

THE  
**WATER WHEEL**

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Greywater for  
Food Projects  
Take Root



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



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- EIA's
- EMPR Compliance Audits
- Water License Applications
- Waste Permit Applications





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**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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## Desalination of sea water investigated

The City of Cape Town has launched feasibility studies into the desalination of sea water. Possible locations for a pilot desalination plant, technological requirements, treatment costs, environmental impact, and conceptual designs are being investigated. The authority reports that consultation has also taken place with the Perth Water Corporation in Australia who are said to be commissioning the world's largest desalination installation and the Robben Island authorities regarding the existing installation on the island.

Meanwhile, Umgeni Water is investigating the potential of sea water desalination for a yet unnamed remote coastal town, with the view of augmenting the potable water supply to the town cost-effectively. The bulk water supplier has called for expressions of interest from consultants to design and construct a 1,5 Mℓ/day desalination plant.



## New limnology publication available

A new publication on limnology in South Africa is now available. Limnology is the scientific study of bodies of fresh water for their biological and physical and geological properties.

The publication, *Limnology in South Africa: Past and Present Status and Future Needs*, was penned by stalwart limnologist Dr Brian Allanson, and forms part of the International Association of Limnology's series on Limnology in Developing Countries. The book provides an interesting introduction into the history of limnology. The origin of limnology in South Africa is said to go as far as the 1930 when Evelyn G Hutchinson and his colleagues undertook studies of the pans and recently built reservoirs on the Highveld of the old Transvaal. The publication also describes a number of major limnological features and trends that are developing in freshwater research within South Africa and, in particular, new methods to ensure that there is a more holistic approach to rivers subject to regulation.

For more information or to obtain a copy of the book, contact Dr Brian Allanson at e-mail: [ba11@mweb.co.za](mailto:ba11@mweb.co.za) or write to PO Box 1196, Knysna, 6570.

## Call for papers

The organisers of the International Conference and Exhibition on Water in the Environment, to take place in Stellenbosch on 20-22 February 2006, has called for papers.

Abstracts can be submitted for any theme related to the protection of water resources; production and treatment of drinking water; wastewater treatment; water chemistry, analysis and microbiology; water business management; and health and social aspects of water. Abstracts need to be submitted by 15 August 2005.

For more information, contact Elsbeth Verhoeven-Lutsch at Tel: (021) 887-4113 or e-mail: [verhoeven@envirowater.de](mailto:verhoeven@envirowater.de)

## WATER BY NUMBERS

- ◆ **145 ℓ** – The litres required to produce one serving of a fizzy soft drink.
- ◆ **250** – The estimated number of estuaries in South Africa.
- ◆ **13** – The number of Cuban water specialists seconded to the Department of Water Affairs & Forestry (DWAF) for a period of three years (2004-2007) in terms of an agreement between South Africa and Cuba.
- ◆ **76%** – The percentage of the county's poor (people living on less than R1 000/month) that are getting their water free of charge, according to DWAF.
- ◆ **665 000** – The number of people killed by natural disasters in the last decade. Over 90% lost their lives in floods and droughts.
- ◆ **12 000 km<sup>3</sup>** – The water polluted worldwide. This is more than the total amount of water contained in the world's ten largest river basins at any given moment.
- ◆ **4 226** – The number of South African schools without adequate sanitation. The majority of them are in KwaZulu-Natal (1 300), Limpopo (995) and the Eastern Cape (849).
- ◆ **US\$105-billion** – The amount spent annually by Europeans on alcoholic drinks. This is ten times the amount required to ensure safe water, sanitation and hygiene for all, according to the Water Supply & Sanitation Collaborative Council.
- ◆ **20 kg** – The weight of water that women in Africa and Asia carry on their heads. This is equivalent to the allowed airport luggage.
- ◆ **3,3** – The average number of blockages per kilometre of sewer pipe a year experienced by South African municipalities. This is ten times the international average.
- ◆ **50%** – The approximate percentage of wetlands that South Africa has lost due to impacts such as agriculture and urban sprawl.
- ◆ **R100-m** – The estimated worth of the existing aquaculture facilities in the country. Most of them are dormant, and some have fallen into disrepair.

## More water for Tshwane

Increasing the supply of clean water remains a priority for the Tshwane Metropolitan Municipality.

In his budget speech, Tshwane Mayor Father Smangaliso Mkhathswa revealed that water and sanitation will account for 15,7% of operation expenditure in the coming financial year. The metro is planning to install 8 200 m of bulk water pipelines and 14 168 m of internal sewer networks as well as 5 000 new meters to non-metered households.

“Through the implementation of these projects we are planning to create 1 400 jobs for local labour, which is an increase of 40% compared to the current year and further approved 23 emerging contractors which shows an increase of 35,3%,” the mayor said.



## New standards for geomembranes

The recent publication of SANS 10409, *Design, Selection and Installation of Geomembranes*, is important news to all involved in water supply, waste disposal, and civil engineering projects that involve geomembranes. Together with SANS 1526, *Thermoplastics Sheeting for Use as a Geomembrane*, there are now two standards that are essential reading for anyone involved in using these versatile liners.

“These two standards address quality of manufacture and utilisation of geomembranes, respectively,” explains Kelvin Legge, a geomembrane specialist at the Department of Water Affairs & Forestry. “SANS 1526 and SANS 10409 are extremely valuable to the South African industry as they offer a mechanism of ensuring performance against a minimum standard to protect users against poor quality products available on the world market.”

To purchase the standards, contact SABS Standard Sales at Tel: (012) 428-6883, Fax: (012) 428-6928 or e-mail: [sales@sabs.co.za](mailto:sales@sabs.co.za)

## Sustainable sanitation solutions crucial



South African government has a long road ahead to ensure sustainable sanitation solutions to the 16 million people that are still without safe toilets. However, no solution will work unless it is accepted by the user.

So said Deputy Minister of Science & Technology Derek Hanekom. Speaking at the Third International Conference on Ecological Sanitation (EcoSan) in Durban in May he said that the sanitation challenge is as much social as it is technological. “We need to address the interface between technology and implementation. No matter how religiously experts believe that technologies such as EcoSan offer a real solution, they will not be applied unless the users – and their political representatives – want them. Households have to be satisfied that the product most closely satisfies their needs.”

The international conference drew about 300 delegates from 30 countries.

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## Millions still drink unsafe water

Eleven years after the establishment of South Africa's democracy, 3,7 million people are still dependent on unsafe water sources, such as rivers and streams. So reported Abri Vermeulen, Senior Manager: Water Services Policy Strategy at the Department of Water Affairs & Forestry (DWAF) at the Second Annual Water Services Convention, held in Midrand in June.

According to Vermeulen, a further five million people have access to some form of water services, but it is not within RDP standard (i.e. further than 200 m from the homestead). "The challenge of supplying these communities is magnified by the current transition of the water services sector, with local authorities taking over the responsibility for water and sanitation services from the national department."

Vermeulen admitted that many municipalities were not equipped to take over this function as has been highlighted by a number of protests across the country over the last couple of months. "It is also unfortunate that it is usually the areas where the least capacity exists where there is the most need for services. Our department is currently evaluating where the greatest support is required in order to provide advice and support."

At the same time, DWAF is adapting legislation to enable it to perform a regulatory role in the water sector. In response to the question whether this would allow national government to act more strongly against local authorities that blatantly misappropriate funds or pollute the environment through, for example, dumping sewage into rivers, Vermeulen reiterated that DWAF would continue to follow its policy of cooperative governance. "Our role is to support rather than prosecute. We would rather work with the municipality concerned in rectifying the problem than merely slap them with a fine. However, if a problem persists, court action would be taken as a last resort."

### Water on the Web

#### [www.pbs.org/wgbh/buildingbig](http://www.pbs.org/wgbh/buildingbig)

This is an excellent site for children of all ages wanting to know more about engineering, including the construction of dams and tunnels. Apart from a series of interviews with engineers, a searchable database on engineering wonders of the world, and an educator's guide, the site includes several 'interactive labs'. Through interactive simulations these workshops allow users to play with shapes, materials, forces and loads to see how they affect large-scale structures. Clicking on the 'Challenges' link allows the visitor to play the engineer, solving problems and making structural choices while building bridges, skyscrapers, dams, domes and tunnels.

#### [www.aasa-aqua.co.za](http://www.aasa-aqua.co.za)

The Aquaculture Association of Southern Africa (AASA) was established in the late 1980s to represent the interests of the then fledgling aquaculture industry in southern Africa. This website is a good starting point for those interested in aquaculture in South Africa. It offers some background on fish farming, and lists a number of service providers in this regard.

#### <http://nsidc.org/glaciers>

The National Snow and Ice Data Center (NSIDC) is a part of the US and includes information such as how glaciers are formed, how they move, and different types of glaciers. Interestingly, it also includes a page on how glaciers affect people, for example, by providing drinking water, helping to irrigate crops, and assisting with the generation of hydropower.

#### [www.africawaterjournalists.org](http://www.africawaterjournalists.org)

Only launched in March, this is still a new website. The Africa Water Journalists Network is aimed at increasing and improving reporting on water in Africa. It supplies African journalists with better information, helps them gain access to sources and provides them with an outlet for their talent. The network is an initiative of Quest Ltd, a company of journalists focused on development issues, and the Water Foundation of the Netherlands.

#### [www.wetlands.org](http://www.wetlands.org)

This is the official website of Wetlands International, a global non-profit organisation dedicated solely to wetland conservation and sustainable management. The website offers more information about this organisation, which is active in 120 countries, as well as the conservation of wetlands in general.

#### [www.ncar.ucar.edu/](http://www.ncar.ucar.edu/)

The National Centre for Atmospheric Research is based in the US and is dedicated to meteorological research. The site includes information on the organisation's divisions and programmes, and includes a general education site about the weather and climate change.

## SADC drought management project underway

A four-year project to manage groundwater and drought in the Southern African Development Community (SADC) has been launched with funding by the World Bank.

The Groundwater and Drought Management Project is being funded by a US\$7-million grant from the World Bank's Global Environment Facility, and US\$0,5-million from the Swedish International Development Cooperation Agency. The overall objective of the project is to develop consensus on a SADC regional strategic approach to support and enhance the capacity of its member states to articulate and implement drought management policies, specifically in relation to the role, availability and supply potential of groundwater resources.

It is reported that the development of countries in the region is highly dependant on adequate and reliable water resources. About a third of the people in southern Africa live in drought-prone areas, where groundwater is the primary source of water. Groundwater is also the main source of water for many ecosystems in these areas. However, these precious resources are under threat from over-exploitation, and pollution.

The project comprises four inter-related components:

- ◆ Testing of practical local groundwater drought management strategies at pilot level in the Limpopo River;
- ◆ Research into groundwater dependent ecosystems, their occurrence, vulnerability, value and protection;



- ◆ The development of groundwater drought management tools and guidelines;
- ◆ The establishment of a regional Groundwater Management Institute of Southern Africa to continue long-term monitoring and the promotion of better management and awareness in the SADC region and at national level.

The project will be executed by the Water Division within the Infrastructure and Services Directorate of SADC.

## DIARY

### REVENUE PROTECTION

**JULY 21-22**

The South African Revenue Protection Association Conference 2005 is taking place in Nelspruit, at the Emnotweni Arena. Enquiries: Gillian; Tel: (011) 789-1384; Fax: (011) 789-1385; E-mail: [gillian@vdw.co.za](mailto:gillian@vdw.co.za); Web: [www.sarpa.co.za](http://www.sarpa.co.za)

### DIFFUSE POLLUTION

**AUGUST 8-11**

The International Water Association Diffuse Pollution Specialist Conference will be held at the Sandton Convention Centre. Enquiries: Dr Ralph Heath; Tel: (011) 726-7027; E-mail: [raphh@phd.co.za](mailto:raphh@phd.co.za)

### ECOLOGICAL SANITATION

**AUGUST 15-19**

The Norwegian University of Life Sciences is hosting a short course on ecological sanitation. Enquiries: E-mail: [ecosan@umb.no](mailto:ecosan@umb.no); Web: [www.ecosan.no](http://www.ecosan.no)

### SEDIMENTS & WATER

**AUGUST 28-SEPTEMBER 2**

The 10<sup>th</sup> International Symposium on the Interactions between Sediments and Water will be held at Lake Bled, Slovenia. Enquiries: Web: [www.iasws.com](http://www.iasws.com)

### ENVIRONMENTAL SCIENCE

**SEPTEMBER 1-3**

The 9<sup>th</sup> International Conference on Environmental Science & Technology will take place in Rhode Island, Greece. Enquiries: Web: [www.gnest.org.cest](http://www.gnest.org.cest)

### WASTE MANAGEMENT

**SEPTEMBER 5**

The South African Association for Food Science & Technology is presenting a workshop/seminar on waste management in the food industry focusing on inter alia wastewater treatment, solid waste disposal, and cleaner production. Enquiries: Gunnar Sigge at E-mail: [goss@sun.ac.za](mailto:goss@sun.ac.za); Web: [www.saafostconference.co.za](http://www.saafostconference.co.za)

### AQUACULTURE

**SEPTEMBER 12-15**

The 7<sup>th</sup> Conference of the Aquaculture Association of Southern Africa entitled Aquaculture for Africa – Unlocking the Potential will be held at Rhodes University, Grahamstown. Enquiries: E-mail: [conference@aasa-aqua.co.za](mailto:conference@aasa-aqua.co.za); Web: [www.aasa-aqua.co.za](http://www.aasa-aqua.co.za)

### ZOOLOGY

**NOVEMBER 7-11**

The Department of Zoology at the University of Johannesburg is hosting a course on Monitoring Contaminant Levels in Freshwater Fish for Contaminant Bioaccumulation Surveys and Human Consumption. Enquiries: Prof Annemarié Oldewage; Tel: (011) 489-2449; Fax: (011) 489-2286; E-mail: [ao@na.rau.ac.za](mailto:ao@na.rau.ac.za)

### WATER & SANITATION SUPPLY

**NOVEMBER 9-11**

Water Africa 2005 West will take place in Accra, Ghana, at the Accra International

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Presents short courses in

## MEMBRANE PROCESSES (for industrial water treatment and groundwater desalination)

28 to 30 September 2005

### COURSE OBJECTIVES

The main objective of this course is to provide the course participant with adequate theoretical and practical knowledge to take informed decisions about the functioning and application of membrane processes in desalination and in water and wastewater treatment.

### WHO SHOULD ATTEND?

The course is aimed at engineers, scientists and technologists involved in the planning, management and operation of water and wastewater treatment.

### COURSE CONTENT

The course is presented over a period of three days and consists of the following:

- General background of reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF), microfiltration (MF) and electro dialysis reversal (EDR).
- Principles of operation.
- Membrane types and characteristics.
- Module configuration and characteristics.
- Mass transfer, flux and rejection and recovery.
- Performance evaluation.
- Pretreatment requirements and processes.
- Membrane fouling and cleaning.
- Membrane evaluation and autopsies.
- Process configurations.
- Cost considerations.
- Practical design of processes using selected software programs.
- Membrane bioreactors (MBR).
- Applications for desalination, softening, effluent treatment, nitrate and fluoride removal.
- Feasibility studies.
- Case studies.

### LECTURERS

**Prof. C.F. Schutte**  
**Prof. J.J. Schoeman**

### ENQUIRIES:

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**Mrs. E. Otto**  
**Telephone:** (012) 420-3824  
**Email:** elmarie.otto@up.ac.za

### COURSE FEES:

(Including notes, lunch, coffee/tea but excluding accommodation).

**R3 950,00 per person.**

For three or more participants from the same company, the fee is reduced to R3 450,00 per person.



## Water Quality Management and Effluent Treatment 24 to 28 October 2005

### COURSE OBJECTIVES

The main objective of this course is to provide the course participant with adequate theoretical and practical knowledge about water quality, and water and wastewater treatment so that they can:

- take informed decisions about treatment and disposal of effluents
- evaluate the operation and control of water and wastewater treatment plants.

### WHO SHOULD ATTEND?

The course is aimed at engineers, scientists and technologists involved in water quality management and control, and in the operation of water and wastewater treatment plants.

### COURSE CONTENT

The course is presented over a period of five days and consists of the following:

#### Background aspects

- S.A. water sources, hydrology and geohydrology.
- Basic water microbiology.
- Basic water chemistry.
- Biological, chemical and physical water quality parameters.
- Point and diffuse sources of pollution.
- National Water Act and other regulatory requirements.

#### Treatment processes

- Overview of water and wastewater treatment processes.
- Flow of material and mass balances.
- Physical-chemical treatment processes.
- Municipal wastewater.
- Biological treatment processes.
- Sludge treatment and disposal.

### LECTURERS

**Prof. C.F. Schutte**  
**Prof. E.N. Chirwa**  
**Prof. J.J. Schoeman**  
**Mr. M.A. Jaffer**

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**Email:** elmarie.otto@up.ac.za

### COURSE FEES:

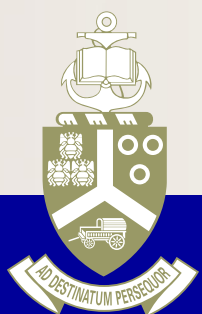
(Including notes, lunch, coffee/tea but excluding accommodation).

**R4 950,00 per person.**

For three or more participants from the same company, the fee is reduced to R4 450,00 per person.

### Certification:

University of Pretoria certificates will be issued on the successful completion of these courses.



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## Global review

- ◆ The first technical workshop of the Regional Research took place in Harare in May. Participants developed focus areas of the alliance (water and food security, project areas include groundwater and rainwater treatment technologies among others.
- ◆ A Nigerian project that uses the seeds of an indigenous tree to purify water for households has received a US\$120 000 grant from the World Bank. The project proposes to purify water for households using the natural coagulative properties in the seeds of the *Moringa oleifera* tree, which is said to have a removal efficiency of 99.5% for turbidity; 98% for suspended solids; 90-99% for bacteria of 1 to 4 log units; and 100% for water hardness. The project is expected to benefit ten million households in Southeast Nigeria.
- ◆ Rural Australians may be suffering from a recently identified psychological condition known as solastalgia, according to researcher Gina Sartore from the University of Newcastle's Centre for Rural and Remote Mental Health, who has been conducting the country's first study into the effects of drought on mental health. According to *ABC Science Online*, solastalgia, or "drought as traumatic environmental change" is among a number of psychological problems afflicting drought-stricken rural communities. For example, Sartore's research reveals that for some rural women the simple loss of their gardens could be a major trauma despite more wide-ranging impacts of drought such as increased workload, anxiety about income and hopelessness about the future.
- ◆ According to a study by Swedish researchers, future action taken to increase food production in sub-Saharan Africa could indirectly affect the capacity of South Asia to produce food. *SciDev.Net* reports that the study shows that human activity – particularly deforestation and crop irrigation – is seriously affecting global circulation of water vapour. Deforestation has decreased the evaporation of water by 4%.
- ◆ The Gobabeb Research & Training Centre, near Walvis Bay, has been inaugurated as a Southern African Development Community (SADC) Centre of Excellence. This means researchers and scholars from SADC states can go to the centre to undertake research or undergo training in fields such as environmental research, natural resource management, land management and desertification, reports *The Namibian*.



### DIARY (continued)

Conference Centre. The exhibition will include products and services serving an array of markets, including surface water development, groundwater development, mains distribution and house connections, water and wastewater treatment, water storage and irrigation, among others. Enquiries: Jacqui Hepworth, Tel: +44 1628 672599; Fax: +44 1204 695165 or E-mail: [jacqui.hepworth@btinternet.com](mailto:jacqui.hepworth@btinternet.com); Web: [www.ace-events.com](http://www.ace-events.com)

#### CLIMATE CHANGE NOVEMBER 13-17

Greenhouse 2005: Action on Climate Change, to be held in Melbourne, Australia, is expected to be the largest climate change conference held in the Southern Hemisphere this year. Enquiries: Simon Tor; E-mail: [simon.torok@csiro.au](mailto:simon.torok@csiro.au); Web: [www.greenhouse2005.com](http://www.greenhouse2005.com)

#### WATER & HISTORY DECEMBER 1-4

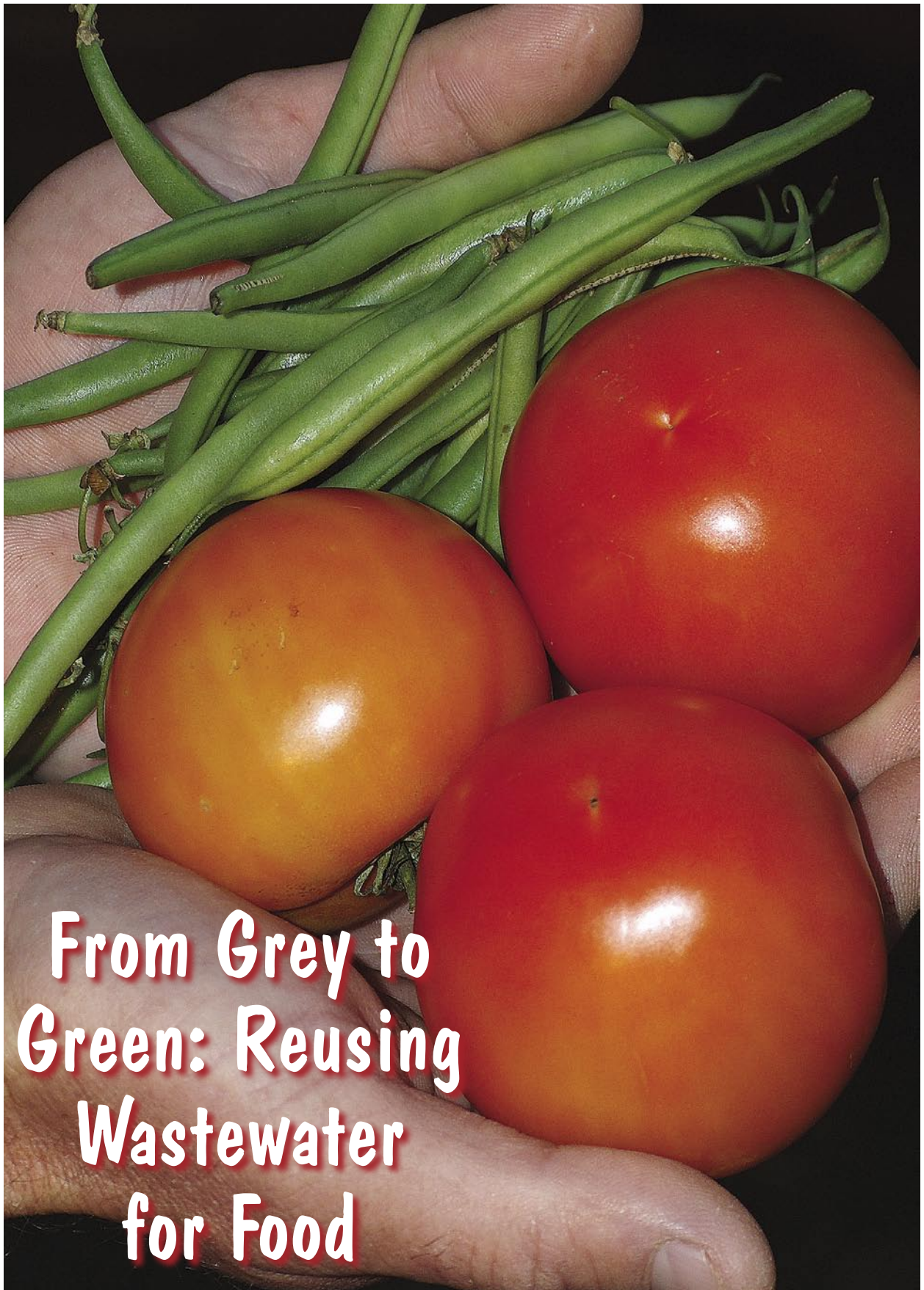
The Fourth International Conference of the International Water History Association is taking place in Paris France. Enquiries: E-mail: [post@iwha.net](mailto:post@iwha.net); Web: [www.iwha.net](http://www.iwha.net)

### Entries invited for international award

Nominations have been invited for the first Kyoto World Water Grand Prize, to be announced at the Fourth World Water Awards in Mexico, in March 2006.

The Award is being organised by the World Water Council, the City of Kyoto, Soroptimist International of Kyoto and the Fourth World Water Forum. A prize of US\$45 000 will be given to the winning individual or organisation whose grassroots-level activities address critical water needs of communities and regions, corresponding to the overall theme of the next forum, *Local Actions for a Global Challenge*.

Candidates have until 31 October to enter. For more information, visit [www.worldwatercouncil.org/kyoto\\_prize](http://www.worldwatercouncil.org/kyoto_prize) or E-mail: [Kyoto\\_prize@worldwaterforum4.org.mx](mailto:Kyoto_prize@worldwaterforum4.org.mx) or Tel: +52 55 5174 4480



**The answer to enhanced food security might lie in your dirty dish water. Research indicates that the reuse of so-called ‘greywater’ – all household wastewater except toilet waste – has huge potential to grow food for peri-urban and rural families.**

**Lani Holtzhausen reports.**

All households produce greywater of some kind. This wastewater can include water from showering, bathing and washing dishes and clothes. The amount of greywater varies enormously between households. Consumption in poor areas can be as low as 15 to 20 l per person per day, while in rich urban areas people may generate more than ten times as much.

Depending on the household the water can contain soap, shampoo, toothpaste, washing powder, disinfectants, shaving cream, bleach and household cleaning chemicals. The water can also contain cooking oil, hair, fat and fibres from fabrics. Greywater is unlikely to contain disease organisms (such as *E. coli*) anywhere in the same magnitude as those found in toilet wastes (unless laundry tubs or basins are used to rinse soiled clothing and babies’ nappies).

**“Greywater can be a significant water resource, contributing to a community’s well-being rather than adding to pollution.”**

Generally in urban areas, greywater is washed away along with other wastewater (sewage) and treated at wastewater treatment plants. In peri-urban and rural areas, however, where people are generally served with dry toilets, such as ventilated improved pit (VIP) latrines and standpipes, there is usually no infrastructure to transport the greywater away and treat it.

As a result, greywater is usually disposed of to the ground in the vicinity of the dwelling, leading to pooling

of this wastewater. In turn, this leads to unpleasant odours, pollution of groundwater and surface runoff, soil erosion, health hazards and mosquito breeding.

### POTENTIAL REUSE

It is believed that greywater can be a significant water resource, contributing to a community’s well-being rather than adding to pollution. One possibility is the reuse of greywater for the irrigation of community gardens. As Odette Beukes of the Agricultural Research Council (ARC) points out: “Malnutrition is an enormous problem in rural communities. While food gardens can alleviate the problem, the water supply is often very limited. Greywater reuse is one possible answer.”

Globally, there remains doubt about the suitability of greywater for irrigation. It is thought that water that contains high levels of sodium, phosphate and chloride can lead to a

build-up of these elements in the soil, with a negative effect on sensitive plants. Questions also arise around the effects that the consumption of crops grown with greywater can have on people’s health.

To investigate this, researchers at ARC Infruitec-Nietvoorbij, in the Western Cape, initiated a project to determine the effect of greywater irrigation on the quality and yield of tomatoes and beans. The project, partially funded by the European Union, also focused on the effect of greywater on infiltration tempo, permeability and element content of three types of soil, sand, loam and clay.

### SURPRISING RESULTS

The greywater used was obtained from the shower, hand basin, kitchen sink and washing machine of a household of an ARC employee, and was not filtered before application. The water was added to potted crops using conventional watering cans.



*In its greywater reuse project at Nietvoorbij, the Agricultural Research Council obtained higher production of tomatoes by using greywater.*

## 12 GREYWATER RECYCLING



In the trials conducted by the University of KwaZulu-Natal, the vegetables fed with greywater (left) have shown considerable more growth than the vegetables fed with municipal tap water (right).

Beukes reports that the results were rather surprising. "Water and soil samples were taken during the course of the trials and analysed for chemical composition. Results indicated that the use of greywater had no detrimental effect on the production of the tomatoes or beans. In fact, higher productions were obtained with the greywater applications compared to the municipal water applications."

Moreover, no negative effects of greywater application on the infiltration rates were observed. Chemical analysis of the tomatoes and beans did show an increase in sodium levels and phosphorus levels, with the macro nutrient levels of the plants grown in sandy soil types consistently the lowest compared to those grown in other soil types.

### FROM TOMATOES TO SPINACH

The University of KwaZulu-Natal's School of Biological and Conservation Sciences, in collaboration with eThekweni Municipality's Water and Sanitation Unit, has been conducting its own trials into the reuse of greywater. Greywater from eight households of the nearby Cato Crest peri-urban settlement was used to irrigate spinach, green pepper, potatoes and madumbes. Drip irrigation was used to water the

plants with municipal water, greywater or a commercially available nutrient solution to compare the results.

Plant growth was measured weekly, and harvested crops were analysed for microbiological contaminants, including *E. coli*, total coliforms and *Staphylococcus*. According to project leader Dr Nicola Rodda, there was a consistent increase in plant height and yield when the crops were irrigated with the greywater, as compared with municipal water, although the nutrient solution yielded the best plants.


Analysis showed that contamination of the crops with bacteria was minimal to negligible, indicating that irrigating with greywater did not produce consistent increases in bacterial levels on the final crops. This is despite a 'worst case' scenario being evaluated, with no waiting period between irrigation with greywater and harvesting, and no allowance made for inactivation of bacteria during food preparation, such as cooking.

These studies certainly indicate that greywater represents a potentially important resource for food production in poor peri-urban and rural communities with minimal additional risk to health association with consumption of the irrigated produce.

### A CAUTIONARY APPROACH

However, despite initially positive results, Dr Rodda and Beukes maintain that the reuse of greywater to irrigate food crops should be approached with caution at this stage. "Before the use of greywater for urban agriculture can be widely promoted, the effect on plant growth, sustainability of greywater irrigation (in terms of medium- to long-term effects on soil quality), community acceptance of the practice and associated health risk during irrigation and as a result of crop consumption needs to be investigated further." These studies are currently in progress at the University of KwaZulu-Natal.

If people have no choice but to use greywater on food crops they suggest that some form of drip irrigation be used, and that users should rather avoid below-ground crops. A resting period, if possible, one month between last irrigation and harvest, is also recommended. Importantly, users should take sound hygienic precautions when handling the greywater, and wash (and preferably cook) produce before consumption.

Greywater reuse shows much potential. It is hoped that further research will answer the remaining questions to turn this pollutant into an important resource. 

# Project Provides New Tools for Weather Man's Toolbox



***From ancient times when societies depended on close observation of nature for signs of coming rain to today's sophisticated computer simulation technologies, weather forecasting has never been an exact science. However, a four-year project undertaken by the University of Pretoria's Meteorology Group has brought South African weather men one step closer to knowing exactly what conditions to expect. Lani Holtzhausen reports.***

**T**he project, funded by the Water Research Commission (WRC) aimed to develop and promote the discipline of regional atmospheric modelling in southern Africa, and thereby to improve knowledge of local-scale weather and rainfall conditions, reports project leader Prof Hannes Rautenbach. It centred on the improvement of an existing numerical weather prediction (NWP)

model to better simulate, and therefore predict, weather conditions over the Southern African Development Community (SADC) and ocean to the south of South Africa.

## **WEATHER BY NUMBERS**

Prof Rautenbach explains that NWP models are basically complex computer programs, run on super-

computers that provide predictions on atmospheric variables such as temperature, pressure, wind and rainfall by using intricate mathematical equations. These models may be used for short-term planning (daily forecasts); air pollution modelling (predicting wind conditions); seasonal risk analysis (seasonal forecasting); and future climate change projections.

However, most numeric models have been developed in the US and Europe. Since these models were developed specifically for those regions, they are not always as accurate when used to simulate weather and rainfall conditions over Africa. "For example, South Africa has many small river catchments, and the steep topography along the escarpment is responsible for complex local atmospheric circulation patterns," explains Prof. Rautenbach. In addition, the convective nature of rainfall systems over the eastern Highveld is complex and, in fact, unique in the world.

As a result most of these models typically overestimate rainfall, especially over the eastern parts of South Africa, by as much as an average 400 mm a month. This is quite significant when considering that the average annual rainfall for the entire country is only about 500 mm.

## FOUNDATION FOR THE FUTURE

The research team based its project on a model developed by the Australian Commonwealth Scientific and Industrial Research Organisation's

Division of Atmospheric Research (CSIRO-AR). The so-called Conformal Cubic Atmospheric Model (C-CAM) is said to be the only model of its kind developed in the Southern Hemisphere and is considered one of the leading regional-scale models in the world.

The research team obtained a non-commercial licence from CSIRO-AR for the use of its NWP model. The project team worked with researchers and scientists from CSIRO-AR and by accessing the source code modified the model to improve the simulation of water-related atmospheric variables over South and SADC (i.e. to more accurately predict rainfall).

Why not just develop our own model? According to WRC deputy chief executive officer Dr George Green, it is not that simple. "Modern atmospheric models are in an advanced stage with sophisticated numerical formation approaches to solving fundamental equations and physical process parameterisation schemes. These models were developed over years, and it would therefore not be easy to start developing a totally new model." However, the project team believes that this project is the first stepping stone towards the creation of such a model for the region. "In fact, some local researchers have been encouraged to start developing code for our own unique limited area model," he says.

Dr Green is quick to point out that working with the modified C-CAM model is not intended to compete with the services provided by the South African Weather Services (SAWS). "Rather it equips students and prospective scientists and forecasters from South Africa and the southern African community with the necessary knowledge and skills to adapt, maintain and use regional atmospheric models through the innovative training they receive."





**PROJECT OUTCOMES**

One of the most significant outcomes of the project is that it has proven that South Africa has the capacity to contribute to numeric model development. By adapting the C-CAM model, the research team has managed to significantly reduce the overestimation of rainfall to only 10 mm to 20 mm a month. This has attracted interest in the model from all over Africa, and several workshops were held bringing together atmospheric modellers from all over SADC. These workshops, which were funded by the WRC, contributed to collaboration,

capacity building and knowledge transfer in the region.

Further, in 2003, a student seminar led to the launch of the Laboratory for Training and Research in Atmospheric Modelling (LRAM) at the University of Pretoria. It will form the base from which future research and training initiatives in atmospheric modelling at the university will be launched.

Moreover, the project has enabled the research team to run the first NWP system independently from the SAWS, a major achievement. The first predictions were generated at the

**MORE ON NUMERICAL WEATHER PREDICTION (NWP)**

NWP uses the power of computers to make a forecast. Complex computer programs, also known as forecast models, run on supercomputers and provide predictions on atmospheric variables such as temperature, pressure, wind and rainfall, through a series of so-called atmospheric equations. A forecaster examines how the features predicted by the computer will interact to produce the day's weather.

The first attempt to use numerical methods to predict the weather was made by British scientist Lewis Fry Richardson in the 1920s. However, it took Richardson months to produce weather forecasts of a few days ahead in time, since he had to solve the extensive meteorological equations by hand. His predictions were rarely accurate because the numerical techniques used to solve the equations were not sophisticated enough.

Improvements on Richardson's techniques only became practical when the first digital computers appeared in the 1940s. Today's sophisticated atmospheric models run on the biggest supercomputers in the world. Over the past few decades atmospheric modelling has advanced to a complex science. Not only have new numerical models been developed to improve and solve the primitive equations, but sophisticated physical schemes have also been introduced.




start of December last year, and since then the model has been producing predictions of four days in advance on a daily basis.

The model simulations are performed by the Meteorology Group at information technology firm NETSYS International, which assists in downloading the initial conditions and provides the computer-networking infrastructure required for performing the weather forecast simulations. Initial atmospheric fields are downloaded from the National Centre for Environmental Protection Prediction's fins resolution AVN data. Model simulations are initiated from this base to produce weather forecasts. The model simulation time is about nine hours.

Weather forecasts for South Africa and the region can now be viewed on the website [www.up.ac.za/academic/geog/meteo](http://www.up.ac.za/academic/geog/meteo) by clicking on Numerical Weather Prediction. Future development includes wind forecasting for the Highveld for pollution modelling; tropical cyclone forecasts for Madagascar; and rainfall forecasts for the Vaal-Gariep river basis. These forecasts will soon be added to the website.

The outcomes of the project have not ended there. It has also led to other research activities, including long climate change scenario simulations for other WRC and Eskom research projects; weather forecasts for the Southern Ocean as part of research for the South African National Antarctic Programme funded by the Department of Environmental Affairs & Tourism; and seasonal forecasting with the SAWS.

"This project is part of a suite of solutions developed under the WRC's water resource assessment thrust area, including simulation modelling work undertaken by Prof Bruce Hewitson of the Climate Change System Analysis Group at the University of Cape Town, and the research work undertaken by Liesl Dyson and Prof Johan van Heerden of the University Pretoria into finding alternative weather forecasting techniques for heavy rainfall over southern Africa," explains Dr Green. "It also complements the data obtained from recent real-time monitoring of rainfall using ground networks and remote sensing. Ultimately, all of these projects assist us in better managing our water resources." 

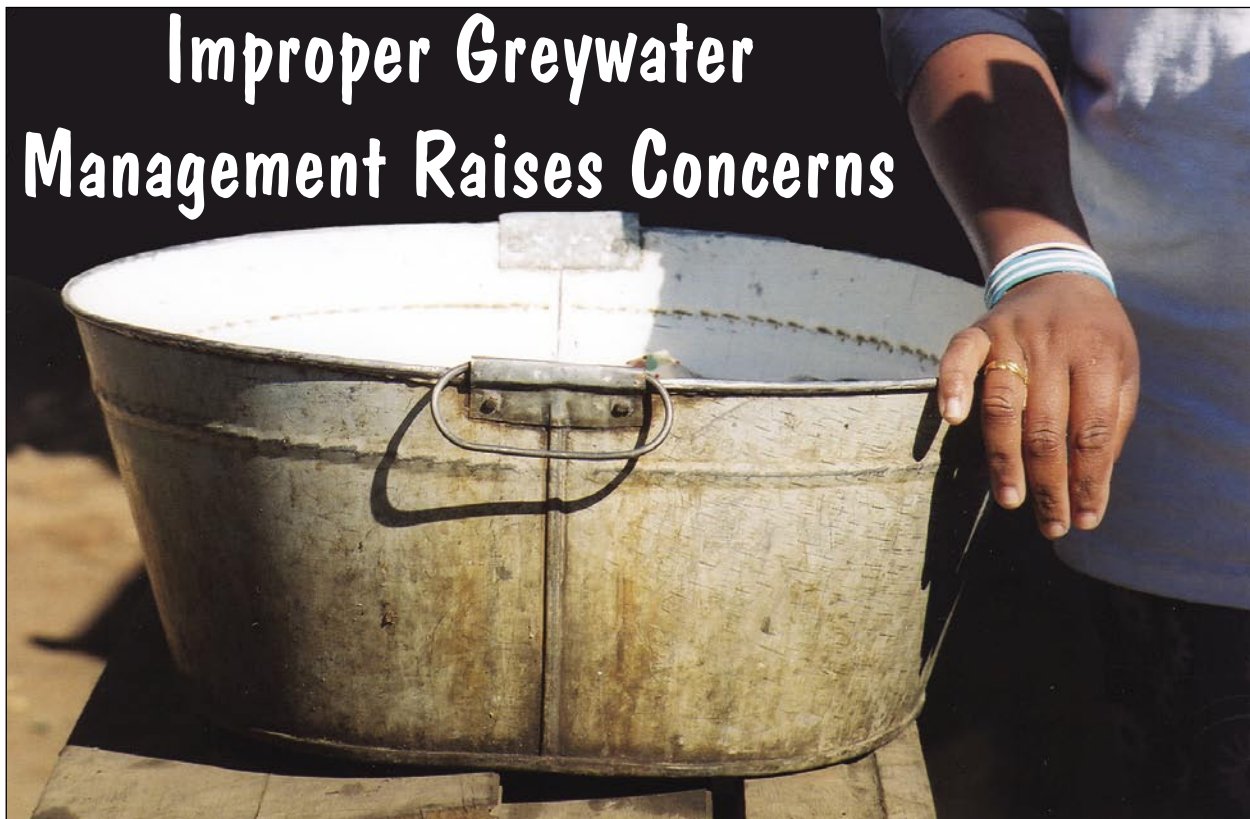
## INTERNATIONAL PRIZE FOR SA RAINMAKERS

A South African project that forces clouds to squeeze out nearly double the amount of rain has won an international prize.

The South African National Precipitation Research and Rainfall Enhancement Programme, a joint effort between the Department of Water Affairs & Forestry, South African Weather Service and the Water Research Commission, has won the first International Prize for Weather Modification. The prize from the World Meteorological Organisation is sponsored by the United Arab Emirates.

The South African entry pipped a number of entries from all over the world. In fact, more than 10 000 pages were entered describing some of the best weather modification experiments in the world. The prize money of US\$200 000 will be used for further research.





## Improper Greywater Management Raises Concerns

**An ongoing study by the University of Cape Town (UCT) is revealing an urgent need for improved greywater management in South Africa's urban and peri-urban settlements. The study, which is being funded by the Water Research Commission, aims to evaluate existing greywater management practices in non-sewered areas with the view of coming up with recommendations for best practice. Lani Holtzhausen reports.**

Many of South Africa's townships have been connected to municipal water supplies in the last ten years as part of Government's efforts to eradicate the backlog of those without access to clean water. Water provision in these areas is more often than not through a public standpipe or a yard connection outside the home.

In this process, however, little attention is generally given to the management of greywater. As a result, this water – the wastewater produced from household processes such as washing dishes, cooking, laundry and bathing – is randomly tossed outside.

What makes matters worse, reports Kirsty Carden of the UCT Greywater

Research Team, is that many of these settlements have dysfunctional or inadequate sewerage systems. All of this creates a serious hazard to the health of the community as well as the surrounding environment.

### HEALTH HAZARD

"Improper greywater management can lead to a variety of health concerns, including mosquito breeding (from ponding of greywater); contamination of drinking water supplies; and odours from stagnant water," Carden tells *The Water Wheel*. "There is also a risk of transmitting waterborne diseases if the greywater has been cross-contaminated with faecal waste. Children are especially at risk as they play in this dirty water.

They get the water on to their hands, clothing and bodies, later transferring this to their mouths, which can result in diarrhoea and other waterborne diseases."

It is clear that greywater management is not receiving enough attention, particularly in informal settlements. "Our research indicates that there does



*Children are particularly at risk as they play in polluted water.*

## 18 DENSE SETTLEMENTS



### **Top left:**

*Improper management of greywater – the wastewater from activities such as cooking, washing dishes, bathing and laundry – remains a huge headache in the majority of South Africa’s peri-urban settlements.*

### **Bottom left and right:**

*The lack of adequate greywater disposal facilities often results in this water randomly tossed outside.*



not seem to be a lack of knowledge by the local authorities – they are only too aware of the problems on the ground in informal settlements, but the planning in this respect seems to be lacking,” notes Carden. “This seems to stem from the fact that the provision of water to all citizens is being prioritised by Government together with emphasis being placed on dry sanitation options, but they do not appear to have taken into account disposal options for greywater.”

She adds that there is also a concern that dwellers lack the political or institutional structures and organisation to deal with the problems of pollution in the settlements in which they live. “There is a perception that by tolerating these conditions it will either provide a strong rationale for upgrading these areas to formal housing and water reticulation systems, or that by making advances on the local authority they will jeopardise their chances of acquiring formal houses.”

The multi-disciplinary team from UCT is currently conducting surveys throughout the country. Social surveys of current and potential greywater management and recycling activities are being carried out in selected communities. Cultural practices pertinent to water use and management are also being examined to determine whether these hinder or promote the adoption of greywater recycling.

### **INTERESTING RESULTS**

While findings of the study will only be finalised in April next year, initial research has shown some interesting results. In the Western Cape, for example, many respondents complained of the possible health implications of mosquito infestations, stagnant water and smells that result from inadequate sanitation services and greywater disposal practices in the settlements.

While the team has not yet investigated specific environmental impacts of ill-disposed greywater, there are concerns. Three of the surveyed sites in the Western Cape are positioned close to sensitive wetlands and/or river systems.

**“Planning and implementation .... must be done at local level, with municipalities being specifically tasked with the responsibility of managing greywater problems in cooperation with the communities themselves.”**

“From our limited water quality sampling the indications are that the greywater in non-sewered settlements has very high levels of phosphates. This is an area of concern from the point of view of greywater entering surface water bodies,” reports Carden. “Other concerns for sensitive

**Bottom left:**

University of Cape Town student Thiyane Suda questions a resident in Mayfield, Gauteng. Existing greywater management practices are being evaluated in non-sewered areas throughout South Africa.

**Top and bottom right:**

University of Cape Town student Tsako Baloyi takes water samples in Mayfield, Gauteng, as part of the greywater management survey.



wetlands and streams include the low levels of dissolved oxygen in the greywater, elevated “oil and grease” levels and microbiological contamination. In general, the most observed impact on receiving water bodies, particularly lakes and wetlands, is the possibility of them becoming overfed with nutrients, leading to eutrophication and algal blooms. This often has dramatic results, especially when blue-green algae release poisonous toxins into the water body,” she says.

Regarding its quality, greywater generally contains high levels of pollution emanating particularly from the use of household chemicals and detergents. “Of particular interest is the fact that phosphate levels seem to be higher in greywater samples where lower-priced detergents are used, although this assumption has not been fully tested yet,” notes Carden. Limited microbiological testing was conducted that

generally showed high levels of faecal contamination in the greywater samples, thereby limiting the potential for reuse.

It has become apparent that greywater is not the primary cause for concern among most residents of informal settlements, and that the provision of toilets, houses, water and electricity are deemed to be far more important. Reuse initiatives are, therefore, not well supported, with most people suspicious of the quality of the greywater and the possible associated health impacts.

## THE WAY FORWARD

Carden believes that national government needs to take greywater management into account in its specification of minimum levels of service to poor communities, particularly in high-density settlements. In addition, methods of reducing levels

of phosphate in greywater need to be investigated, possibly by discouraging the use of high-phosphate detergents. “Planning and implementation, however, must be done at local level, with municipalities being specifically tasked with the responsibility of managing greywater problems in cooperation with the communities themselves.” (The required tools for both assessing and managing greywater disposal options at this level will be one of the outputs of this project).

“The key to successful management appears to lie with the attitude of the communities towards the greywater problem as well as the level of commitment by the local authority concerned,” says Carden. “It is essential that greywater be properly managed to reduce health risks by eliminating inappropriate disposal, as well as to provide benefits in terms of reuse.”



# What Next for Western Cape Water?



**After two years in the grip of drought, and months of stringent water restrictions, the citizens of Cape Town are breathing a collective sigh of relief following good winter rains. Sue Matthews reports.**

**W**ater storage in the Cape's five major dams had reached an all-time low of 26,3% by 11 April, when a massive storm in the preceding 24-hour period dumped 127 mm of rainfall in the catchment area of the largest dam, Theewaterskloof. The storm heralded the start of good winter rains, and by 20 June overall dam storage had recovered to 50,3% – a fairly typical level for this time of year.

The water restrictions remain in force for now, but at least gardens are green again. The restrictions aim to ensure not only that there will be plenty of water in storage to see the city through summer, but also that the goal of a 20% reduction in water demand in the year to September has been achieved. By the end of June, only about 65% of the desired 66 million kilolitres of water had been saved.

When the water restrictions were introduced last September, water and sanitation tariffs were also raised, partly to recover the anticipated loss in

revenue due to reduced water sales, but also to promote water conservation by the public. Domestic users are not charged for the first 6 000 ℓ of water supplied and 4 200 ℓ of sewage treated per month, after which they are billed according to a steeply rising incremental tariff that discourages high consumption.

"We need to bring about an attitudinal and behavioural change in the ways water is used in our city," says Councillor Saleem Mowzer, mayoral committee member for trading services. "Being water-wise is a moral duty; it is everyone's business."

The City of Cape Town had no option but to implement water restrictions after the Department of Water Affairs and Forestry (DWAFF) announced that a second successive winter with abnormally low rainfall necessitated curtailing water supplied by the Western Cape Water Supply System by 20% over a year, in order to ensure the sustainability of the resource in the medium term. The system – made

up of the Theewaterskloof, Voëlvele, Wemmershoek and Steenbras upper and lower dams – supplies water to the greater Cape Town area as well as municipalities and irrigation boards further afield. Agriculture uses some 30% of the water, while urban demand accounts for the remainder.

By the end of winter last year, storage levels of the Theewaterskloof and Voëlvele dams, which together supply two-thirds of Cape Town's water, remained below 55%. Only the Steenbras upper and lower dams – situated in the cloud-trapping Hottentots Holland mountains near Grabouw – were relatively full at 92% and 73% respectively, but their combined yield meets less than 11% of the city's water needs.

This was the second time that water restrictions have had to be implemented in recent years, although many people abandoned the good water-use habits they adopted in the summer of 2000/2001. The Western Cape Water Supply System is clearly hard-pressed to meet Cape Town's

existing requirements during a drought cycle. So what does the future hold, given the city's growing population and burgeoning development?

Construction has already begun on the R1,5-billion Berg Water Project, which will increase water supply to the region by 18% when it becomes operational in 2007. Situated on the uppermost reaches of the Berg River near Franschoek, the 126 Mm<sup>3</sup> dam will operate in conjunction with Theewaterskloof, to which it will be linked by the Riviersonderend inter-basin transfer tunnel. The supplement scheme involves diversion of water at a weir 9 km downstream into an off-channel storage dam, from where it will be pumped back into the Skuifraam Dam or Theewaterskloof via the tunnel.

"The Berg Water Project should keep us in water until about 2013 – that's assuming we achieve our water demand management objective," says Michael Killick, planning manager for the City of Cape Town's Bulk Water division.

He points out that the Berg Water Project was approved as a parallel process to the city implementing water demand management, and the target being worked towards is a 20% reduction in the projected demand for water by the year 2010. The WDM strategy incorporates measures such as user education, tariff structures, pressure management, leakage repair and elimination of automatic flushing urinals. The city is also promoting the use of recycled effluent from wastewater treatment plants for irrigating sportsfields and parks.

But even with all these initiatives, the total urban water demand is anticipated to increase at approximately 2% per year. So what happens after 2013, when demand is expected to exceed supply?

Various options for increasing water availability in the region have been

proposed in three major studies conducted over the past 15 years. Way back in 1989, DWAF initiated the Western Cape Systems Analysis to assess future water needs and means of meeting them, and the subsequent public participation process generated a dozen stakeholder-supported options. In 1999 the former Cape Metropolitan Council launched the Integrated Water Resource Planning Study to investigate water demand initiatives and supply schemes within its jurisdiction. The CMA Bulk Water Supply Study in 2001-2002 took a broader view, and recommended investigating three options – the Voëlvei Augmentation Scheme, desalination and the TMG Aquifer – in more detail.

Now DWAF is gearing up for a new three-year consultative study for the Western Cape, which will help decide the next scheme to implement after the Berg Water Project. It is the first of a number of Reconciliation Strategy studies to be done around the country.

"Essentially the study involves a reconciliation between water supply and demand, and the strategy needed to ensure that these somehow balance", explains Frans Stofberg of DWAF Head Office. "We will review yields that the current system can provide, forecast how demand will change in future, investigate possible additional developments, and then prioritise options and strategise how to achieve them. The idea is to revisit the plan of action developed in the Western Cape Systems Analysis, because it's amazing how things can change in ten years."


The initial list of options – each of which will be assessed in terms of technical, financial, environmental and socio-economic aspects – includes building new dams and raising existing dam walls, constructing diversions and transfer schemes, clearing alien vegetation, and implementing water-

efficient irrigation practices. The priorities for further investigation identified by the Bulk Water Supply Study will also be evaluated.

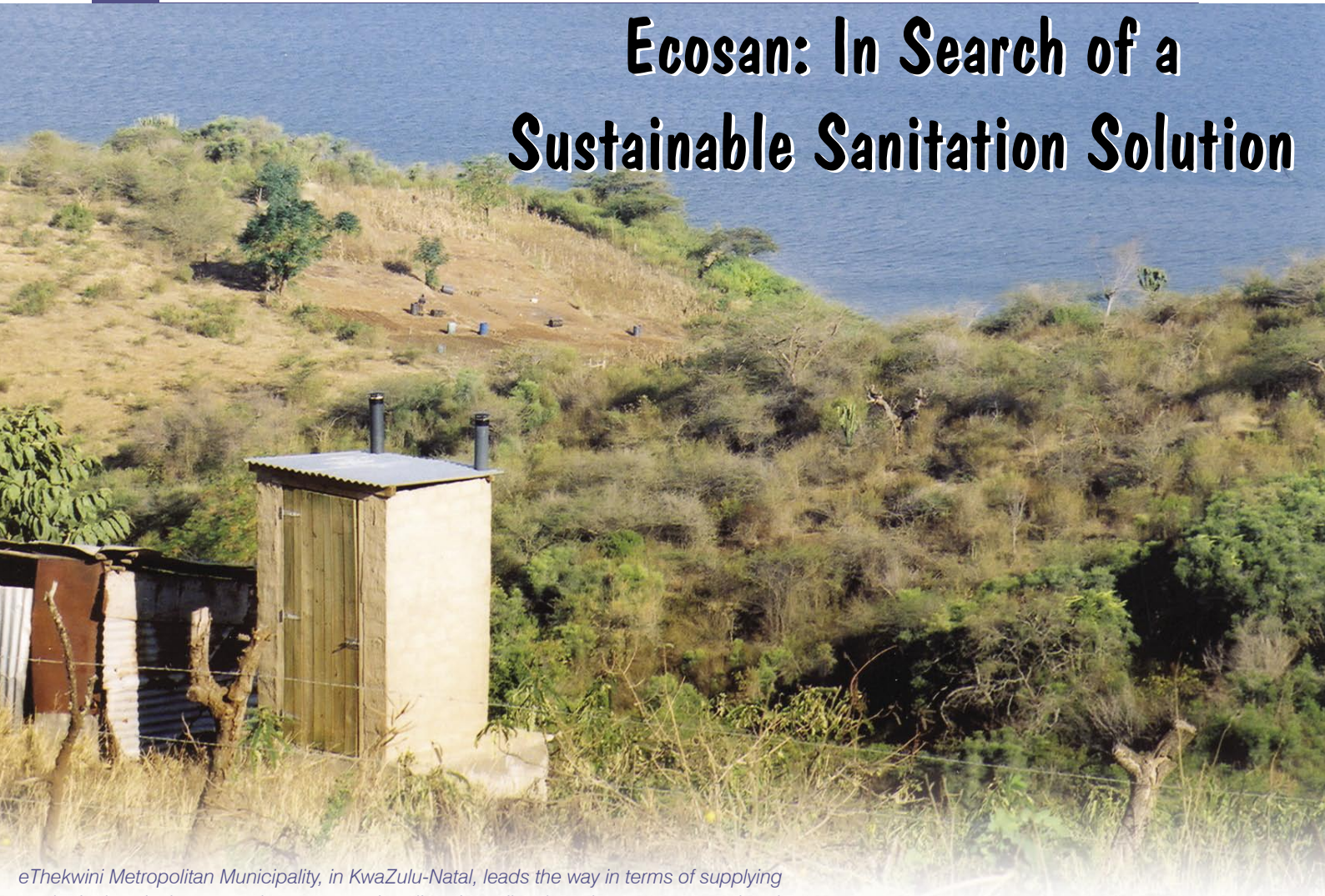
The City of Cape Town recently commissioned a feasibility study on desalination, including possible locations for a pilot desalination plant, technological requirements, conceptual designs, treatment costs and environmental impacts. Initial findings have indicated that although the costs of desalination have decreased significantly, they are still approximately double those of the Berg Water Project.

Another study – the TMG Aquifer project – aims to determine the feasibility of using the groundwater systems of the Table Mountain Group geological formation to augment Cape Town's water supply. The Western Cape's environmental authorities have recently given the go-ahead for exploratory drilling at 27 sites within the study area, which extends from Cape Hangklip in the south to Tullbagh in the north. No water will be extracted during the exploratory phase, other than limited pump-testing of two boreholes for a fortnight each.

"If all goes well we're looking at doing a pilot wellfield in a few years time, which would yield some 3-5 million cubic metres per year for three years," says Karen Shippey of Ninham Shand, the consulting group co-ordinating the environmental assessment. "We want to start very slowly because we're not sure what the impacts are going to be. So the TMG Aquifer is not likely to become a water source for Cape Town within the next 10 years, but it's important to investigate it for future planning." (See more on this project elsewhere in this issue)

It is comforting to know that some proactive thinking and long-term planning is taking place. But there is certainly no cause for complacency – after all, that curve ball called climate change may still knock us for a six! 

# Ecosan: In Search of a Sustainable Sanitation Solution



*eThekweni Metropolitan Municipality, in KwaZulu-Natal, leads the way in terms of supplying ecological sanitation, more than 30 000 urine diversion toilets have been constructed to date.*

***During her budget speech earlier this year Minister of Water Affairs & Forestry Buyelwa Sonjica alluded to the fact that 16 million South Africans still do not have access to safe, hygienic sanitation. In its quest to eliminate this backlog, the government has started to explore a number of alternative options, one being ecological sanitation (ecosan).***

It is not news that the pathogens and parasites found in excreta are widely responsible for a variety of illnesses in rural and peri-urban areas, including cholera and diarrhoea. The majority of pathogens can be found in human faeces. Therefore, the main risk lies in the contamination of the environment by faeces spread near places where people and animals live and next or into drinking water sources.

The most basic type of 'improved' sanitation applied in South Africa is the ventilated improved pit (VIP)

latrine. While it has brought safe sanitation to thousands of households, it is not always practical. Many areas have high water tables, or difficult terrain, making the construction of VIPs impractical. And what happens to these toilets once they are full?

Ecosan is not so much a technology than a sanitation philosophy. It can be viewed as a three-step process: containment, sanitation and recycling of human excreta. This can include soil-based composting toilets in shallow reinforced pits, dry urine diversion toilets with storage vaults, urine

diversion mini-flush toilets and even high-tech vacuum systems.

The ecosan approach to sanitation promotes a cycle or 'closed' system (as opposed to the linear nature of water-borne sanitation). Human excreta are treated as a resource, processed (usually dried and/or composted) until they are completely free of disease organisms. The nutrients contained in the excreta are then recycled by using them as fertilizer in agriculture. This does not only save water but reduces pollution. By not introducing them into the water cycle,

contamination of surface and ground-water can be avoided.

The most widely adopted ecosan solution in South Africa is the urine diversion toilet. Waste is deposited in a chamber and dry material (usually sand or ash) is added after each use to deodorise decomposing faeces while controlling moisture and facilitating biological breakdown (composting).

Urine is diverted through a specially adapted pedestal. In this country most of the urine is led to a soak-away pit, but it can be tapped and used as a fertilizer in home gardens. This is because in urine three major plant nutrients can be found, namely nitrogen, phosphorus and potassium.

## ECOSAN IN SOUTH AFRICA

More than 40 000 ecosan toilets have been constructed in South Africa to date. By far the majority of these can be found in the eThekweni municipal area, outside Durban, in KwaZulu-Natal, where double-vault urine diversion toilets are being built as part of the metro's efforts to provide peri-urban citizens with basic sanitation. At last count 30 000 of these urine-diversion toilets had been constructed in the area at a rate of 1 000 a month.

In the Northern Cape, non-governmental organisation Mvula Trust and others have been assisting the provincial government and the Department of Water Affairs & Forestry with the conversion or replacement of bucket toilets in poor and remote small towns. Here about 15 000 urine-diversion toilets have been constructed. Pilot studies are also underway in Khayelitsha, in the Cape Town, and townships in Ekurhuleni, Gauteng, to test the suitability of ecosan toilets in these areas. In addition ecosan toilets can be found at Buffalo City and Umtata, in the Eastern Cape, and Taung, in North West.

## THE QUEST FOR ACCEPTANCE

As with any new technology, introducing the ecosan concept to South African users has not been easy. Most people aspire to have a flush toilet, and any other option is considered second best. What makes this sanitation method even more challenging is that in ecosan, success depends on proper operation and management, and thus depends on user participation to a far greater extent than conventional sanitation systems.

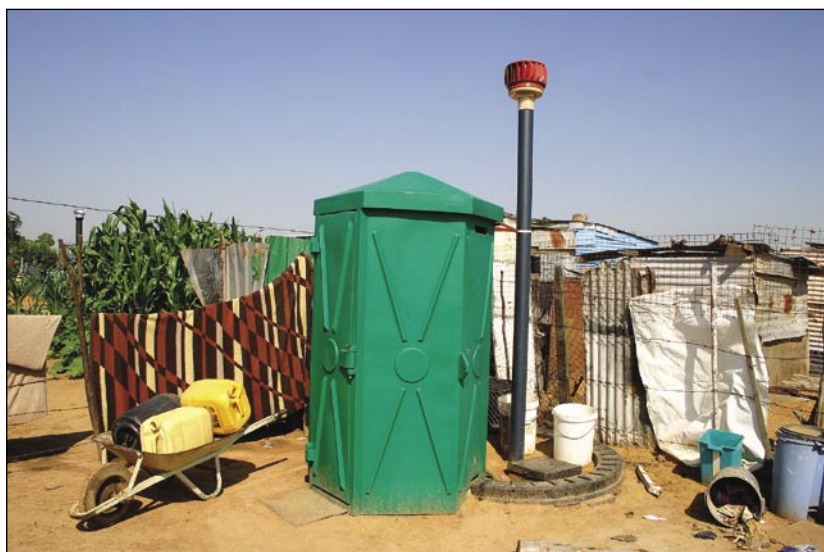
So despite convincing environmental and economic reasons to support this approach acceptance of the technology as a whole has been rather limited, as illustrated by a recent study undertaken by Gertrude Matsebe and Louiza Duncker of the Programme for Sustainable Human Settlements at CSIR Boutek. They undertook research of the social perceptions of users of urine diversion sanitation systems in Taung in the North West, Mpushini in KwaZulu-Natal, and Barkley West and Augrabies in the Northern Cape.

## DID YOU KNOW?

In Third World countries an average 90% of sewage is discharged completely untreated into surface water.

Their study showed that 16% of households with urine diversion toilets did not use them at all or used them for unintended purposes, such as storage areas or animal pens. In other cases the toilets were used only when there were no alternatives (VIPs) available or reserved for use by visitors. Generally, users accepted the urine diversion toilet as a toilet, but not the concept of handling and re-using human excreta.

The issue seems to be a social rather than a technical one. In all except one case (Augrabies) communities were not offered a choice between ecosan and conventional systems. In all three provinces the local authorities took the leading role during the implementation process of the projects. Users were only involved after a decision was taken, just before the construction started.



*About 16 million South Africans still do not have access to safe sanitation prompting government to look at alternative technologies such as ecological sanitation. This technology is being piloted in several areas, including Mayfield, on the East Rand.*



*About 16% of South African households with urine diversion toilets do not use them at all or use them for unintended purposes, such as storage areas or animal pens.*

The research showed that initially, people liked the toilets because they were properly built compared to pit or VIPs. However, as time passed users' interest in the toilets lessened, mainly because of operation and maintenance issues. Despite the fact that most users were informed about their roles (emptying the vault) the findings showed 86% of them were unwilling to handle their own excreta. Blocked or full toilets were abandoned, with many people converting back to using the old unhygienic toilets.

Alternatives, such as getting local entrepreneurs to do the job, were not explored. It is thought that if such a collection/disposal service were to be introduced, it would address the problem of handling human excreta. The waste could then be sold as compost to farmers in the vicinity, or be used to fertilize municipal gardens.

"There is a general norm among many people to not handle human faeces, therefore, the removal of faeces from the vaults of the urine diversion toilets is perceived as an unacceptable practice as well as unhealthy and unhygienic," the researchers comment. "Unfortunately, ecosan is also perceived by the users

as a temporary and alternative sanitation technology, meant only for the poorest of the poor, and therefore substandard to their aspirations for waterborne sanitation."

The importance of good user education was also emphasised. Matsebe & Duncker found that in the North West, for example, users had no knowledge on basic operational information, such as using sand, ash or dry soil after defecating.

### **THE WAY FORWARD**

It is clear that where top-down approaches to sanitation have the potential of being unsustainable, the chances are magnified where ecosan is concerned. As Matsebe & Duncker point out: "Local councils are put under pressure to spend the budget allocated before the end of the financial year. This leads to insufficient time and planning allocated for projects to be undertaken. In this scenario, the software issues (community concerns) are overlooked or engaged at a minimal scale with the main focus on the hardware (infrastructure). Proper planning should be undertaken to ensure that sufficient time is allocated to various tasks of the project, especially the human element."

The main lesson here is that user participation is vital prior, and during, project implementation. While consultation, education and communication are important issues, they form only part of the process of participation.

Sanitation technologies and services should meet the needs and interests of the users, and should be designed so that they complement existing social and cultural practices. A variety of suitable sanitation technologies should be introduced to the users (in the form of, for example, demonstration models) in order for them to make informed decisions on the options available. Users should also be informed about the national strategy and purpose behind a specific sanitation technology in order for them to understand why waterborne sanitation is not an option. Only if these criteria are met will alternative sanitation technologies such as ecosan find acceptance in the market.

Ecosan is not a zero-risk solution, but rather a search for new possibilities. It should not be seen as the solution to South Africa's sanitation problems, but rather as another tool in the fight for better community health and well-being. 

# Search Continues for Liquid Gold



***Investigations into the potential of the Table Mountain Group (TMG) aquifer – cited as one of the richest untapped water resources in the country, have reached an advanced stage. The Water Wheel takes an in-depth look at this multimillion Rand project, searching for possible solutions to the Western Cape's continuing water woes.***

The fractured rock groundwater systems of the TMG constitute a vast aquifer system, extending from just north of Nieuwoudtville southwards to Cape Agulhas and eastwards to Port Elizabeth. The full volume of the aquifer rocks in this whole region comprises a staggering 100 000 km<sup>3</sup>.

The groundwater intersections or pathways in the aquifer are commonly at depths of greater than 100 m below ground. The recharge to the TMG aquifer is believed to be in the

range of 7% to 23% of mean annual precipitation (i.e. snow, rainfall and mist).

Groundwater from this aquifer is said to be among the purest in the country as regards electrical conductivity and total dissolved solids. However, the pH is as low as 5, which is very acidic and therefore corrosive. This means that, should bulk water supply from the TMG aquifer ever be considered, some form of treatment will have to be included to ensure that the water is of potable standard and to

minimise damage to water distribution infrastructure.

## UNEXPLOITED POTENTIAL

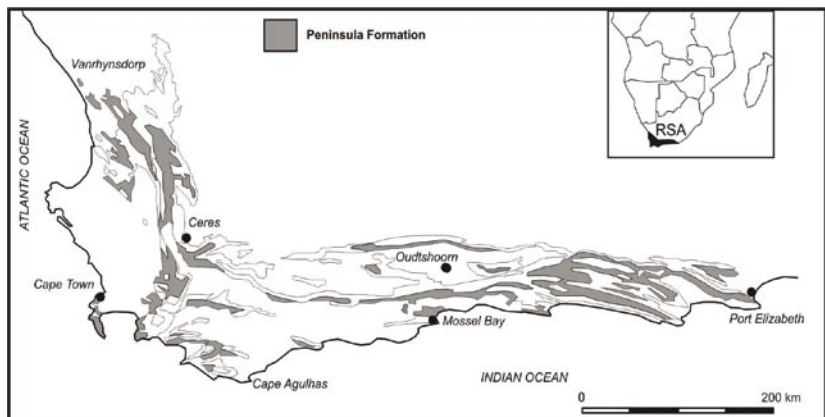
The proposal to investigate groundwater in the TMG aquifer as a potential source for bulk water supply for agricultural and urban use has been discussed since the early 1970s. The possibility of large-scale groundwater supply to the Cape Metropolitan Area (CMA) from the Cape Flats and West Coast aquifers was evaluated during the Western

### THE FOUR MAIN PHASES OF THE TMG AQUIFER FEASIBILITY STUDY & PILOT PROJECT:

- ◆ **Inception Phase (2002):** During this phase the Terms of Reference were finalised.
- ◆ **Preliminary Phase (2002-2004):** In this phase, the study focused on the selection of the most favourable targets areas and sites for exploration boreholes and potential wellfields, after having considered all relevant factors, e.g. hydrogeological criteria, environmental impacts, and infrastructure requirements, among others.
- ◆ **Exploratory phase (2005-2007):** Currently underway, this phase is intended to verify the predicted hydrogeological characteristics and to refine the siting of the target wellfields.
- ◆ **Pilot Borehole Phase (2007-2009):** During this final phase a number of boreholes will be drilled to develop one or more wellfields with a target yield of three to five million cubic metres a year.

Cape Systems Analysis (WCSA) in the early 1990s.

Although mentioned in the WCSA, the TMG Aquifer was not evaluated in much detail. In the mid-1990s, Umvoto Africa's detailed study of the TMG Aquifer in the catchment of the Olifants River for the Department of Water Affairs & Forestry showed that there would also be opportunity for developing the TMG Aquifer to supply the Western Cape Supply System, which serves the municipalities of Cape Town, Stellenbosch, Paarl and Wellington, as well as towns on the West Coast and in the Swartland area. Irrigators along the Berg and Eerste rivers, and irrigators and urban



*The Table Mountain Group Aquifer.*

users in the Rivieronderend catchment also receive water from the system. However, groundwater extraction from this system is still only a fraction of overall water supply.

The CMA Bulk Water Supply Study (2001), which investigated various water supply and water demand management options at reconnaissance level, again highlighted the potential of the TMG aquifer to augment water supplies to the area. Among others the study concluded that the TMG aquifer has the potential of yielding high volumes of good quality water; the overall cost of developing and operating wellfields in the aquifer compares favourably with other water supply schemes; and that it is important to study this potential at fully feasibility level. This led to the rollout of the TMG Aquifer Feasibility Study and Pilot Project, which started in 2002.

### PHASED APPROACH

The present study is investigating the potential of the TMG aquifer situated between Tulbagh and Kleinmond or the so-called Peninsula Formation. The TMG Aquifer Alliance (TMGAA), comprising Ninham Shand, Umvoto and KBR, have been appointed to undertake this investigation.

According to TMGAA project manager Alan Shelly, the study involves

four main phases, two of which (the Inception and Preliminary phases) have already been completed. The project team is about to start the Exploratory Drilling Phase (the third phase). This phase will entail the detailed siting of exploration boreholes, followed by the exploration drilling and associated environmental management activities. The outcome of this phase will be the verification of the hydrogeological predictions made in the Preliminary Phase and refining the location of the potential target wellfields.

**..... The study concluded that the TMG aquifer has the potential of yielding high volumes of good quality water; the overall cost of developing and operating wellfields in the aquifer compares favourably with other water supply schemes; and that it is important to study this potential at fully feasibility level.**

Drilling will be undertaken at various depths, possibly up to 1 000 m. The initial emphasis in an exploration drilling programme is obtaining core

samples of the fractured rock aquifer to undertake careful logging of the rock types and fracture sets intersected, and to undertake various laboratory tests on the rock materials.

The Exploratory Phase is preceded by an application to the provincial Department of Environmental Affairs & Development Planning (DEA&DP) to obtain a Record of Decision (ROD) for proceeding with the drilling of the exploration boreholes. At the time of writing, the ROD had been issued and the project team was awaiting any appeals before exploring the properties of the groundwater via exploratory drilling from 26 potential sites along the aquifer.

## PROTECTING THE ENVIRONMENT


At this stage the potential impact on vegetation, including the Western Cape's unique fynbos biome, as a result of groundwater exploration in the Peninsula Formation is largely unknown. For this reason, the TMG Aquifer study is also informed by a

parallel investigation, commissioned by the Water Research Commission, into the ecological and environmental impacts of large-scale groundwater development in the TMG aquifer system. The investigation is being conducted by a team led by the CSIR.

The public has been part of the process from the start. The engagement of the public from an early stage of the project has proved to be important and valuable, says Shelly. As such, a Key Stakeholder Forum comprising more than 20 relevant organisations has been established. It convenes every six months or so.

Moreover, a process of public communications and participation was initiated towards the end of the Preliminary Phase. A public website ([www.tmg-aquifer.co.za](http://www.tmg-aquifer.co.za)) has also been developed. "The public generally support the approach to the study, which is a precautionary one in that it evaluates all potential factors (i.e. technical, environmental, societal etc.) that could influence the viability of the project," notes Shelly.

Once the Exploratory Phase has been completed in 2007, the findings of the investigation will be submitted to the City of Cape Town's Mayoral Committee for a decision on whether or not to proceed with the last (pilot) phase. In parallel, a submission will be made to DEA&DP for approval for the pilot phase activities. If approved, this phase will involve the development of pilot-scale groundwater abstraction (i.e. 3 to 5 Mm<sup>3</sup>/a), including the necessary environmental management.

"Praise has to go to the City for Cape Town for initiating and funding this project and taking a leading management role. This study plays a significant role in the pro-active long-term planning of water supply to the Western Cape, by filling the scientific gaps in the complexity of the structural geology, to gain a better understanding of possible environmental impacts, to pro-actively set up monitoring frameworks, and so forth, in order to ultimately be able to make an informed decision on the viability and acceptability of the TMG aquifer as a potential resource," concludes Shelly. 



**Left:** The Exploratory Drilling Phase (the third phase) will entail the detailed siting of exploration boreholes, followed by the exploration drilling and associated environmental management activities.

**Right:** The fractured rock groundwater systems of the TMG constitute a vast aquifer system, extending from just north of Nieuwoudtville southwards to Cape Agulhas and eastwards to Port Elizabeth.

## History of Water Treatment

**South Africa's tap water is considered of the highest quality in the world. But it doesn't start out that way. In fact, the water goes through a complex treatment process before it is considered safe to drink.**

The history of water treatment is still being written, as discoveries continue to document its origins. There is evidence, however, that even in ancient times people saw the importance of treating water in some way before drinking it. Ancient Egyptians treated water by siphoning water out of the top of huge jars after allowing the muddy water from the Nile River to settle. Hipocrates, known as the father of medicine, directed people in Greece to boil and strain water before drinking it. In turn, the Romans passed water from aqueducts through settling basins to clarify it (remove impurities). Back then the focus was on the aesthetic quality of water i.e. if the water was clear and had no smell it was considered clean.

The first water facility to deliver water to an entire town was built in Paisley, Scotland in 1804 by John Gibb to supply his bleachery and the town and, within three years, filtered water was even piped directly to customers in Glasgow, Scotland.

In 1806, a large water treatment plant began operating in Paris. The plant's filters were made of sand and charcoal and were renewed every six hours. Pumps were driven by horses working in three shifts. Water was settled for 12 hours before filtration. In 1827 Englishman James Simpson

built a sand filter for drinking water purification.


It was only in the 1870s that Drs Robert Koch and Joseph Lister demonstrated that microorganisms existing in water supplies can cause disease. Although by the start of the twentieth century, use of sand filtration sometimes preceded by some form of chemically assisted sedimentation or clarification was reasonably established, this did not prevent outbreaks of waterborne diseases such as cholera and typhoid. The first recorded use of chlorine on a permanent basis was in Middlekerk, Belgium, in 1902. This fundamental process is still used today, however, much work has been to refine the process since then.

Water is usually treated using the following steps:

- ◆ **Screening:** Screens or sieves are used to block large objects such as trash and leaves out of the water.
- ◆ **Flocculation:** The water is treated with chemicals that form a chemical floc which entraps dirt particles.
- ◆ **Rapid sand filters:** The use of rapid sand filters is the most common form of treating water. Passing flocculated water through a sand filter strains out the floc and the particles trapped in it.

- ◆ **Disinfection:** The filtered water is then disinfected with chlorine gas or another form of chlorine before it is pumped into the distribution system.

(Source: Wikipedia, the free encyclopedia)

Other more modern water treatment technologies include the use of ozone or ultraviolet light. Water can also be purified using membrane technology. A membrane is a plastic sheet through which water is pushed under high pressure. This membrane acts as a barrier against pollution, leaving impurities behind. 



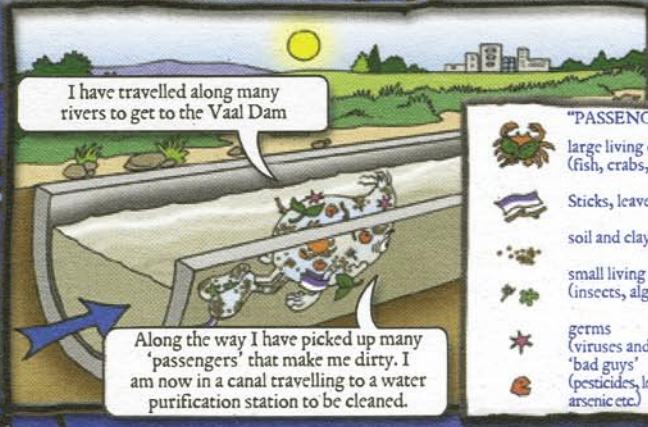
### CHECK IT OUT!

The Water Research Commission has developed a new Education link on its website ([www.wrc.org.za](http://www.wrc.org.za)) for all those budding water scientists out there. The page provides fascinating insight into the world of water, such as water's unique properties. There is also information on the water cycle, dams, water treatment, groundwater, and water pollution, among others.

### DID YOU KNOW?

- The longest tunnel of any kind is the New York City West Delaware water-supply tunnel. It has a diameter of 4,1 m and runs for 169 km.
- Water leaves the stomach five minutes after consumption.
- An average tap left running can deliver 15 l of water in one minute.
- Over 70 000 different water contaminants have been identified.

# HOW IS TAP WATER CLEANED?



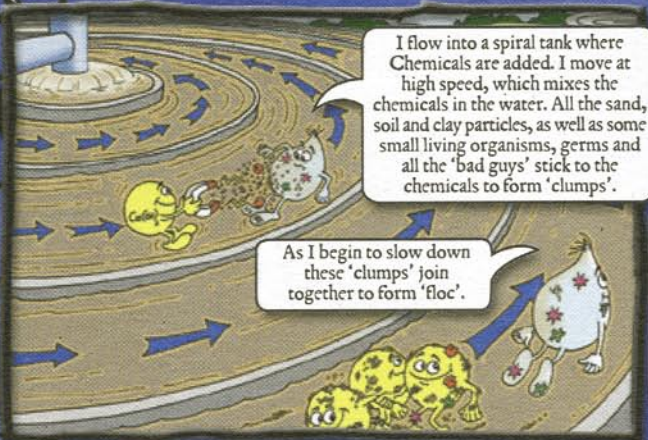
I have travelled along many rivers to get to the Vaal Dam

Along the way I have picked up many 'passengers' that make me dirty. I am now in a canal travelling to a water purification station to be cleaned.

- "PASSENGERS"**
- large living organisms (fish, crabs, floating plants)
  - Sticks, leaves and litter
  - soil and clay particles
  - small living organisms (insects, algae and plankton)
  - germs (viruses and bacteria)
  - 'bad guys' (pesticides, lead, mercury, arsenic etc.)

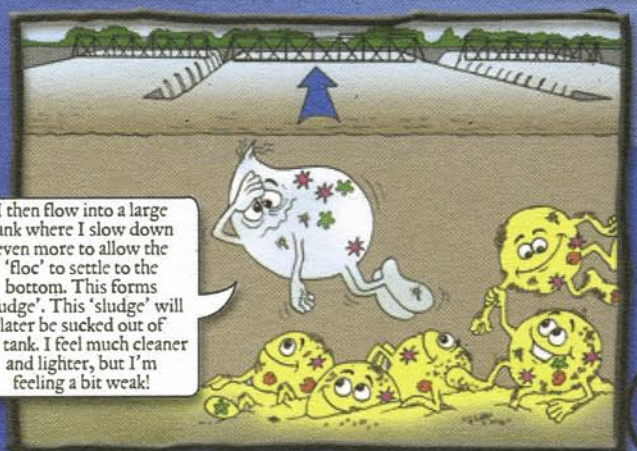


When I arrive at the station I pass through screens that trap large living organisms, sticks, leaves and litter.



I flow into a spiral tank where Chemicals are added. I move at high speed, which mixes the chemicals in the water. All the sand, soil and clay particles, as well as some small living organisms, germs and all the 'bad guys' stick to the chemicals to form 'clumps'.

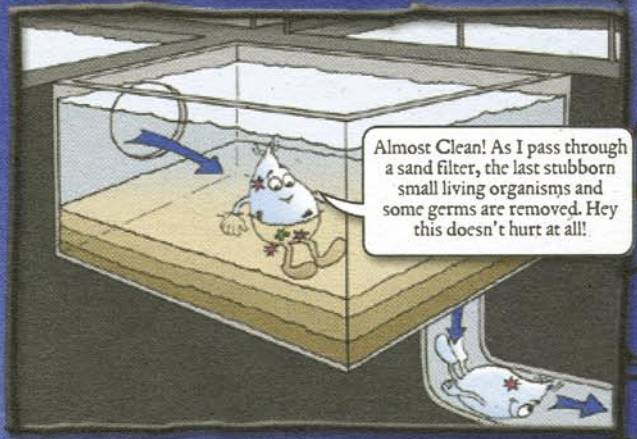
As I begin to slow down these 'clumps' join together to form 'floc'.



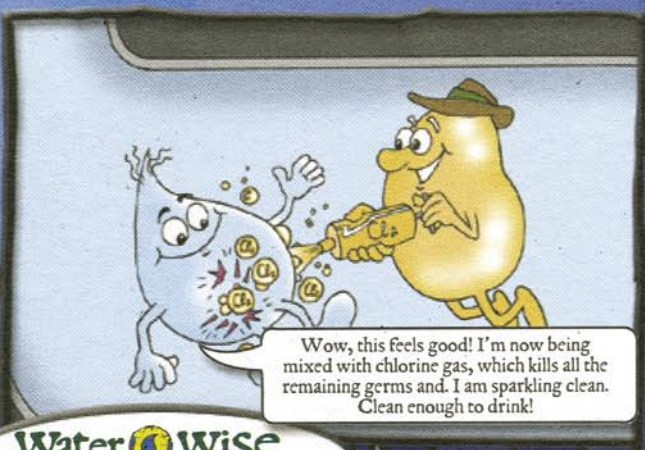
I then flow into a large tank where I slow down even more to allow the 'floc' to settle to the bottom. This forms 'sludge'. This 'sludge' will later be sucked out of the tank. I feel much cleaner and lighter, but I'm feeling a bit weak!



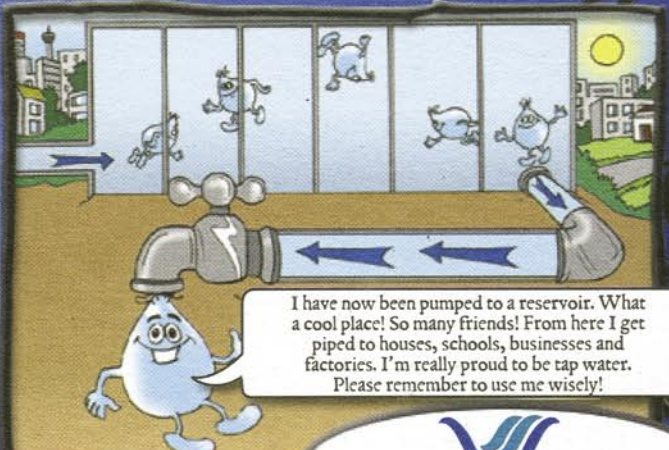
Ooh this is ticklish! I have flowed over a weir and into another tank where carbon dioxide is bubbled into me. I am feeling much better!



Almost Clean! As I pass through a sand filter, the last stubborn small living organisms and some germs are removed. Hey this doesn't hurt at all!



Wow, this feels good! I'm now being mixed with chlorine gas, which kills all the remaining germs and. I am sparkling clean. Clean enough to drink!



I have now been pumped to a reservoir. What a cool place! So many friends! From here I get piped to houses, schools, businesses and factories. I'm really proud to be tap water. Please remember to use me wisely!



FOR MORE INFORMATION ABOUT THE WATER WISE EDUCATION PROGRAMME, PLEASE CONTACT RAND WATER ON (011) 682 0732 OR WWW.RANDWATER.CO.ZA



# Free State Boffins Win Water Prize

**Three learners from Setjhaba se Maketse Combined School in Botshabelo, 54 km east of Bloemfontein, are jetting off to Sweden to compete in the international Stockholm Junior Water Prize after winning the National SA Youth Water Prize competition.**

The international competition aims to encourage young people's interest in issues concerning water and the environment. The award, which attracts hundreds of entries from all over the world, is given annually for an outstanding water project by a young person or a small group of young people. South Africa hopes to reclaim the title it won in 2003 after narrowly losing out to Japan in 2004.


The three South African winners, Pontso Moletsane, Motebele (Elvis) Moshodi and Sechaba Ramabenyane scored top marks from the judges for their invention, the nocturnal hydro minimiser, which uses light and moisture sensors to control irrigation while minimising water wastage.



*Elvis Moshodi, Sechaba Ramabenyane and Pontso Moletsane, winners of the 2005 National SA Youth Water Prize.*

The electrically-operated automatic watering system uses affordable parts to control a tap opening compressor, only allowing water through

at night and when the sensor motions that the lawn is dry. The water is switched off automatically once enough moisture is sensed in the root area. Further water savings are obtained through the use of smaller hoses and a high-pressure system.

"In our settlement, people like growing lawns as they prevent soil erosion and reduce the amount of dust in the area. They are also aesthetically pleasing," explains Moletsane. "However, they tend to be overwatered, leading to huge mud puddles and potholes forming in the streets. With our creation we hope to take the pain out of having the water the lawn, while saving water at the same time." 

THE SOUTH AFRICAN INSTITUTE OF AGRICULTURAL ENGINEERS  
KWAZULU-NATAL BRANCH



DIE SUID-AFRIKAANSE INSTITUUT VAN LANDBOU-INGENIEURS  
KWAZULU-NATAL TAK

## CONTINUING PROFESSIONAL DEVELOPMENT EVENT 2005 21 TO 22 SEPTEMBER 2005

**Objective:** Provide information on the latest developments on selected topics.

**Venue:** University of KwaZulu-Natal, Pietermaritzburg Campus

### Topics to be covered:

**Plenary sessions:**

- 1) *Energy – the future in SA* by Dr Brian Purchase;
- 2) *Water – the future in SA* by Prof Roland Schulze;
- 3) *Food processing – the future in SA* by Mr Andrew Murray

### Parallel sessions:

- |   |  |
|---|--|
| <p><b>Water:</b></p> <ul style="list-style-type: none"> <li>• Course on Design Flood Estimation using Visual SCS-SA</li> <li>• Workshop on the Impacts of Climate Change on Water Resources in South Africa</li> </ul> <p><b>Environment:</b></p> <ul style="list-style-type: none"> <li>• Environmental Impact Assessments (EIA)</li> </ul> <p><b>Farming Systems:</b></p> <ul style="list-style-type: none"> <li>• Tractor Performance Optimisation</li> <li>• Grain Handling</li> </ul> <p><b>Professional practice:</b></p> <ul style="list-style-type: none"> <li>• Strategic Approach to Farming Success</li> </ul> <p><b>Food Engineering:</b></p> <ul style="list-style-type: none"> <li>• Hygienic Design of Food Processing Plants</li> </ul> <p><b>Emerging farmers:</b></p> <ul style="list-style-type: none"> <li>• Engineering for Sustainable Rural Development</li> </ul> <p><b>Other hot topics:</b></p> <ul style="list-style-type: none"> <li>• Value and Supply Chains</li> </ul> | <ul style="list-style-type: none"> <li>• Course on ACRU Agrohydrological Modelling System</li> </ul> <ul style="list-style-type: none"> <li>• Vegetation use in the Rehabilitation of Mine, Domestic and Industrial Wastes</li> </ul> <ul style="list-style-type: none"> <li>• Mechanisation Planning</li> <li>• Precision Agriculture in South Africa</li> </ul> <ul style="list-style-type: none"> <li>• Engineering Consulting</li> </ul> |
|---|--|

For more information and registration information follow the links to "Symposia 2005" on the SAIAE website at <http://www.saii.co.za/> or contact (033) 260-5490

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**Four and a Half Day Short Course on  
Coastal Engineering**  
at the University of Stellenbosch (Dept. Civil Engineering, Room S202), Stellenbosch, South Africa  
5 to 9 September 2005  
Course commences at 08:00 for 09:00 on 5 September 2005

**List of invited speakers, institutions and topics**

SPEAKER	INSTITUTION	TOPIC
<b>Monday 5 September 2005 (course registration 08:00 to 09:00)</b>		
Registration (08:00-09:00)		
Mr Vonk Claassens	National Port Authority (Chief Engineer)	Opening Address
Mr Eddie Bosman	University of Stellenbosch	Introduction to Coastal Engineering
Dr André van Tonder	ENTECH	Short wave theories and characteristics of regular waves. Appropriate wave theory for different design cases.
Dr André van Tonder	ENTECH	Irregular waves, measurement and analysis for design purposes.
Mr Marius Rossouw	CSIR (ENVIRONMENTEK)	Wind fields and generation of ocean waves.
<b>Tuesday 6 September 2005</b>		
Mr Marius Rossouw	CSIR (ENVIRONMENTEK)	Wave hindcasting and forecasting. Statistical analysis to establish design wave and define wave climate.
Mr Eddie Bosman	University of Stellenbosch	Principles of transformation of deep-sea waves into shallow water (wave refraction, shoaling, diffraction and reflection).
Mr Cobus Rossouw	Zietsman Lloyd & Hemsted	Numerical model (SWAN) as tool for the transformation of deep sea waves into shallow water, with case study.
Mr Eddie Bosman	University of Stellenbosch	Surf zone hydrodynamics : including long waves and currents and extreme water levels in surf zone.
<b>Wednesday 7 September 2005</b>		
Mr Sven Coles	Marine Geosciences Unit of Council for Geoscience	Marine Geology, hydrographic and sub bottom surveys.
Mr Eddie Bosman	University of Stellenbosch	Site Characterisation (project orientated field studies).
Dr Koos Schoonees	CSIR (ENVIRONMENTEK)	Long-shore and cross-shore sediment transport.
Mr Stephen Luger	CSIR (ENVIRONMENTEK)	Numerical modeling of waves, currents, sediment transport and water quality with DELFT 3D (case studies)
Mr Piet Huizinga	CSIR (ENVIRONMENTEK)	Hydrodynamics of tidal inlets/estuaries (including astronomical tides).
<b>Thursday 8 September 2005</b>		
Dr André van Tonder	ENTECH	Outfall pipeline stability design and case studies.
Mr Ton Fijen	ENTECH	Outfall pipeline effluent dilution/diffusion design and case studies.
Mr Anton Holtzhausen	Prestedge Retief Dresner Wijnberg	Rubble mound and vertical breakwater design with example cases.
Mr Jo Dresner	Prestedge Retief Dresner Wijnberg	Open coast mooring jetty design: Case Study: MOMA.
Mr Phil Smith	Prestedge Retief Dresner Wijnberg	Marine concrete and other marine construction material
<b>Friday 9 September 2005 (morning only)</b>		
Dr Allan Wijnberg	Prestedge Retief Dresner Wijnberg	Durban harbour Entrance widening and Small Craft harbour at Durban harbour Entrance.
Mr Dave Phelp	CSIR (ENVIRONMENTEK)	Visit Table Bay harbour and Durban harbour physical models in the CSIR's hydraulics laboratory.

**Scope**

The objective of this course is to provide the participants with a firm understanding of the basic coastal processes, methods and procedures to assist participants towards more effective planning, design, construction and maintenance of coastal projects. Speakers invited from outside the university who are specialists and have extensive experience in their respective fields will participate together with university staff in the presentation of the course. In addition to speakers' course notes, the latest version of the Coastal Engineering Manual (CEM), which is a comprehensive update of the Shore Protection Manual (SPM) by the U.S. Army Corps of Engineers, will be used as the main reference document in the course. All participants will be provided with an electronic copy (on a CD) of the latest version of the CEM.

This course will also serve as a basis for a week long course on Port Engineering (including commercial ports and small craft harbours) scheduled by the University of Stellenbosch for September 2006.

An open invitation is extended to all who are interested to attend the course as either an introduction to Coastal Engineering or as a refresher course. The course (including course notes) will be presented in English. Participants who are interested can also earn credits towards a MEng or MSc degree since the course also forms part of a post graduate study programme offered by the University of Stellenbosch.

For more information on the post graduate study programme, please refer to [www.civeng.sun.ac.za](http://www.civeng.sun.ac.za), "2005 Postgraduate Brochure" or contact Mr Eddie Bosman at [debosman@sun.ac.za](mailto:debosman@sun.ac.za). For a registration form or for enquiries contact Mrs Marechia Jacobs at Tel: +27 21 808 4352 or Fax: +27 21 808 4351 or e-mail [msjacobs@sun.ac.za](mailto:msjacobs@sun.ac.za)

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