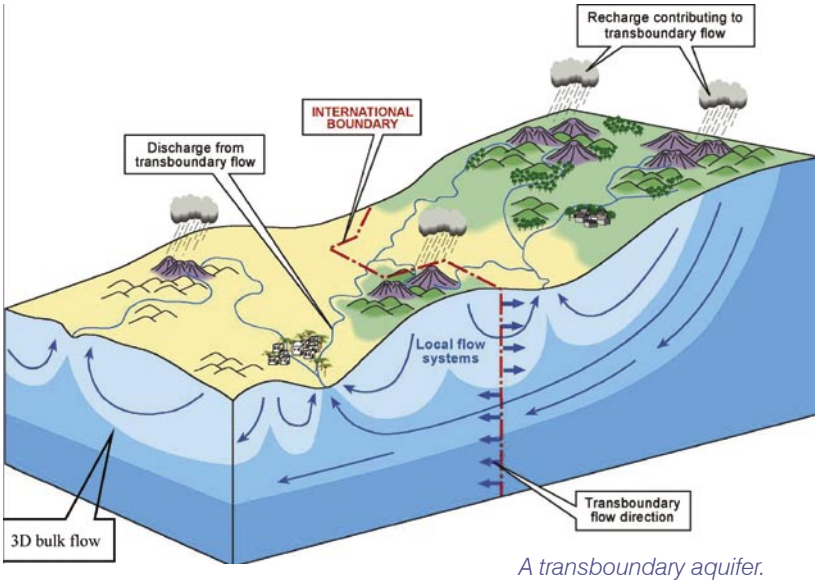
and environmental departments are responsible for different aspects of groundwater management, with both central and regional offices of the departments further diffusing responsibility.

Dr Turton reports that there is only one known international agreement involving management of groundwater systems in SADC, focused on the waters shared by Botswana and Namibia in the Chobe-Linyanti area of the Caprivi Strip.

Investigations by organisations such as CSIR indicate that various transboundary aquifer systems are not yet on record. This tends to make these aquifers more vulnerable to overabstraction and pollution as countries sharing the same resource might have different policies regarding groundwater use and protection.

One possible reason why transboundary aquifers have remained largely in the shadows could be the lack of political interest, former Department of Water Affairs & Forestry (DWAF) Deputy Director: Geohydrological Information, Jan Girman, points out. "International transboundary groundwater resources, such as the Nubian Sandstone Aquifer System, shared between Libya, Egypt, Chad and Sudan, have been highly politicised. The same cannot be said for southern African aquifers."

As of yet there does not seem to be the same intense competition for transboundary groundwater resources between countries as there are for shared surface resources. Generally, where large-scale abstraction takes place on one side of the border, little or no abstraction takes place on the other side. Of course, this could change significantly in future as more groundwater resources are earmarked for social and economic development, reports Girman.



Courtesy ISARM

A transboundary aquifer.

While South Africa's water legislation and policies have received worldwide acclaim, there is a significant gap as far as management of transboundary aquifers are concerned, DWAF Deputy Director: Groundwater Resource Assessment & Monitoring, Eddie van Wyk tells *the Water Wheel.* "This can be seen with groundwater resources such as the Zeerust-Gaborone Aquifer, straddling South Africa and Botswana, which, despite being prone to pollution, is not being managed as a transboundary aquifer."

Another example is the Pomfret-Vergelegen Aquifer, a high-yielding karstic aquifer in the North West of South Africa, straddling the border with Botswana. Water abstraction for irrigated agriculture from this aquifer has been increasing on the South African side, causing a dewatering of the overlying unconfined upper

TABLE 1
Transboundary aquifers in SADC as identified by ISARM

Aquifer Name	Countries
Rift Aquifers	Kenya, Tanzania, Uganda
Kagera Aquifer	Tanzania, Uganda
Kilimanjaro Aquifer	Tanzania, Kenya
Coastal Sedimentary Basin I	Kenya, Tanzania
Coastal Sedimentary Basin II	Mozambique, Tanzania
Limpopo Basin	Mozambique, Swaziland
Coastal Sedimentary Basin III	Angola, DRC
Coastal Sedimentary Basin IV	Angola, Namibia
Coastal Sedimentary Basin V	Namibia, South Africa
Congo Intra-cratonic Basin	Angola, DRC
Karoo Sandstone Basin	Mozambique, Tanzania
Shire Valley Alluvial Aquifer	Malawi, Mozambique
Northern Kalahari/Karoo Basin	Angola, Botswana, Namibia, Zambia
SE Kalahari/Karoo Basin	Botswana, Namibia, South Africa
Ramotswa Dolomite Basin	Botswana, South Africa
Nata Karoo Sub-basin	Botswana, Namibia, Zimbabwe
Tuli Karoo Sub-basin	Botswana, South Africa, Zimbabwe
Medium Zambezi Aquifer	Botswana, Mozambique, South Africa, Zimbabwe
Karoo Sedimentary Aquifer	Lesotho, South Africa

Source: ISARM

Groundwater is playing an increasingly important role in water supply, especially in rural areas.

Kalahari Aquifer, a CSIR report reveals. This also has the potential to unknowingly impact upon groundwater users in Botswana, because of the inherent transmissivity of the system.

Differing legislation in the two countries and the differing approach to groundwater management and water resource protection can cause South African farmers to migrate to Botswana to exploit the groundwater there from the same aquifer.

Where international surface water treaties are in place, the lack of understanding of groundwater resources can cause it to be largely ignored when it comes to developments in transboundary basins. The government of Botswana is reportedly going ahead with construction of the Lower Shashe Dam to be built about 50 km east of Francistown. The dam, which is expected to be completed by 2010, will be the largest in the country at an estimated 4,9 million cubic metres fill volume.

The Shashe River is one of the main tributaries of the Limpopo River, shared between South Africa, Zimbabwe, Mozambique and Botswana. On the South African side, huge volumes of water are abstracted from the alluvial deposit below the Limpopo River for use in the kimberlite treatment process at De Beers' Venetia Mine and by irrigation farmers at Weipe and Pontdrift, explains Willem du Toit, Deputy Director: Water Resources Information: Limpopo.

"Lack of institutional capacity at all levels seriously hampers transboundary groundwater management."

"Potential recharge reduction as a result of the dam could not only impact these water users, but also the already endangered riparian forest remaining along the Limpopo River and the emergent Limpopo-Shashe Transfrontier Park." All indications are that users of the alluvial aquifer were not informed of plans to construct the dam prior to approval by the Botswana government.

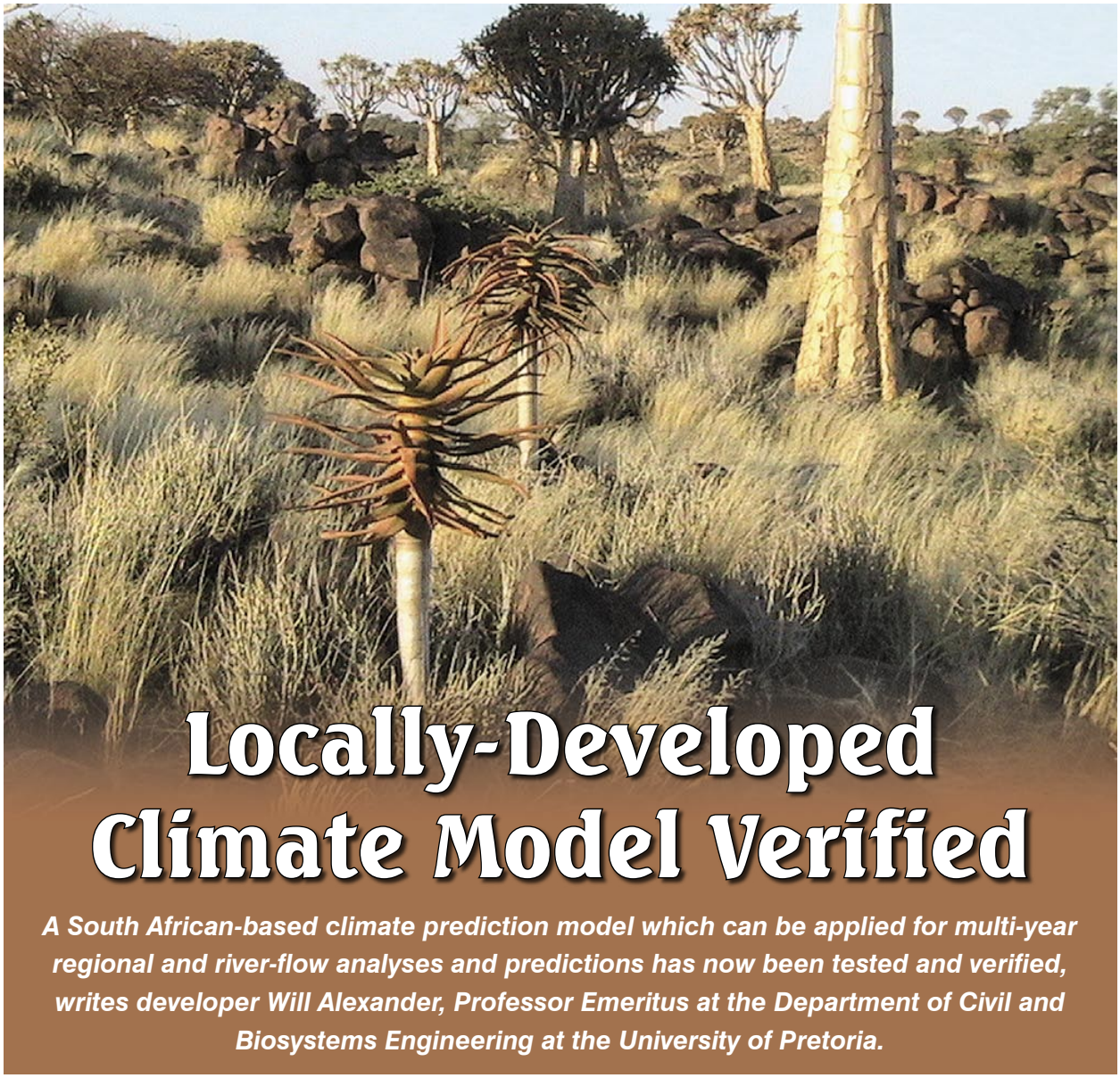
Lack of institutional capacity at all levels seriously hampers transboundary groundwater management. "In South Africa, for example, groundwater issues were largely ignored until 1998 when the National Water Act officially recognised groundwater as part of the hydrological cycle," says Girman. "Much has needed to be done since then to quantify the country's groundwater resources, build a strong scientific understanding of the aquifers present and, more recently, to evaluate and award groundwater licenses. All of this has stretched the limited available skills base. At this stage, transboundary aquifers are just not at the top of the to-do list."

SADC GROUNDWATER INITIATIVE

Despite the challenges in implementing sound transboundary aquifer management, the region does have a good starting point, namely the SADC Protocol on Shared Watercourses, which came into force in 2003. A regional strategic plan for IWRM was developed in 1998 which includes 31 priority projects, one being regional groundwater management.

To assist with the latter, the international donor community is funding a project investigating ways to enhance regional cooperative management of transboundary aquifers. This forms part of a larger drought management initiative. Funded jointly by the World Bank, the Global Environment Facility and the Swedish Development Agency, the US$7,5-million SADC Drought Management Project has the establishment of a regional Groundwater Management Institute of Southern Africa (GISA) as one of its objectives. This institute will continue long-term monitoring of transboundary groundwater resources.

It is hoped that the tools developed through this project will assist in building some consensus regarding the management of transboundary groundwater resources. There is also a hydrogeological mapping component to this project, which is being funded by the French and German governments. Once established, GISA will be the custodian of these outputs.



Locally-Developed Climate Model Verified

A South African-based climate prediction model which can be applied for multi-year regional and river-flow analyses and predictions has now been tested and verified, writes developer Will Alexander, Professor Emeritus at the Department of Civil and Biosystems Engineering at the University of Pretoria.

In particular, it is believed that the model can be used with greater assurance than current methods for multi-year simulations required for water resource development and management. In November 2005, during the then present drought, the first of four flood alerts were issued based on the model. Details of action for local authorities to limit the potential loss of life in informal settlements were included.

Three months later large regions of the African subcontinent were wetter and greener than at any time in human memory. Floods occurred in many rivers from Angola in the north through to the coastal rivers of the southern Cape. Dams filled over most of the region. The loss of life was minimal thanks to the emergency services in the areas.

The threatened succulent (Quiver tree) and fynbos species are now in a healthy condition throughout the region. This is in contrast to claims that global warming would result in threats to the region's water supplies, the destruction of these valuable plants, and large areas of southern Africa becoming a desert within the next 50 years.

VERIFICATION OF THE MODEL

The prediction model is based on the statistically significant (and therefore predictable) 21-year periodicity in South African hydrometeorological data. Two figures generated by Alwyn van der Merwe illustrates the application of the model following the first complete hydrological year after its publication.

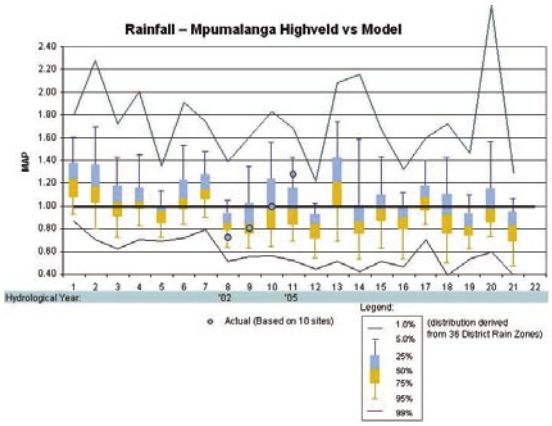


Figure 1: Annual rainfall for the Highveld region.

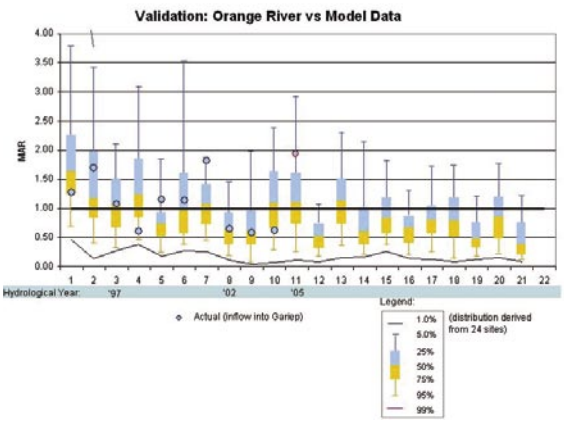


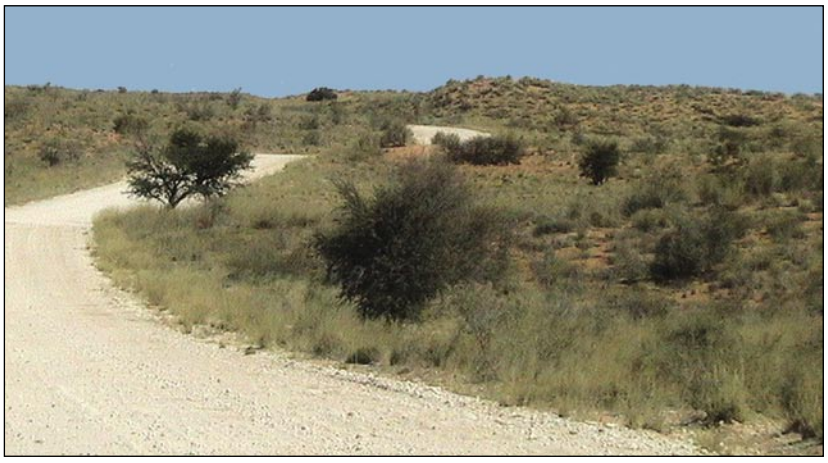
Figure 2: Annual river flow in the Orange River.

Figure 1 shows the annual rainfall for the Highveld region where the interest is in the availability of water for cooling at the coal-fired power stations. Figure 2 shows the annual river flow in the Orange River where the interest is in hydropower generation at the Gariep and Van der Kloof dams.

The figures show box and whisker probability plots derived directly from recorded data within the regions of interest. The outer thin lines show the observed maximum and minimum values. The upper values are off the sheet in the Gariep Dam figure. Current simulation models used for water resource analyses assume that all the boxes are in the same vertical position, i.e. there is no year-to-year variability in the probability distributions.

The next ten years will be critical for water resource development and operation. This has nothing to do with global warming.

While not the purpose of the analyses, besides confirming the validity of the model, they highlight the serious shortcomings in present climate change science. The model is based on the observed 21-year periodicity in the data. Although not included in the model, the synchronous linkage with sunspot activity is beyond all doubt.



The stabilised fossil sand dunes in the Kgalagadi National Park. They show no signs of being rejuvenated as a result of global warming.

This negates the fundamental view of national and international climate change scientists that solar activity is not the cause of climatic variations. From this it was erroneously maintained that all multi-year changes are the result of the discharge of undesirable greenhouse gases into the atmosphere from industrial and other activities.

Note the increase in rainfall relative to the mean values during the four years in Figure 1. This is contrary to publications of climate change scientists in which it was maintained that global warming would result in a decrease in rainfall within this region.

Also note that the observed annual rainfall and river flow during the past years were nowhere near the historical maxima and minima. This is contrary to claims in the climate change literature that global warming will result in an intensification of the hydrological cycle with increases in the magnitude of floods and droughts.

Most importantly, refer to Figure 2 and note that, with the sole exception of year 13 (2007/08), the mean values of the predictions for the next ten years are all less than the long-term mean annual runoff (MAR). The predictions for the present hydrological year in both regions are below average rainfall and river flow.

The next climate reversal from drought to flood conditions based on the analysis of historical data is only expected to occur in 2016. This confirms the linkage with the double sunspot cycle. The next ten years will be critical for water resource development and operation. This has nothing to do with global warming.

WATER RESOURCE DEVELOPMENT IN THE DECADE AHEAD

It is extremely important that all those involved with water resource studies should appreciate that there are fundamental flaws in present global climate models used for climate change applications. These models fail to accommodate the statistically significant, multi-year periodicity in the rainfall and river flow data observed and reported by South African scientists and engineers for the past 100 years. They also failed to predict the recent climate reversal based on the Alexander climate prediction model.

Those who have expressed concerns regarding the environmental consequences associated with water resource development should appreciate that the provision of water to meet rising demands is essential for the prosperity of any nation. South Africa does not have the luxury of abundant water supplies.

Courtesy of Lutz Ebrecht

Rejuvenation of the vegetation in the Namib Desert after the widespread rains of January-February 2006.

The provision of water and conservation of the water environment are non-commensurate objectives in that one cannot be met without sacrificing the other. Reasoned compromises will have to be made. This can only happen if all parties have a sound knowledge of the multiyear properties of rainfall and river flow. The Alexander climate prediction model goes a long way towards meeting this requirement.

Further reading:

- www.wrc.org.za/downloads/watersa/2005/Apr-05/1788.pdf
- *Climate Change and Its Consequences – An African Perspective,* available from Prof WJR Alexander, Tel: (012) 991-3151; E-mail: alexwjr@iafrica.com

The Kalahari dessert countryside completely grass covered with a prolific scattering of seed along the desert roads.

Solutions sought for SA AMD 'hot spots'

The pollution of South Africa's scarce water resources through mining is arguably one of the greatest challenges facing the country. While South Africa is considered a global leader in mine-water treatment technology the magnitude of the problem threatens to engulf progress made to date. Lani van Vuuren attended the Water Institute of Southern Africa's recent Mine-water Conference where present challenges and possible solutions were discussed.

Acid mine drainage (AMD) is not unique to South Africa. In fact, it is a truly international problem faced by all the major mining countries, with some arguing that it is perhaps the industry's most significant environmental legacy. The problem with South Africa is that the country does not have much water to begin with, thus any pollution could have serious future consequences.

More than 120 years of formal mining has left its mark on the South African landscape. The country is reported to have an estimated 10 000 km^2 of hydraulically interlinked coal mines in Mpumalanga alone, with about 300 km of interlinked gold mines on the Witwatersrand. Many of these mines were operated at a time when legislation was not cognisant of environmental management and mine rehabilitation. Thousands of mining operations have been left unrehabilitated and ownerless as dwindling resources and changing markets forced their closure.

The Department of Minerals & Energy's abandoned mines database has recorded more than 4 770 derelict and ownerless mines across the country. This excludes abandoned

sand quarries and other small operations, which brings the number to about 8 000. These mines have now become the legacy of the State, and will take years, even decades, to fully rehabilitate. Meanwhile, all of these mines threaten the air, soil and water, and thus the health of the communities, around them.

WINDS OF CHANGE

Recent international trends have started to bring about change. As Dave Salmon of Anglo American's Civil & Environmental Engineering Department pointed out: "There is increasing recognition globally, and at all levels of society, that management of water resources is essential to everything in life, such as food, energy, transportation, nature, leisure, culture, enhancing living standards and ecosystems health. Mining cannot afford to ignore this trend. "

There has been some international collaboration in efforts to stem the problem of AMD through, for example, the International Network on Acid Prevention (INAP). This is an organisation of international mining companies dedicated to reducing the liabilities associated with sulphide mine minerals. Member companies have agreed to freely share information on issues of common concern. The network is supplemented with a Global Alliance of key research organisations (including South Africa's Water Research Commission), which are actively developing management and treatment options for AMD. Present INAP initiatives include the development of a global guide to the management of AMD.

AMD 'HOT SPOTS'

Meanwhile there are several AMD 'hot spots' in South Africa which require urgent intervention to prevent total ecological disaster. These hot spots have largely driven research into new technologies for the management and treatment of polluted mine-water. Several areas were highlighted at the mine-water conference.

"The country is reported to have an estimated 10 000 km² of hydraulically interlinked coal mines in Mpumalanga alone."

Delegates heard how radioactive and acid mine-water is threatening the health and well-being of communities and wildlife in the Western Witwatersrand Basin. Mine-water decanting from the 44 926 778 km³ mined-out void has flowed into the headwaters of the Tweelopiespruit, which flows through the Krugersdorp Game Reserve. While some of the water is treated by Randfontein Estates, on whose property the decant is taking place, suggestions are that contaminated water is still entering the river.

Investigations of the hydrochemistry of the surface water of the Tweelopies through the Krugersdorp Nature Reserve has confirmed that the water quality has deteriorated to such an extent that it is unfit for human and animal consumption. In fact, the river is now considered a Class V river with a "very high acute hazard."

Downstream communities have little to no access to piped water, and are thus very vulnerable. These include the Sterkfontein informal settlement and Krugersdorp Brickworks hostel dwellers. The Tweelopies further flows through a camp site used by church and youth groups. It has been reported that groundwater quality in the area is also deteriorating.

Of concern is the fact that the Tweelopiesspruit flows through the Cradle of Humankind. Contaminated water, especially water with a low pH, could affect the natural water resource base of several sections of this World Heritage Site, which includes the Sterkfontein Caves. A working group has been established

Courtesy: SA Tourism

The future of the Sterkfontein Caves, a World Heritage Site, could be in the balance if decanting mine-water on the West Rand is not brought under control.

Pollution due to mining remains one of the greatest threats to South Africa's water resources.

to investigate possible solutions. It comprises Harmony Gold (which owns Randfontein Estates); Department of Water Affairs & Forestry; Department of Minerals & Energy; Department of Agriculture; Council for Geoscience; independent consultants, Mogale City and the Gauteng Department of Agriculture, Conservation and Environment.

COLLECTIVE ACTION

In the Klerksdorp-Orkney-Stilfontein-Hartbeestfontein (KOSH) area, Simmer and Jack, Harmony Gold and AngloGold together with the Midvaal Water Company are collaborating to formulate a long-term water strategy to deal with AMD in the area. The underground mine systems of these gold-mining companies are all interconnected, and they all rely on responsible and collective mine-water management to sustain their individual operations.

Most water is pumped out at Margaret Shaft, located on Stilfontein Gold Mine. While the mine itself is no longer in use, about 37 Mℓ/day is pumped to the surface to allow surrounding mines to continue to operate deep underground. At the time of writing, Chemwes Limited, which is reworking some of the old Stilfontein tailings dams, was using 18 Mℓ/day from Margaret Shaft; while another substantial amount was being conveyed to Buffelsfontein Gold Mine for general potable and process use. A small fraction of the water is stored and chlorinated before distribution to a number of farmlands in the area.

"Downstream communities have little to no access to piped water, and are thus very vulnerable."

The remainder of the water is released into the Koekemoer Spruit, a tributary of the Middle Vaal River. It has been reported that the deteriorating water quality from the Koekemoer Spruit is impacting on the treatability of the water from the Midvaal.

A study was undertaken last year to assess a number of different mine-water scenarios, and to establish the amount of available water for reclamation and reuse from Margaret Shaft. Dr Ralph Heath from Golder Associates, the firm responsible for the study, indicated that the most probable future scenario would be the establishment of a softening/membrane desalination plant to treat the Margaret shaft water before blending it with Midvaal water for distribution to municipal, industrial and mining water users.

An independent Section 21 (not-for-gain) company will most likely be established to manage the water from Margaret Shaft. The new company will be responsible for the operation of the shaft and the operation of all pumping equipment at the shaft to transfer all fissure water to surface on a daily basis. Each of the mining companies have agreed to provide one-third of the start-up capital required on loan account to the new water company. It is expected that the proposed water company will operate for the next 18 years or so while the existing mines remain in operation.

SOUTH AFRICAN FIRST

In Mpumalanga, excess water from more than a century of coal-mining has led to the first initiative in South Africa where treated mine-water will be sold to a local municipality. A R300-million joint initiative between Anglo Coal and Ingwe Collieries will see the neustralisation and treatment of 20 Mℓ/day of AMD from three collieries using mainly membrane technology for sale to the Emalahleni Local Municipality (Witbank) – for more details about the process, see the May/June 2006 issue of *the Water Wheel.*

According to Anglo Coal senior project manager Peter Günther, the treatment plant was fast nearing completion, with commissioning expected by March. Meanwhile, a similar project has been initiated in the Steve Tshwete municipal district (Middelburg), and initial studies into the best process to treat mine-water from those coal mines have begun.

SA Irrigation Innovation Scoops International Award

The developer of a uniquely South African water administration system, which has increased the productivity of water use in irrigation agriculture, has won a sought-after international accolade.

Dr Nico Benadé was awarded the International Commission on Irrigation and Drainage's (ICID's) Innovative Water Management Award for the Water Administration System (WAS) at a ceremony held in Kuala Lumpur, in Malaysia in September 2006. This is the first time a professional represented by the South African National Committee on Irrigation and Drainage (SANCID) has scooped the award in this category.

To provide irrigation schemes with decision support for efficient water management, the WAS was developed with funding from the Water Research Commission (WRC). WAS is a decision-support program for use by water user associations on irrigation schemes in managing their water accounts and their water supply to clients through rivers, canal networks and pipelines.

"This water management system is a prime example of taking the innovation process through the full cycle – from research to practical application to exploitation of its commercial potential," comments Dr Gerhard Backeberg, Director: Water Utilisation in Agriculture at the WRC, and Chair of SANCID, who nominated Dr Benadé for the award. "The gratification associated with the ICID Award is the international recognition of an innovation which is truly South African."

The system can be implemented at various levels from a small water office that manages a few abstractions and measuring stations up to a catchment management level with thousands of abstraction points and measuring stations. Among its capabilities, WAS calculates water releases from rivers and canal networks, taking lag times and various water losses into account.

Largely as a result of Dr Benadé's efforts, the WAS is now being implemented on irrigation schemes with a total area of 142 843 ha, which is almost 28% of the irrigated area of South Africa serviced by water user associations (formerly government water schemes and irrigation boards). This includes about 9 500 abstraction points. In some schemes, WAS has been operational for the last 15 years, with great effect.

Field measurements have shown that losses at these schemes have been reduced by 10% to 20% through improved water releases in canals and rivers. With an average water allocation of 8 147 m^3 per hectare and estimated losses of 20%, this translates to an average water saving of between 23 to 46 million m^3 of water per year.

Training is offered to all end-users of the program, and Benadé has set up a private company to provide services support. "Feedback from WAS users at training courses indicates that after converting, it is considered impossible to manage irrigation schemes without the use of the WAS program," he concludes.

TABLE 1: Irrigation schemes where the WAS program is used

Irrigation scheme	Area (ha)	Quota allocation (m^3/ha)	Full quota (m^3)	Abstraction points	Years in use
Impala WUA	17 012	10 000	170 120 000	423	10
Gamtoos Irrigation Board	7 408	6 000	44 448 000	808	3
Groenland Irrigation Board	5 864	6 000	35 184 000	146	6
Hartbeespoort Irrigation Board	13 915	6 200	86 273 000	1 721	9
Hereford Irrigation Board	3 425	7 700	26 372 500	53	3
Korentte Vetterivier Irrigation Board	852	7 000	5 964 000	121	4
Lower Olifants River WUA	9 212	12 200	112 386 400	1 415	10
Loskop Irrigation Board	16 135	7 700	124 239 500	794	15
Groot Marico Government Water Scheme	2 523	5 300	13 371 900	309	5
Mooirivier Government Water Scheme	4 954	7 700	38 145 800	603	12
Orange/Riet WUA	15 941	11 000	175 351 000	679	6
Sandvet Government Water Scheme	10 542	1 080	11 385 360	616	10
Vaalhartz WUA	35 060	9 140	320 448 400	1 873	12

WatSave Award winner Dr Nico Benadé and WRC Director: Water Utilisation in Agriculture Dr Gerhard Backeberg.

Courtesy of SA Tourism

KwaZulu-Natal's Catchment Keepers

KwaZulu-Natal Wildlife has embarked on a catchment-wide conservation approach to safeguard biodiversity from source to sea. Lani van Vuuren reports.

KwaZulu-Natal's conservation approach starts with its estuaries, many of which are of national and even international importance. By far the greatest amount of estuarine habitat is found along the northern coast of the country, where the largest number of estuary-dependent species in South Africa is to be found. The nursery areas along this part of the coast support inshore marine biodiversity and fisheries, including crustacean fisheries such as those of the Thukela banks.

Just over half of the country's estuarine area is made up by the St Lucia estuary alone (over 38 000 ha). A Ramsar World Heritage Site, St Lucia forms a critical habitat for a great number of species, including the largest, southern-most population of hippos, and at least 1 000 crocodiles.

Specific challenges threatening the health of the province's estuaries include siltation due mainly to inappropriate agricultural practices in the catchments and flow reduction as a result of increased upstream water demand. Urban encroachment, particularly developments around estuary mouths, industrial pollution and uncontrolled exploitation of living resources also threaten the biodiversity of KwaZulu-Natal's estuaries.

According to an assessment of South African estuaries undertaken under the leadership of the South African National Biodiversity Institute estuaries along the intensely developed areas of KwaZulu-Natal's coastline are most threatened. Estuaries fed by larger catchments tend to be in poorer health than the estuaries in adjacent smaller catchments.

As Dr Peter Goodman, Coordinator of Biodiversity Research at KwaZulu-Natal Wildlife, points out, there is probably not a single estuary in the province that has not been affected by upstream activities in some way. Even the well protected St Lucia has experienced a reduction in freshwater inputs compromising its function as a nursery habitat. These challenges confirm that managing the estuaries in isolation is not an option.

LOOKING UPSTREAM

Beneficial to this catchment-wide approach is the fact that due to KwaZulu-Natal's boundaries, almost all of the catchments fall entirely within the provincial boundary. This reduces the need for cross-boundary collaboration, and allows for more specific focus on the biodiversity needs of the province.

Of course, this does not mean that KZN Wildlife works in isolation. As trainee aquatic ecologist Mncedi Nkosi points out: "In this planning process you deal with many stakeholders, from other government institutions such as the department of Water Affairs & Forestry and Agriculture, to municipality and tribal community representatives."

Conserving biodiversity starts with the estuaries. Of the more than 70 estuaries in KwaZulu-Natal, 25 have been identified to date as being of strategic importance. The estuaries are selected mainly on their biodiversity attributes. This includes the number of aquatic species to be found in the estuary, the number of rare species, the actual estuary type as well as goods and services provided by the estuary.

"In the end we aim to conserve a representative sample of all our different types of estuaries," explains Dr Goodman. There is no point in safeguarding all the estuaries along the North Coast, but none at the South Coast, for example. The objective is to protect the biodiversity of these estuaries against potential pollution, streamflow reduction activities, and overutilisation.

Apart from St Lucia, other priority estuaries include Kosi Bay (also a Ramsar site); Mhlatuze (one of South Africa's largest mangrove estuarine habitats); Mgobezeleni (situated at Sodwana Bay it is the only estuary between St Lucia and Kosi Bay); Mtamvuna; and Mzimkulu.

RIVERS, WETLANDS AND LANDSCAPES

The second step in this process looks at rivers and wetlands which are crucial to the functioning of the priority estuaries and need to be preserved. The idea is to identify rivers and wetlands which still have a healthy ecology and to include these in the overall biodiversity conservation plan.

These freshwater systems can either be located in primary catchments or smaller subcatchments that feed the strategic estuaries. Of course, protection does not imply exclusion, and limited human activities which do not affect the ecological state of the river or wetland, such as regulated fishing, and small-scale agriculture will still be allowed.

Investigations into the state of KwaZulu-Natal rivers' ecological health continue. KZN Wildlife contract aquatic ecologist Nick Rivers-Moore reports that the task is made difficult by the lack of historical data. "We do not know what constituted a pristine river a hundred years ago. A river we may regard as being in a natural state might not actually be so." Data on invertebrate biodiversity also remain sketchy.

Dr Goodman and his team are also exploring the concept of preserving the last remaining natural free-flowing rivers in the province as 'heritage rivers'. This is a relatively new concept taking off internationally aimed at protecting rivers that have significant recreation, nature conservation scenic or cultural heritage attributes from future impoundment. "The Mkhuze River, the largest river feeding Lake St Lucia, for example, is one such a potential heritage river. Keeping this river free from future impoundments could go a long way in protecting the estuary." Another potential heritage river is the 160 km-long Mtamvuna River which forms the KwaZulu-Natal/Eastern Cape border.

More than a 1 000 crocodiles call St Lucia home.

Linked to aquatic biodiversity targets are terrestrial or vegetation targets. "Freshwater and land systems cannot be separated, and thus within our already identified primary or sub-catchments we will also identify where we can achieve most of our terrestrial biodiversity targets," notes Dr Goodman.

The fourth component looks at the province's primary water production areas, these are the headwater catchments which deliver the most freshwater during the high rainfall months (November to March). It is crucial that the integrity of these water production areas, such as the Drakensberg escarpment, be conserved, not only for the ecosystems lower in the catchment, but also for other uses (agriculture, industrial, and domestic consumption).

By incorporating all of these elements the strategically important catchments for the protection of biodiversity (both terrestrial and aquatic) can be identified. This provides for a more focused approach to conservation.

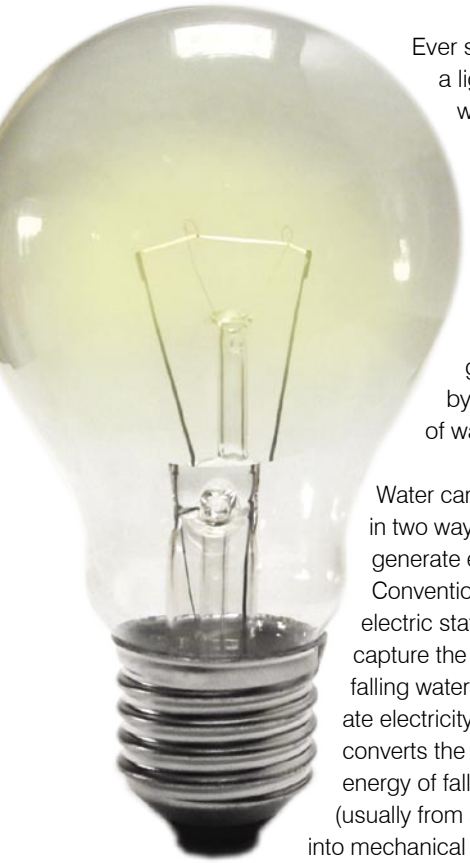
THE TIME IS NOW

Dr Goodman notes that there is no better time for the implementation of such a conservation plan than now. "With the extent of degradation of the province's terrestrial and freshwater ecosystems we might already struggle to find enough areas to protect in order to meet our biodiversity targets. Tomorrow might be too late."

The final conservation plan is expected to be completed by March.

WATER Kidz

The Power of Water



Ever switch on a light and wonder where the electricity came from? It might have just been generated by the power of water.

Water can be used in two ways to generate electricity. Conventional hydroelectric stations capture the energy of falling water to generate electricity. A turbine converts the kinetic energy of falling water (usually from a dam) into mechanical energy. Then a generator converts the mechanical energy from the turbine into electrical energy. The electricity generated is fed on to the transmission lines that link up with the national electricity grid. Once the water has run through the turbines it is discharged back into the river below the power station to continue its course.

On the other hand, pumped storage schemes reuse water to generate power. The schemes use off-peak energy to pump water into an elevated dam from a lower dam from which it can be released to generate electricity when required. When the energy is needed, the water is released from the top dam to flow through the power station to the bottom dam.

The amount of electricity a hydropower plant produces depends mainly on how far the water falls (i.e. the further the water falls, the more power it has, this is usually dependent on the size of the dam); and the amount of water falling (more water falling through the turbine will produce more power, the amount of water available depends on the amount of water flowing in the river).

While hydropower stations are considered more environment-friendly than coal-fired stations, there is some debate whether they should really be actively pursued. This is because most hydropower stations involve the construction of a dam, which can be disruptive to the surrounding environment and to communities who might be displaced.

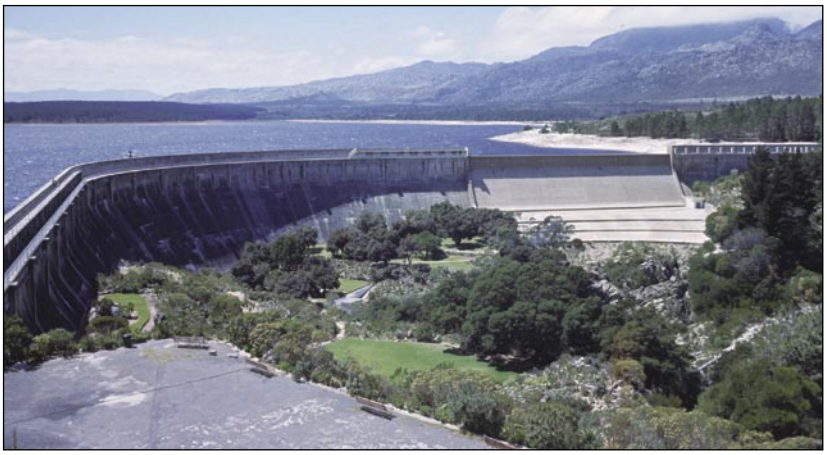
Because of its limited water resources and erratic rainfall, South Africa does not have much potential for large hydropower stations. Whereas, worldwide, about 20% of all electricity is generated by hydropower, in South Africa it varies between 2% and 4%. The country's largest power producer, Eskom, operates six hydropower schemes at present.

There are two hydropower stations on the Orange River. The Gariep

THE BASIC COMPONENTS OF A CONVENTIONAL HYDROPOWER UNIT

Dam: Most hydropower plants rely on a dam that holds back water, creating a large reservoir.
Intake: Gates on the dam open and gravity pulls the water through the penstock, a pipeline that leads to the turbine. Water builds up pressure as it flows through this pipe.
Turbine: The water strikes and turns the large blades of a turbine, which is attached to a generator above it by way of a shaft.
Generators: As the turbine blades turn, so do a series of magnets inside the generator. Giant magnets rotate past copper coils, producing alternating current (AC) by moving electrons.
Transformer: The transformer inside the powerhouse takes the AC and converts it to higher-voltage current.
Outflow: Used water is carried through pipelines, called tailraces, and re-enters the river downstream.

Source: www.howstuffworks.com

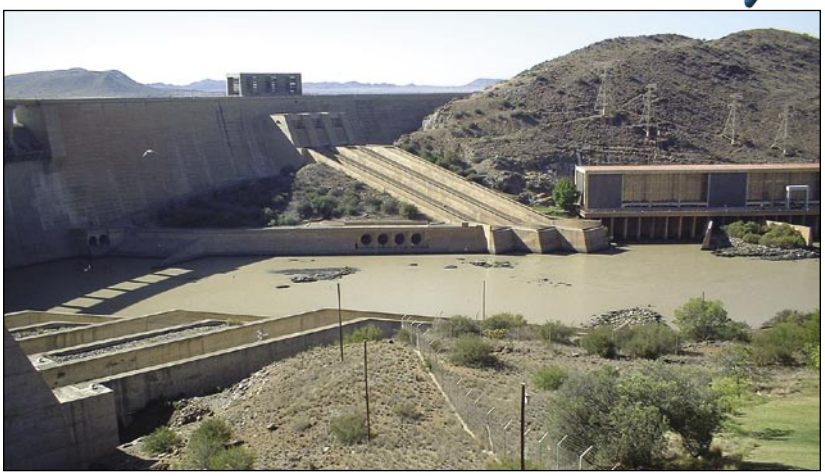


The Steenbras Dam forms part of the Palmiet Pumped Storage Scheme, in the Western Cape.

(formerly known as Hendrik Verwoerd) hydropower station started feeding into Eskom's transmission system in 1971. Vanderkloof, a similar hydropower station, was commissioned in 1977.

Eskom also operates four smaller hydropower stations, namely Colley Wobbles (Mbashe River), First Falls and Second Falls (Umtata River), and Ncora (Ncora River). The Eastern Cape (particularly the area of the former Transkei) and parts of KwaZulu-Natal have been identified as having the most potential for the future development of hydropower in South Africa.

In addition, there are two pumped storage schemes at present. The Drakensberg Pumped Storage Scheme not only supplies the country with 1 000 MW of electricity during peak periods, it also assists in supplementing the Vaal Dam with water transferred from the Tugela River in KwaZulu-Natal. Completed in 1988, the 400 MW Palmiet Pumped Storage Scheme is situated about 50 km from Cape Town. This scheme is also used to pump water from the Palmiet River catchment into the Steenbras Dam to supplement Cape Town's water supply. At present, Eskom is also developing a third pumped storage scheme at Braamhoek, in the Klein Drakensberg (for more details, see the article elsewhere in this issue).



The Gariep Dam is also used for hydropower.

There are also a number of independently-operated hydropower stations in South Africa, for example, the 2,5 MW Friedenheim mini-hydropower plant situated on the Crocodile River, near Nelspruit, Mpumalanga. This plant has been operational since 1998 to provide power for the Friedenheim Irrigation Board while excess power is sold to Mbombela Municipality.

The Bethlehem Hydropower Project is currently under construction. The project comprises two generation facilities: a 2,2 MW run-of-river site located on the As River, midway between Bethlehem and Clarens; and a 1,7 MW facility at the existing concrete wall of the Saulspoort Dam, in Bethlehem. The first electricity is expected to be delivered later this year.

HYDROELECTRIC FIRSTS IN SOUTH AFRICA

- The first hydropower plant on the Orange River was constructed near Kakamas, in the Northern Cape.
- The Sabie River Gorge power station was the first hydropower station to be erected by Eskom. It started commercial operations in 1927, and was built mainly to support mines in the area. The plant closed in 1964.
- The hydroelectric power station at the Vanderkloof Dam was the first power station in South Africa situated entirely underground.
- The Friedenheim Hydro Power plant is recognised as the first independent power producer in South Africa.

TABLE 1
Eskom's hydropower & pumped storage schemes

Hydroelectric Stations	Area	Total Capacity
Colley Wobbles	Mbashe River	42 MW
First Falls	Umtata River	6 MW
Gariep	Orange River	360 MW
Ncora	Ncora River	2 MW
Second Falls	Umtata	11 MW
Vanderkloof	Orange River	240 MW
Pumped Storage		
Drakensberg	Bergville, KZN	1 000 MW
Palmiet	Grabouw, Western Cape	400 MW

Source: Eskom

HYDRO-ELECTRIC WEBSITES

- http://www.dme.gov.za/energy/renew_hydro.stm
- http://assets.panda.org/downloads/africahydropowerreport2006.pdf
- www.eskom.co.za
- http://mp2mas26.eskom.co.za/heritage/main.htm
- http://people.howstuffworks.com/hydropower-plant.htm

Excellent Research Rewarded

The Excellence in Research Awards are held biennially in Honour of Dr Gerrie Stander, the first Executive Director of the Water Research Commission (WRC), who was recognised internationally for his contributions to water research. Hosted by the Water Institute of Southern Africa (WISA), the evening allows three young researchers to share the stage with an experienced water sector professional. This year, the memorial lecture was presented by Prof Peter Rose, Director of the Environmental Biotechnology Research Unit at Rhodes University on South Africa's contribution to the remediation and treatment of polluted mine-water. Also presenting their research were Dr Jonathan Taylor of North West University, Jennifer Molwantwa of Golder Associates and Scott Sinclair of the University of KwaZulu-Natal.

Above: Dr Jonathan Taylor, Prof Peter Rose, Jennifer Molwantwa, Scott Sinclair and Master of Ceremonies, Prof Fred Otieno.

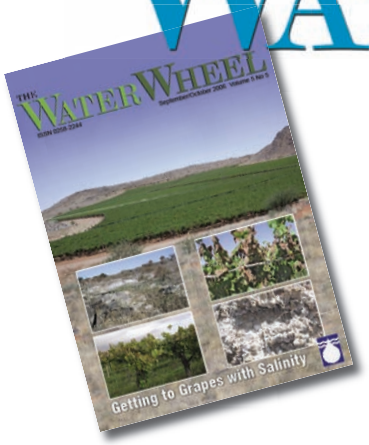
Deon Nel of Biwater SA, WISA CEO Wallace Mayne and Koetoe Botha, husband of WISA president Dr Marlene van der Merwe-Botha.

Left: Dr Renias Dube, Jay Bhagwan, Dr Shafick Adams and Dr Kevin Pietersen, all of the WRC.

Jennifer Molwantwa, Tebogo Sehlabelo of Golder Associates, Laetitia Coetser of SRK Consulting, Tracy Heath, wife of Dr Ralph Heath of Golder Associates, and Siyanda Ngebulana of Biwater SA.

Liezl and Dr Marius Claassen of CSIR, and Dr Ralph Heath of Golder Associates.

THE WATER WHEEL



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