SA waterbulletin

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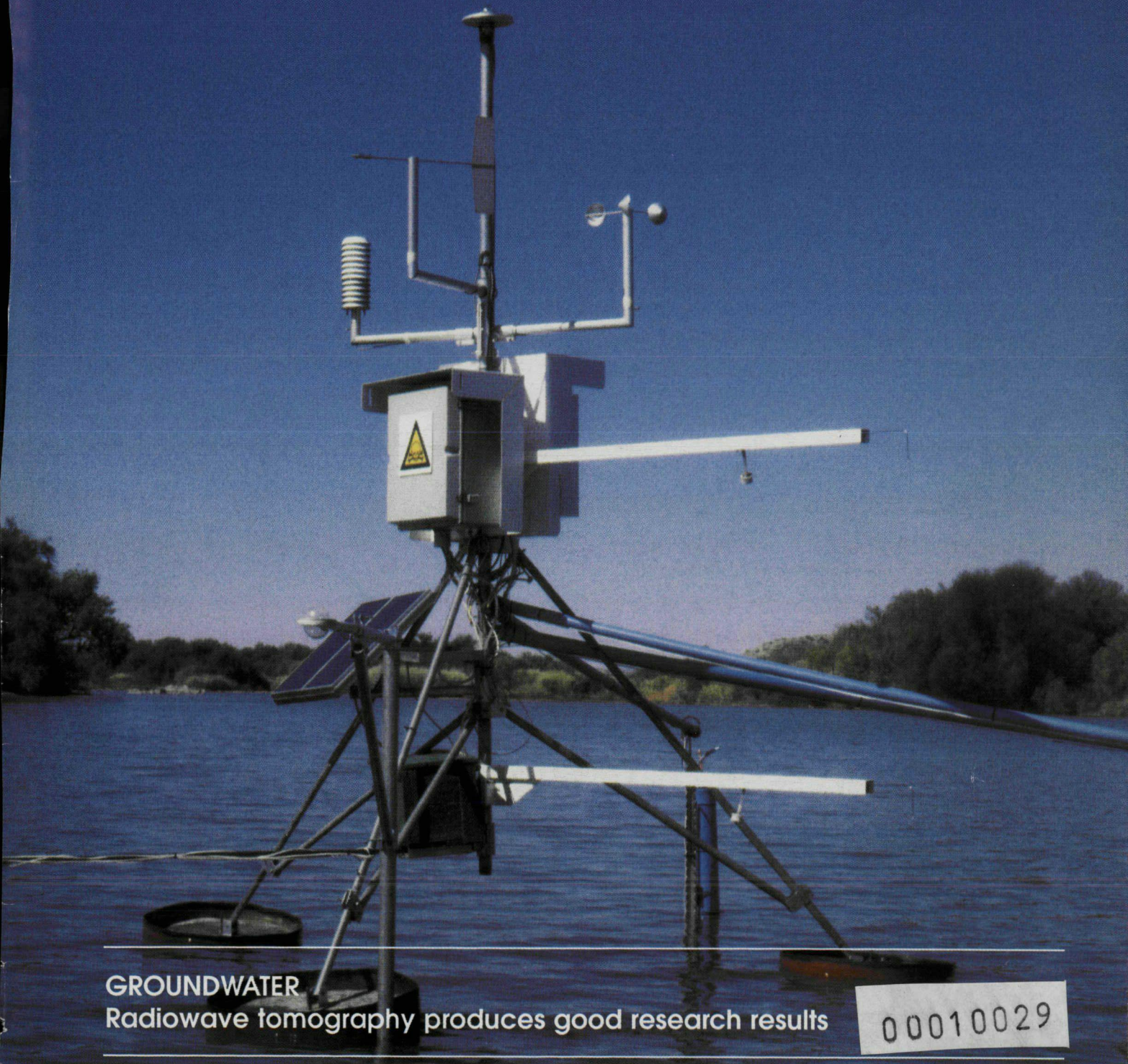


GROUNDWATER
Radiowave tomography produces good research results

HYDROLOGY
Researcher quantifies evaporation losses from the Orange River

GROUNDWATER
Impact of Agricultural practices on SA groundwater resources assessed

UAWS 2000 CONGRESS

PARTNERSHIP AND SUSTAINABLE DEVELOPMENT FOR WATER AND SANITATION

Durban, South Africa **20-25 February 2000**

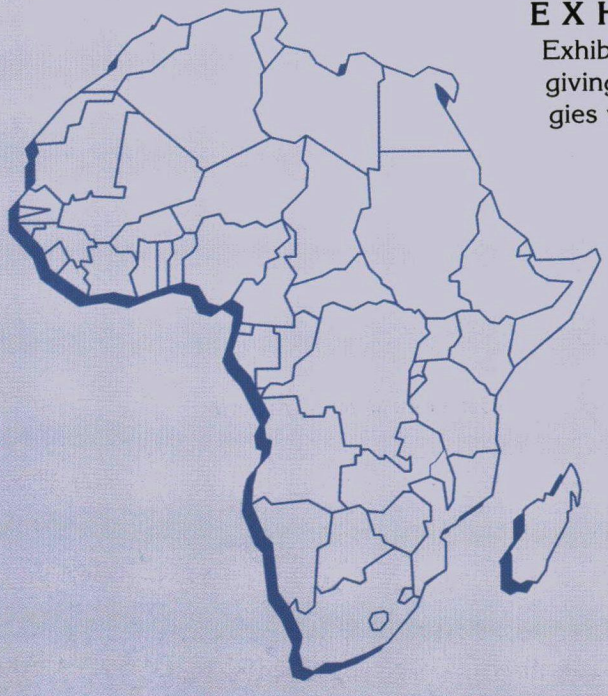
The 10th Union of African Water Suppliers (UAWS) Congress and Exhibition in Durban will be the first time this Congress is held in Southern Africa. At the last Congress held in Casablanca, Morroco, in February 1998 some 800 delegates from more than 38 countries attended.

This Congress and Exhibition, to be held under the banner of the newly merged International Water Association (IWA), is of major importance and significance for the southern African region. It will provide an excellent opportunity for those all those involved in the water sector in South Africa, both in manufacturing and in the field of water services, to meet with potential customers from Africa and many other parts of the world.

THEMES

The themes to be addressed during the Technical Sessions at the Congress are:

- The Institutional Reforms in the Water Supply and Sanitation (WWS) Sector in Africa.
- Sanitation: Wastewater Re-use and their By-products in Africa.
- Innovations in the Control of Water Quality.
- Water Supply and Sanitation in Peri-urban Areas, Informal Settlements and Small Municipalities.
- The Financing of Urban Sanitation: Institutional, Technical, Sanitary and Environmental Aspects.
- Information Technology and Information Management in the Water Sector.
- Performance Indicators.



EXHIBITORS FORUM

Exhibitors Forum sessions will be held every afternoon giving exhibitors the opportunity to present new technologies which have been developed for the water sector.

ENQUIRIES

Should you be interested to attend or to exhibit at the 10th UAWS Congress please direct your request for further information to:

Congress International
18 Rapson Road,
Morningside 4001
DURBAN,
South Africa

Tel: +27 (0)31 312-3494 or 312-3442
Fax: +27 (0)31 303-5875
E-mail: ci@dbn.lia.net

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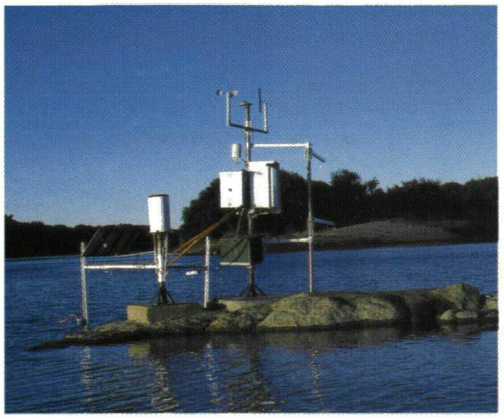

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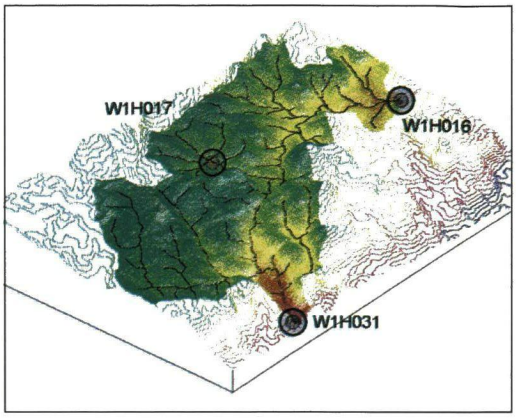

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Cover: Evaporation monitoring on the Orange River using the Bowen ratio technique (Photo: Courtesy of Dr Colin Everson)

SA Waterbulletin 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. Editorial offices: Water Research Commission, PO Box 824, Pretoria 0001, Republic of South Africa. Tel (012) 330-0340. Fax (012) 331-2565. WRC Internet address: http://www.wrc.org.za Editor: Jan du Plessis (E-mail: Jan@wrc.org.za). Asst Editor: Helene Joubert (E-mail: Helene@wrc.org.za). Ed Secretary: Rina Human (E-mail: Rina@wrc.org.za). Layout: Ronel Urquhart - 4Images. Colour Separations: 4Images. Printing: Beria Printers.

Mangondi shows the way

The Mangondi Water Wise Organic Food Production Project near Thohoyandou (Venda) in the Northern Province is the result of an inspiring partnership between local people, the Department of Water Affairs and Forestry (DWAF), the Jewish National Fund (JNF) and ABSA. The initiative and achievement of the Mangondi village community, along with the support of JNF and DWAF and all the other sponsors and contributors, was recognised and celebrated in September with an opening ceremony for the project. The Minister of Water Affairs and Forestry, Mr Ronnie Kasrils, as well as the Ambassador of Israel, Mr Urin Oren, addressed the community at the opening ceremony.

Some three years ago the community of Mangondi received a tract of land from the village chief to farm. A group of 60 women and a few men undertook the clearing of 20 hectares of bush by hand and the digging of irrigation trenches. They also took the initiative to make contact with the Department of Water Affairs and Forestry. At the same time the Jewish National Fund of South Africa was looking for such a community to assist as they have been facilitating community based environmental improvement projects since 1990. Thus the Mangondi Community Project was born, and now serves as a pilot project for the Jewish National Fund of South Africa's scheme: Water and Food for Africa. Mrs Isla Brito, chairperson of the JNF says that they have also received outstanding sponsorship co-operation from ABSA Bank for the Mangondi project.

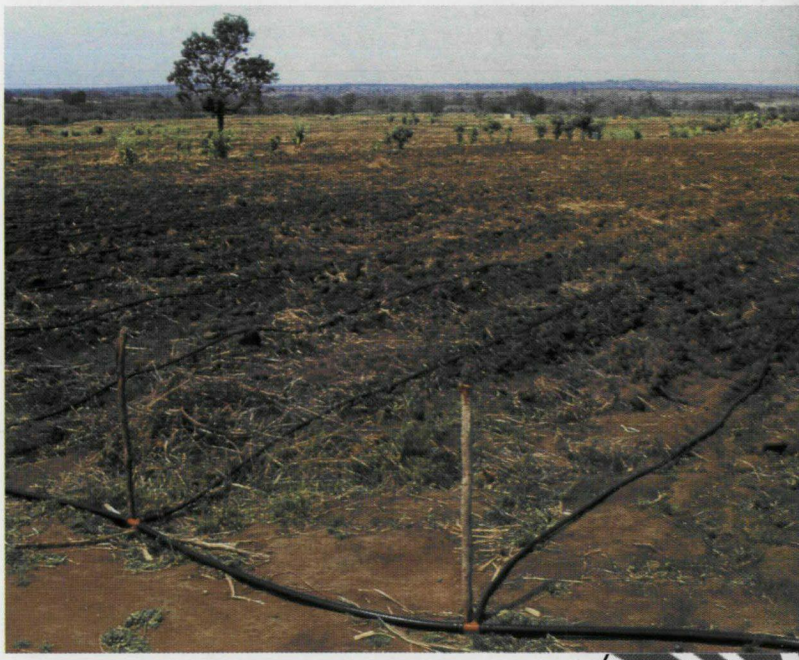
The primary aim of this project is to demonstrate the value of water for life and as an economic resources with the emphasis on efficient use of water. The specific aims of this project are:

- ❒ supply community with domestic water
- ❒ deliver water for agricultural purposes
- ❒ educate farmers in efficient water practices, basic farming, organic farming, basic knowledge, marketing and literacy.

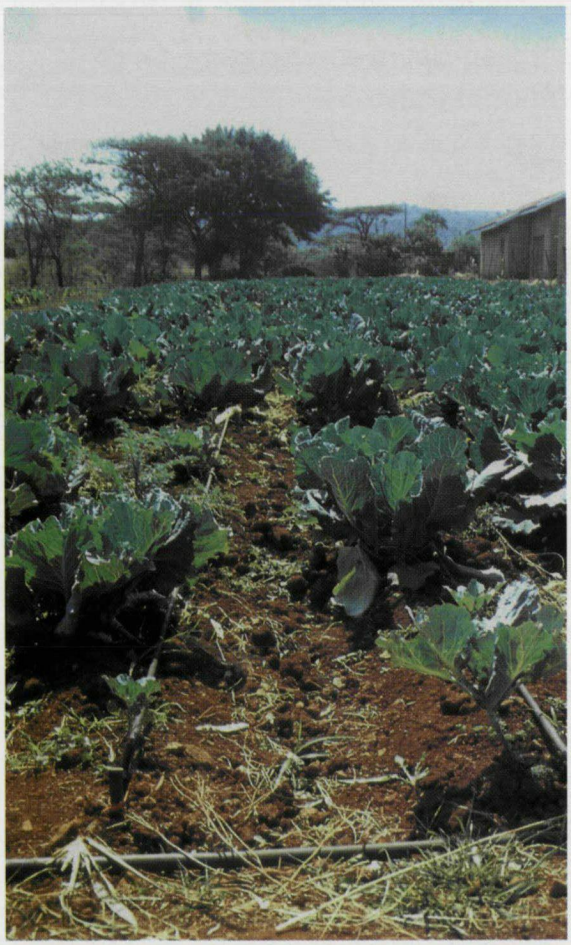
Initially the agricultural community gardens were watered from a borehole and by hand, however with the help of JNF and sponsors a new drip irrigation scheme has been established, following the Israeli drip irrigation technology which has made barren desert in Israel to flower and produce excellent crops. Drip irrigation not only reduces pumping costs and crop losses, it demonstrates the wise and efficient use of water.

The Minister of Water Affairs and Forestry, Mr Ronnie Kasrils, addressing the people of Mangondi at the opening ceremony. The community gardens are in the background with newly planted seedlings for the next crop.

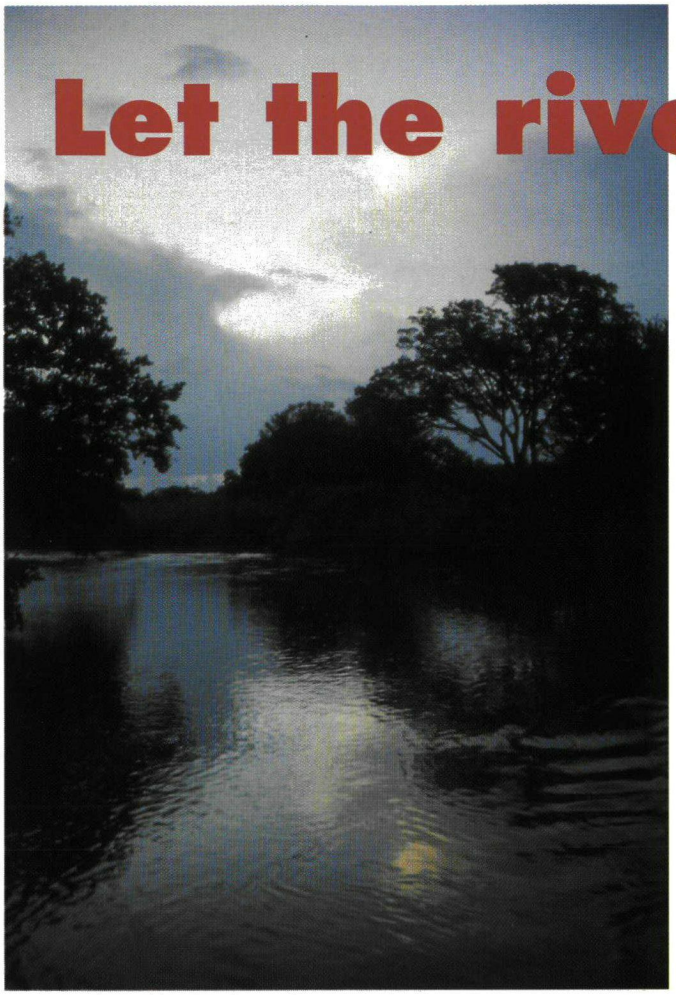
Close-up of a drip irrigation line showing the drip hole and newly planted seedlings at Mangondi.



The drip irrigation lines at Mangongdi for economic and efficient water use. Past sales from the community gardens, then watered by hand, have produced an income of approximately R200 per person per month.



A few kilometres from Mangondi SA Waterbulletin spotted an enterprising Venda small farmer's crop of vegetables produced with drip irrigation !



Let the rivers flow ...

Worldwide the vital role of river ecosystems has increasingly been recognised, and this recognition has flown into a progressive integration of the management and scientific study of rivers in recent years.

"Integrated Management of River Ecosystems: An International Experience" was the theme and focus of a workshop and post-workshop course which was held during August at Berg-en-dal in the Kruger National Park.

The workshop focused on the African experience within the context of global trends, and was of particular interest to consultants, researchers, resource managers, planners and students involved with river ecosystems, hydrological sciences and water resource issues in developing countries. Some sixty delegates participated in the two-day workshop, and seven of the delegates hailed from four neighbouring countries in southern Africa.

The post-workshop course on integrated management of river ecosystems was presented by Prof Charles Breen (Institute for Natural Resources, University of Natal), Prof Kevin Rogers (Centre for Water in the Environment, Wits University) and Prof Jay O'Keeffe (Institute for Water Research, Rhodes University) along with Dr Freek Venter (Kruger National Park) and Dr Mark Dent (Computing Centre for Water Research, University of Natal), all involved in the Kruger National Park Rivers Research Programme (KNPRRP).

The purpose of the course was to share the range of protocols, methodologies and tools which have been developed within the Rivers Research Programme. These capabilities provide an aid for river management aiming to achieving ecological sustainability (through)

The course covered the following topics:

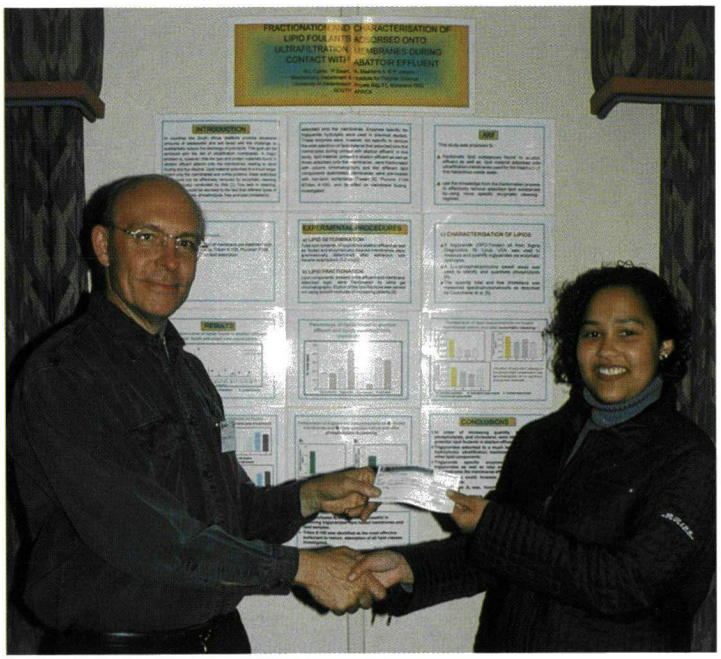
- A river management approach
- New methods of determining management objectives
- The water allocation bargaining process
- Prediction of physical processes and responses
- Prediction of biological responses
- New approaches to addressing problems of scale (macro/micro and long-term/short-term processes) in terms of time and geography, and
- Integrated systems for managing divers information.

The course was attended by 23 scientists and resource managers from various stakeholder institutions, which will be participating in the future management of the ecology of rivers and their catchments. Four delegates from neighbouring countries also attended the two-day course.

The workshop and course was organised by the Kruger National Park Rivers Research Programme (KNPRRP), and supported by the Water Research Commission (WRC), the Department of Water Affairs and Forestry (DWAF), the National Research Foundation (NRF), the South African National Parks Board, Mpumalanga Parks Board, the Institute for Natural Resources, and the Department of Environmental Affairs and Tourism.

Enquiries regarding the Kruger National Park Rivers Research Programme can be directed to:
KNPRRP Secretariat,
National Research Foundation
Tel: (012) 481-4103
Fax: (012) 481-4005
E-mail: gayle@ nrf.ac.za

Membrane technology specialists gather for Workshop



Dr Gerhard Offringa presenting Ms Heidi Cyster, a post-graduate student at the Department of Biochemistry of the University of Stellenbosch, with the R1000 prize for the best student presentation/poster at the MTD Workshop.

The Membrane Technical Division (MTD) of WISA held their third Biennial Workshop conference with great success during September in the tranquil setting of the Drakensberg. The conference itself, however, was a hive of activity attended by a 100 people, including some international delegates.

Almost a third of the delegates were students, and a great delight to the organisers as the transfer of technology to students and the involvement of students in the presentation of papers is a high priority with the MTD. Some 27 of the 43 papers and poster at the workshop were presented by students. According to Dr Gerhard Offringa, chairman of the MTD, the students' presentations were of good quality. Ms Heidi Cyster of the Department of Biochemistry, University of Stellenbosch was the student fortunate to walk away with the R1000 prize for the best student poster.

Membrane technology courses were presented on the third day, as has became customary at these MTD workshops. Forty two of the delegates attended the introductory course on membranes as well as a course on membrane bioreactors which were presented by a team of local and international experts.

Since such a large number of stakeholders in the water membrane field, from academic institutions as well as industry, were gathered at this workshop the Water Research Commission (WRC) utilised the opportunity to review the Strategic Plan for Water Related Membrane Research in South Africa. Dr Offringa, research manager: membrane technology at the WRC, says that the up-dated Strategic Plan has been be made available on the WRC's home page at www.wrc.org.za .

Characterising fractured rock aquifers with modern radiowave technology

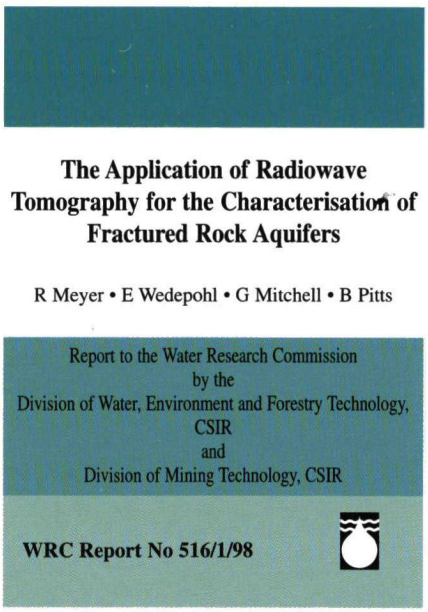
Research into secondary (fractured rock) aquifers has been identified by the Water Research Commission as one of its primary focus areas for groundwater research and forms part of a longer term ground water research programme. Furthermore, fractured rock aquifers play a major role in South African geohydrology as more than 80 per cent of the country's ground water reserves are found in such aquifers. The physical nature and behaviour of fractured rock aquifers, however, are not well understood and therefore South African researchers are in a unique position to conduct research into this category of aquifers.

Over the past ten years there has been a growing awareness of the complexity of fractured rock aquifers. Internationally this has been driven by the need to manage waste disposal activities, in particular nuclear waste, located within these environments. In South Africa the emphasis has been on gaining a better understanding of the flow of groundwater in these fractured rock aquifers in order to more effectively manage groundwater for sustainable water supply purposes.

Traditionally, percussion techniques have been utilised to drill boreholes in hard rocks, with the result being a poor representation of the geometry of fractures within the aquifer. Although borehole geophysical tools and down-the-hole cameras can provide greater information on conditions within the borehole, and core drilling can provide an intact core showing for example orientation and apertures of fractures, little information of conditions between boreholes can be obtained. Even conventional hydraulic tests yield questionable results in these environments as most of the interpretation tools have been developed for primary aquifers.

WRC PROJECT

To gain a better understanding of the physical nature of hard rock aquifers through the application of sophisticated geophysical techniques not generally applied in groundwater research, the Water Research Commission (WRC) supported a research project at the Divsion of Water, Environment and Forestry and the Division of Mining Technology at the CSIR.

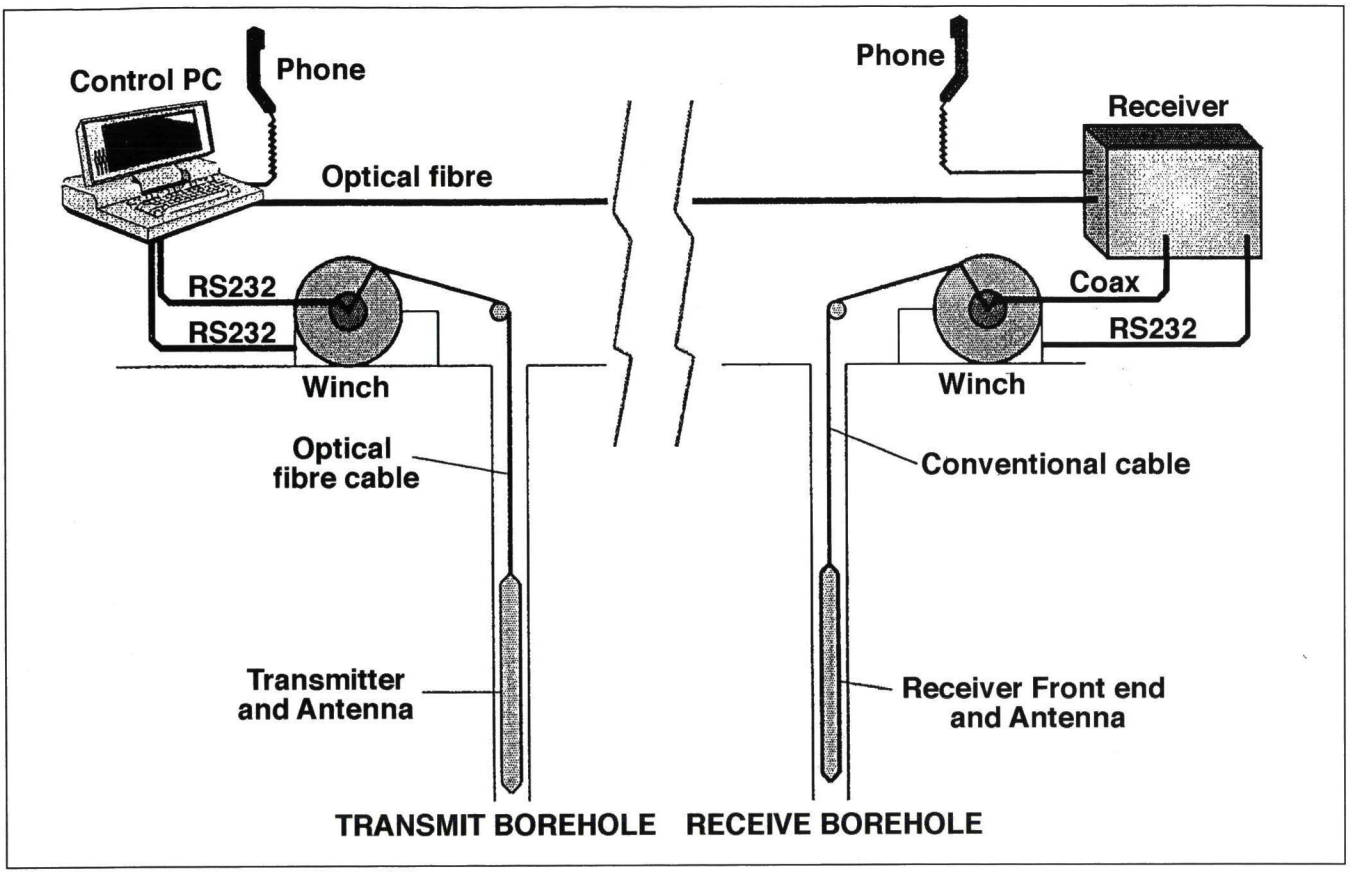


The researchers, R Meyer, E Wedepohl, G Mitchell and B Pitts, say in their final report to the Commission that "initially, it was envisaged that seismic borehole tomography and borehole radar imaging techniques would be applied. But, although both these techniques were used, the main emphasis shifted during the course of the project to the application of radiowave tomography.

AIMS

The primary objectives of the project were:

- To investigate seismic borehole tomography and borehole radar imaging as fracture detection and characterisation techniques, through theoretical modelling studies for different fracture geometries and distributions. The aim of this investigation was to gain knowledge on the theoretical limits of the techniques when used as tools to study secondary aquifers.
- To collaborate with the Institute of Groundwater Studies (IGS) at the University of the Orange Free State in their projects related to fractured aquifer research and in particular as it relates to the Campus Test Site. The results from Packer tests, cross hole test data, detailed geological investigations and other information collected for the test site were to be incorporated in the research programme.
- To relate the geophysical characteristics obtained from seismic tomography and radar technologies to the storage coefficient and hydraulic conductivity.
- To compare the accuracy and reliability of the methods regarding their presentation of the physical conditions and hydraulic characteristics.
- To use geostatistical techniques for the three dimensional interpolation of the data, as well as to define the accuracy and certainty with which the data represent the geology.
- To assess the cost of applying the methods versus the reliability for the cost benefit analysis.



Instrument layout for cross borehole Radiowave Tomography (RT) surveys.

TECHNIQUES

Ground penetrating radar operates on the principle that electromagnetic waves, emitted from a transmitter antenna, are reflected from buried objects and detected at another antenna, called the receiver. The signals recorded at the receiver provide a map, or cross section of the subsurface that is similar in appearance to those obtained with the well-known seismic reflection technique, used widely in the oil industry. Ground penetrating radar is a high-resolution geophysical technique which is similar to normal radar, with the exception that the electromagnetic pulses are transmitted through the ground rather than through free space.

Radiowave tomography is a novel geophysical technique which utilises radiowaves to interpolate geological information between boreholes by producing attenuation images of the intervening rock mass. Since radiowave attenuation rate is primarily a function of conductivity, geological features which correlate to changes in conductivity are mapped.

The radiowave tomography equipment comprises of five logical units. These are down borehole radiowave transmitter and receiver probes, a radiowave receiver unit located at the borehole collar, cabling and winches for lowering the probes down the boreholes, a PC based control unit and fibre optics link for recording the data and controlling the transmitter and receiver units, and data processing software.

In general, radiowave tomography is applied at frequencies of between one and 30 MHz. However, for this project, frequencies of up to 90 MHz were used. At 90 MHz the radio wavelength in granite is approximately one metre, providing a survey resolution of between 25 and 50 cm.

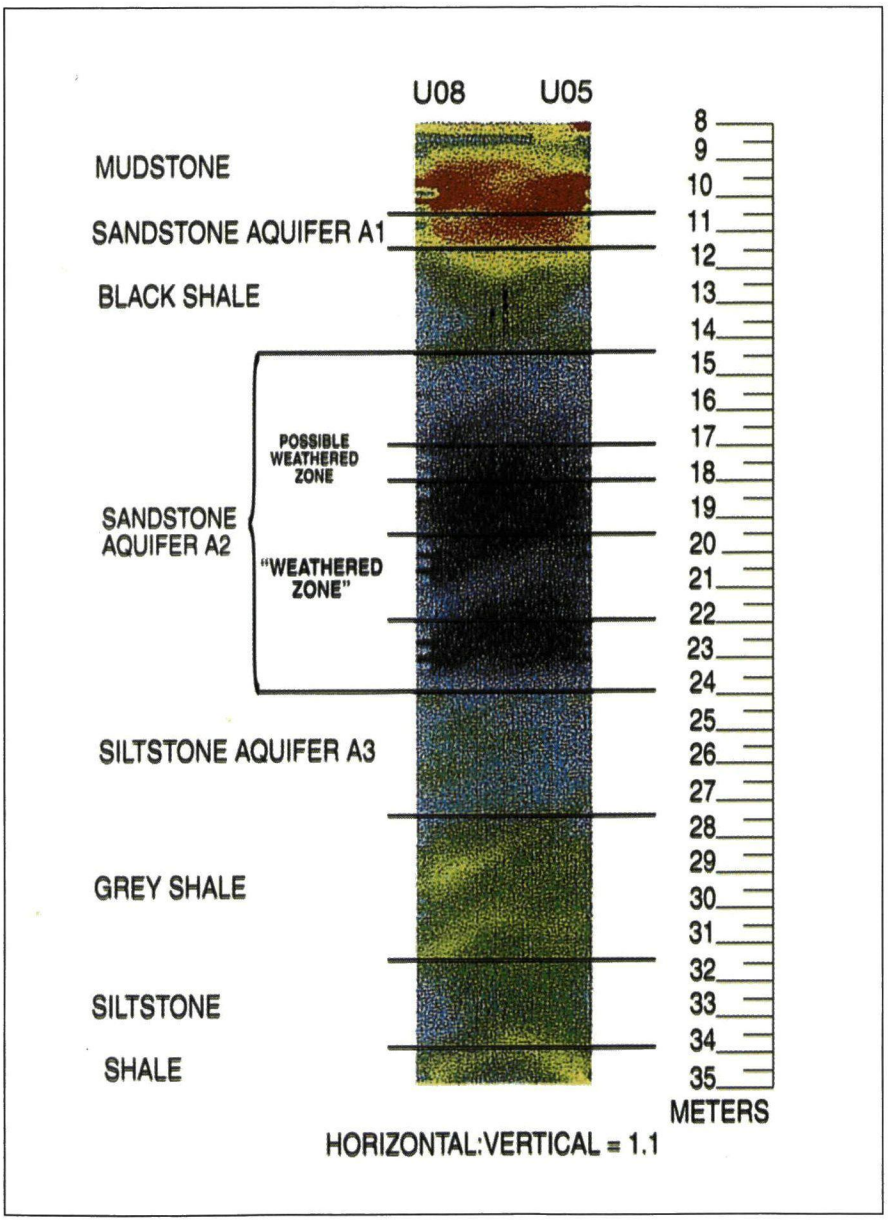
Different scanning modes were applied. These included Reconnaissance Parallel Scans, used to determine operating ranges and frequencies. Background Imaging used for lithology characterisation, Differential Tomography to produce images of the gradient of the attenuation of the rockmass with respect to frequency, and Alterant Tomography which is used to track tracer flow directly, thereby giving an indication of flow paths and the porosity of the medium. In general the technique is most applicable to mapping conductive features in resistive country rocks. Features which fall into this category are weathered zones, fissures filled with saline water, base metal mineralization, and electrically distinct lithologies such as clays and sandstones.

The principle of Seismic Tomography is similar to that of radiowave tomography. Whereas in radiowave tomography the variations in electrical conductivity are mapped, the variation in seismic velocity is what is mapped in seismic tomography. Similar to radiowave tomography, a seismic source (a transmitter) is lowered in one borehole while geophones (the receiver) are lowered in the second borehole. Seismic borehole tomography provides a propagation seismic velocity section in the borehole plane, which can lead ultimately to the respective geologic section, using all other available information to construct a meaningful geo-

logical picture of the rockmass between the two boreholes.

Similar to ground penetrating radar Borehole Radar operates on the principle that electromagnetic waves, emitted from a transmitter antenna, are reflected from surfaces and objects in the rock and detected at another antenna, the receiver antenna. The differences are, however, mainly in the design where one of the challenges is to design suitable antennae that can fit into a borehole. Using radar tomography, the presence of fresh water can be mapped. Here radar travel time is measured in transmission mode and images of radiowave velocity instead of attenuation rate, are produced. Radar tomography, although originally included in the research programme was, however, not applied extensively in this project.

Borehole radar can be used in two modes: single-hole reflection or cross-hole measurements. In the single-hole reflection application the transmitter and the receiver are lowered into the same hole, along with fibre-glass rods used as separators. Optical fibres are used for transmission of signals between the control computer and the borehole probes and to transfer data from the receiver to the control unit. The advantage of optical fibres are that they have no electrical conductivity and therefore do not cause wave propagation along the borehole. Moreover, since optical fibres are never disturbed by electrical noise, signals do not deteriorate along the cable, and signal quality is thus completely independent of cable length.



A typical 50 MHz Radiowave Tomography background image for lithology characterisation between two boreholes.

FIELD STUDIES

Field studies were concentrated on the Vaalputs Nuclear Waste Repository Site in Northern Cape Province and the Karoo Aquifer Test Site of the Institute for Groundwater Studies (IGS) on the campus of the University of the Orange Free State. In addition, borehole radar experiments were conducted at the newly established waste disposal facility at Chloorkop near Midrand. These sites were selected because a great deal of information had already been gathered for each site which would reduce the drilling of additional and expensive boreholes, and it presented the opportunity to test the technique under different geological environments.

At Vaalputs the techniques employed consisted of ground magnetic and electromagnetic surveys, and a wide variety of different radiowave tomography scan configurations. Radiowave tomography scans at definite time intervals were also observed while an electrically conductive tracer was introduced into a borehole and the migration with time was studied. This presented the opportunity to observe the preferential flow paths of water in the fractured medium.

At the IGS site, the experiments concentrated on the use of radiowave techniques. The experiments were designed in such a way as to get high resolution results over relatively short distances. Borehole selection was specifically done in such a way that three dimensional constructions of the geohydrological environment between boreholes could be achieved. As in the case of Vaalputs, the injection of conductive tracers was also done and provided good insight into the flow paths and interconnection of fractures and bedding (planes in the sedimentary Karoo aquifer). Also at this site, some of the radiowave tomography experiments were repeated, although at much reduced intensity, using the seismic tomography and borehole radar experiments. The seismic tomography technique produced good results but the borehole radar results were less successful.

CONCLUSIONS

- Based on the three pilot studies using Radiowave and Seismic Tomography, it was demonstrated that these high resolution geophysical techniques can assist in characterising the nature of aquifers on a micro-scale (over ranges of metres, with resolutions of tens of centimetres). The work was supported by the use of more conventional geophysical techniques.

- The Radiowave Tomography results proved that it is a flexible technique that not only finds application in secondary-phase mineral exploration, for which it was originally developed, but can be applied equally well in the environmental, and in particular the fractured rock aquifer research, field.

- Radiowave tomography and seismic tomography, in contrast to other more conventional geophysical techniques, demonstrated the potential to interpolate aquifer geometry between boreholes.

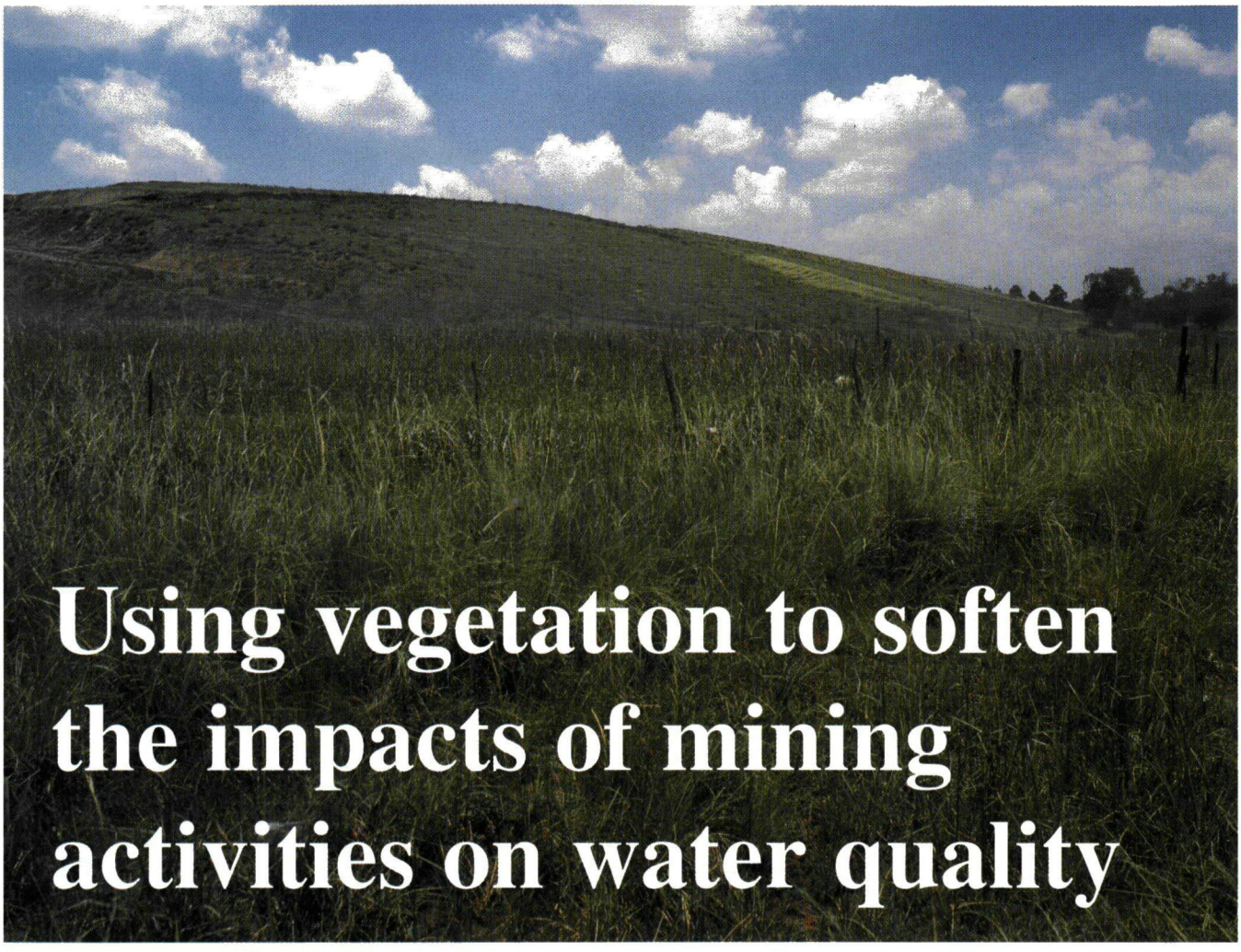
- The characterisation of the physical nature of the aquifer can be done indirectly by pin-pointing lithological controls on the aquifer geometry, and directly by using alterant tomography to track water flow. It was demonstrated that radiowave tomography and seismic tomography, when used in combination, have the ability to map different lithologies and lateral variations therein, major fractures, and water flow directly. Alterant scans confirmed that the water flow could be mapped directly using a conductive tracer.

- Radiowave tomography has developed to a stage where the efficiency, consistency and repeatability of results is sufficiently high to render the technique useful as a monitoring tool. The technique produces information essential in the development of both geological and geohydrological models.

- Radiowave tomography has proven to be a major advance in the formulation of groundwater flow models, which are usually derived from sparse and often incomplete data sets. For example, radiowave tomography can be applied in the identification and delineation of flow paths within aquifers as an aid to the development of such models.

- No surface geophysical technique can, at present, characterise aquifers directly at a micro-scale. These techniques can, however, provide useful background information and can support the more time-consuming and expensive down-the-borehole techniques.

Copies of the report entitled **The Application of Radiowave Tomography for the Characterisation of Fractured Rock Aquifers** (WRC report 516/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 30,00 - via surface mail).



Using vegetation to soften the impacts of mining activities on water quality

Mining activity at, or close to, the soil surface goes hand in hand with the disturbance of surface soils and the shattering of bedrock. This in turn affects the water balance of the affected area in that infiltration is mostly increased while surface runoff is decreased. The exposure of hitherto unweathered surfaces usually cause the water quality of the percolate from these areas to deteriorate markedly in comparison to the undisturbed condition. It is the combined effect of increased through-flow of water (as a result of increased infiltration following disturbance) and percolate quality degradation, that result in the (sometimes dramatic) deterioration in ground and surface water quality following on mining activities in an area.

In a project supported by the Water Research Commission researchers from the Division of Water, Environment and Forestry at the CSIR proposed to limit the water quality degradation associated with mining activity, by reducing the flow of water through disturbed material. According to the researchers, DB Versfeld, CS Everson and AG Poulter, trees with a deep root system and high transpiration requirement can achieve this by intercepting a large percentage of percolating water before it drains to below the root zone. The project assessed the degree to which vegetation can be effective in utilizing rain and surface water, thereby preventing its movement through, and leaching of, mining waste piles and replaced or fractured profiles which result in acidic or otherwise polluted ground and surface waters. Results from this project also have application potential in other areas, (eg. effluent disposal) where reduced through-flow of water can be expected to reduce the pollution load.

The aims of the project were defined as follows:

- To assess the degree to which vegetation can be effective in utilizing rain and surface water, thus preventing its movement through, and leaching of, mining waste piles, replaced or fractured profiles, resulting in acidified or otherwise polluted ground and surface waters. This comprised four areas of focus, namely
- To evaluate sites, growing conditions, and the success in establishment of species already found either colonising mining sites or planted within the landscape for commercial, woodlot, ornamental or other purposes. The role of indigenous grasses and woody species, and that of established pastures, will also be considered. Sites and species will be selected for further research.
- To determine through field measurement of how much water could be utilised by those different species and vegetation types which have potential for establishment on mining waste

piles, replaced soil profiles, and land surfaces disturbed by sub-surface mining activity (eg. coal longwall mining).

- ❒ To develop modelling and predictive methods to extrapolate water use estimates by species over scales of space, time and climate variation, and
- ❒ The assessment of species for establishment, and how effective measures are likely to be in achieving the management objectives of minimizing through-flow to the sub-surface and groundwater.

MAIN RESULTS

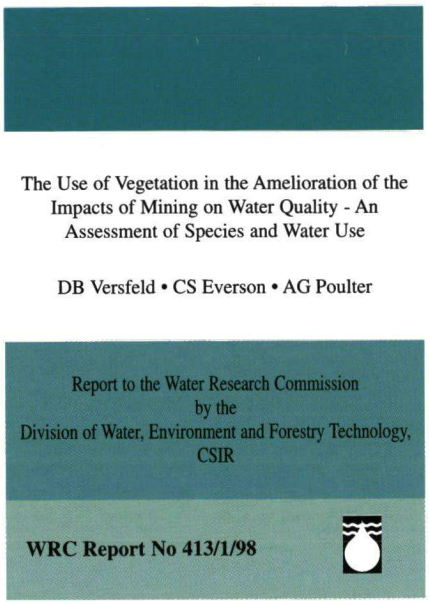
Research was limited to eucalypts - recognised water-users and the most successful colonisers of mine sites. There have also been a number of deliberate plantings at mine sites which provided research material. Research was aimed at establishing the principles and potential of water use by eucalypts, whilst recognizing the potential role of other tree species.

The following mining activities, sites, and species were researched:

❒ Gold slimes dams
Robinson Deep, Western Areas, Durban Deep, Withok and West Extension: *E. sideroxylon, E. camadulesis* and *E. viminalis*. Two acacias (*A. Bailleyana* and *A. melanoxylon*) were included in a pilot study at Robinson Deep.

❒ Coal - Rehabilitated open cast
Hendrina: *E. macarthurii*

❒ Coal - High extraction underground
Secunda: *E. viminalis*. Evaporation from grassland was monitored concurrently on adjacent sites.



The main results and conclusions are as follows:

- ❒ Mining environments are adverse both in terms of climate and substrate for growing trees. Although trees have now been successfully established on a number of mine sites, and have been seeded on gold dumps and slimes dams for many years, there remains a paucity of material useful for water use research.
- ❒ Trees were found to use more water than grass under most of the circumstances examined (see Table 1). Although different species were measured on different sites, a general pattern for daily water use can be derived.
- ❒ Grass can, if the cover is exceptional, compete with trees in the summer, as was found at Secunda where both natural grass cover and trees were using in the order of 5 mm per day. However, the evergreen nature of trees makes them more 'efficient' water users, continuing to transpire at 3 mm/day during winter while the value for grass is close to zero. This difference during winter may result in a substantial difference in water use between grass and trees on a annual basis.
- ❒ Tree water use expressed on the basis of evaporation per unit leaf area was generally within the range expected for commercial forestry tree species.
- ❒ Distinct differences in rates of water use were evident amongst trees. Mature trees with fully developed canopies showed greater rates of water loss than younger trees.

Copies of the final report entitled **The Use of Vegetation in the Amelioration of the Impacts of Mining on Water Quality - An Assessment of Species and Water Use** (WRC report 413/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Site	Season	Daily evaporation		
		Grass (mm)	Trees (mm)	Trees (ℓm^{-2})
Western Areas	Nov./Dec.	2 mm (average) 3 mm (18-30 Nov.)	- 7.0 mm	- 2.5ℓ
West Extension	Feb.	-	1 - 12 mm	0.9 - 2.5ℓ
Durban Deep	Dec./Jan.	-	1.5 mm	1.0ℓ
Withok	Jan./Feb.	2 mm	7.0 mm	2.5ℓ
Secunda	Feb.	3 mm	0.5 - 4 mm	0.4ℓ
Feb./March	-	2.5 mm	0.4ℓ	
Hendrina	Feb./March	1 mm	2.6 mm	0.5ℓ
Hendrina	May	-	1.5 mm	0.2ℓ
Withok	May	1 mm	4.0 mm	1.0ℓ
Durban Deep	May	-	0.5 - 1 mm	0.5ℓ
Hendrina	June	0.2 m	1 - 2.5 mm	0.4ℓ
July	-	1 - 2.5 mm	0.4ℓ	
Secunda	Aug./Sept.	0.1 mm	0.8 - 3 mm	0. - 1.0ℓ

Table 1: Values of water use by trees and grass from all research sites.

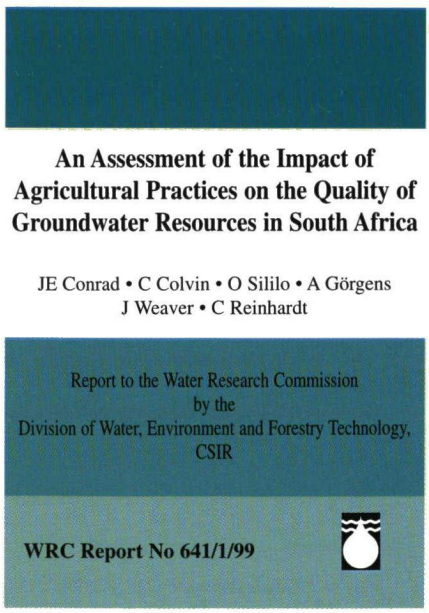
Researchers assess the impact of agricultural practices on SA's groundwater resources

Results are available from a study in which the contribution of five agricultural practices to groundwater contamination was evaluated, namely, intensive animal husbandry, the use of sewage sludge as fertilizer, the use of inorganic fertilizers, irrigation and the use of pesticides. According to the researchers, JE Conrad, C Colvin, O Sililo and J Weaver (all from the Division of Water, Environment and Forestry Technology at the CSIR) in collaboration with A Görgens of the Department of Civil Engineering at the University of Stellenbosch and C Reinhardt of the Department of Plant Production and Soil Science at the University of Pretoria, the contribution each of these practices makes to groundwater contamination in South Africa was evaluated separately, thereby consolidating researchers' knowledge on the impact of agricultural practices on groundwater quality.

The researchers say the agricultural sector has been identified as the largest consumer of groundwater in South Africa. It is estimated that 78 per cent of all groundwater abstracted is used for irrigation, seven per cent for rural domestic purposes and six per cent for stock watering. The remainder is used in the urban environment and for mining.

Traditionally, the urban areas have been the focus of groundwater research and investigation, and, as a result, little is known about the status of groundwater used by the agricultural sector in South Africa, and more significantly, the impact of agricultural practices on groundwater quality.

It is recognised worldwide that the agricultural sector contributes to diffuse contamination. Problems include irrigation practices, animal feedlots and the use of fertilizers, pesticides and herbicides. Point sources of pollution which exacerbate the problem include septic tanks and pit latrines and the disposal of household and agricultural waste products.



Locally, research has been undertaken in specific areas where agricultural activities have had an impact on the quality of groundwater. Areas such as the Springbok Flats, Breede River, Fish River (Middleton) and the Hex River Valley are some examples. On the whole, however, little quantified information is available as to the impact of agricultural practices on groundwater resources and the status of such resources. This lack of information is viewed as an obstacle in the formulation of a groundwater protection policy for South Africa.

In order to investigate the impact of agricultural practices on groundwater quality the Water Research Commission has funded this project at the CSIR's Division of Water, Environment and Forestry with the following aims:

- ❒ To confirm the contamination impact on groundwater quality resulting from those agricultural activities identified as posing the most serious threat;
- ❒ To identify practical and easy-to-implement strategies and practices which can be used to prevent or reduce contamination resulting from agricultural activities; and
- ❒ To prepare a non-technical booklet, which transfers the information to farmers and members of the public associated with the agricultural sector. (To be published early next year.)

MAIN RESULTS

❒ Intensive animal husbandry

An impact on groundwater quality was seen at all the field study sites with vulnerable, shallow, unconfined or semi-confined conditions. Nitrate was the most common agricultural contaminant evident in groundwater sampled. Nitrate

distribution and isotopic analyses of NO_3-N indicated the most important sources to be sludge, manure and soil biota. Elevated dissolved organic carbon levels were associated with sludge application and intensive animal husbandry. Potassium, ortho-phosphate and microbiological indicators of faecal pollution, contaminated groundwater as a result of intensive animal husbandry practices.

❒ Sewage sludge as fertilizer

The greatest impact was seen at a site where sludge was applied to agricultural land. Nitrate levels were elevated to 268 mg/ℓ in the dolomitic aquifer directly beneath the sludge-application area and were persistent to a level of 30 mg/ℓ to a distance of greater than one kilometre. However it should be noted that sludge was applied at this site primarily as a means of disposal and application rates were not tied to crop requirements. There was therefore a long history (fifteen years) of over application. At the other sludge sites, where sludge was used to condition sandy soils, limited increases in nitrate levels were seen. At one site, shallow groundwater (<3 metres below ground level) was contaminated to a maximum of 38 mg/ℓ but this was not persistent with depth. This site also had a long history of application. At the other site, only a 2 mg/ℓ increase in nitrate levels was noted during the first season of application. Cumulative impacts of sludge application therefore appear to be significant. Increased dissolved organic carbon levels 10 - 30 mg/ℓ were seen in shallow groundwater samples at two of the sludge field sites.

Significant impacts on groundwater quality were seen at an intensive animal husbandry site, overlying a shallow alluvial aquifer. Pollution was associated with livestock concentration in pasture and irrigation of effluent. The highest nitrate levels seen at this site were 156 mg/ℓ. Increased levels of dissolved organic carbon, potassium, ortho-phosphate and faecal coliforms were also seen. Another animal feedlot showed some contamination by nitrate and faecal streptococci while a third site showed no contamination as a result of natural aquifer protection and good practices.

❒ Inorganic fertilizers

Limited impacts on groundwater quality were found to be associated with the application of inorganic fertilizers. High nitrate levels (>10 mg/ℓ) were seen at all the fertilised sites. However, the source of this nitrate was not exclusively inorganic fertilizers. Fertilizers are believed to contribute to high nitrate levels but other activities, such as the application of organic fertilizers and deep rip ploughing are also thought to play a significant role.

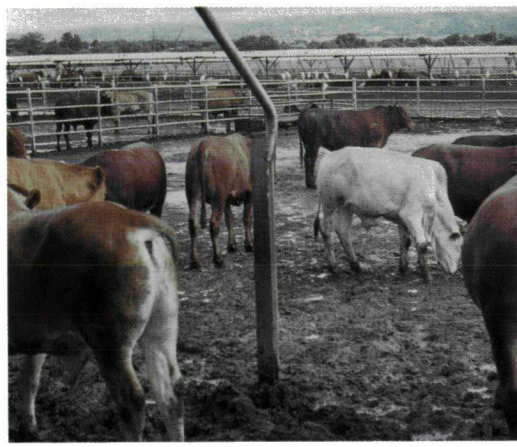
❒ Irrigation

The literature reviewed in the assessment of the impact of irrigation showed that percolates from the root zone and irrigation return flow can cause the salinisation of groundwater in irrigated aquifer systems. Significant salinisation has been reported in groundwater underlying the irrigated lands of the Great Fish Sundays River basin (TDS increased from 2 000 to 3 400 mg/ℓ). At the Vaalharts irrigation scheme it is estimated that between 17 and 63 million cubic metres percolate to the water table annually carrying nearly 30 000 tons of dissolved salts. This has resulted in increased groundwater salinity, a rise in the water table and some water logging of soils.

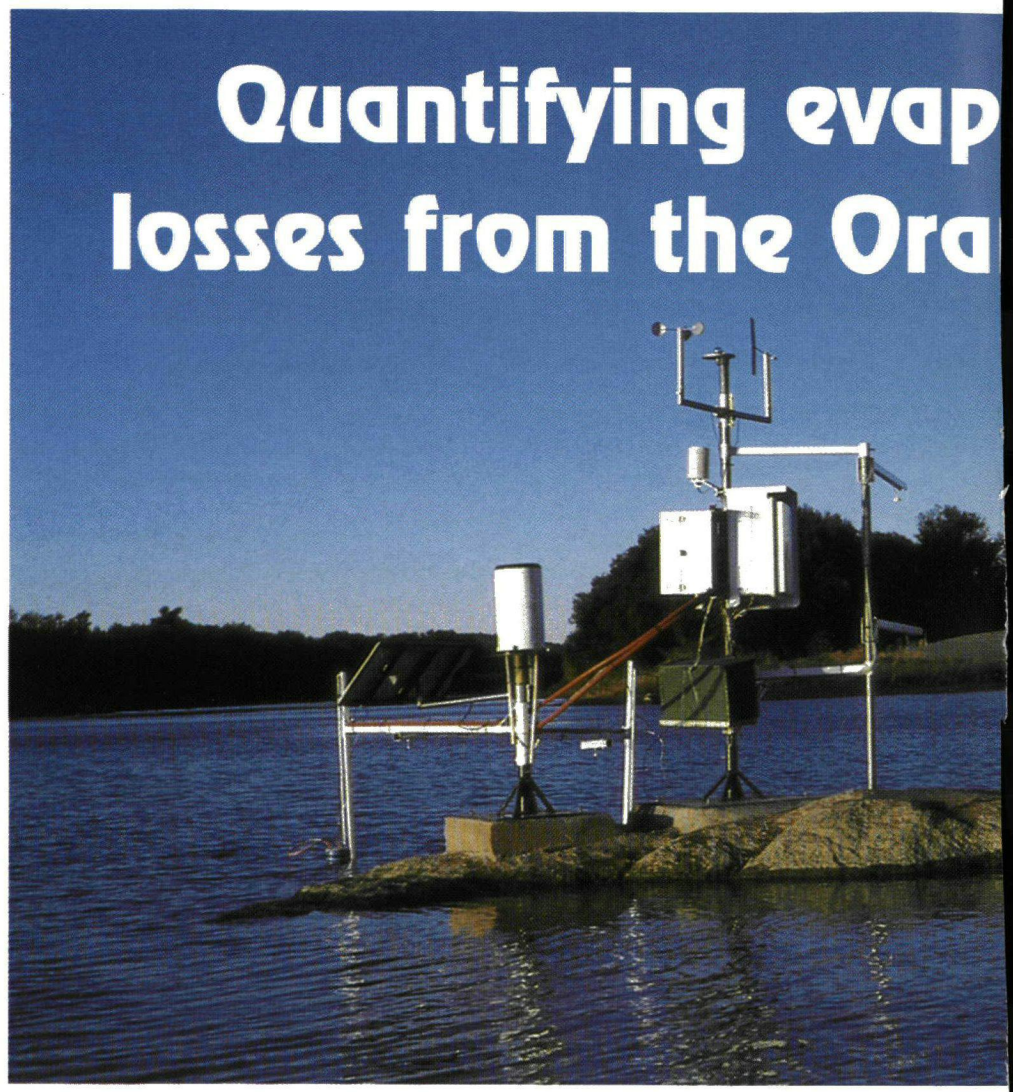
❒ Pesticides

The review of pesticide contamination of groundwater showed that limited, scattered information is available. In the early 1990s, a study showed that the herbicide atrazine was present in most rivers and dams in the maize producing areas of South Africa. These included the Olifants, Vals, Vaal, and Renoster rivers. This river water is used in many areas for irrigation and therefore, where aquifers are recharged, acts as a source of herbicide contamination. Tests of the herbicides methochlor and terbuthylazine have shown that they leach beneath the root zone in a wide variety of South African soils.

Copies of the report entitled **An Assessment of the Impact of Agricultural Practices on the Quality of Groundwater Resources in South Africa** (WRC report 641//1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 35, via surface mail).



Quantifying evap losses from the Ora



The Bowen ratio apparatus sited on a small outcrop in the middle of the Orange River, ten kilo

The Orange River Basin is one of the largest in southern Africa (about one million square kilometers) supporting agriculture, industrial and municipal water demands, as well as hydro-electric power generation at two dams, the Gariep and the Van der Kloof. Although the Orange River currently has sufficient water to meet these demands, there is growing concern that water shortages will be experienced in the river when the Lesotho Highlands Water Scheme becomes fully operational. One of the unknown factors in the water budget is the amount of water lost directly by evaporation losses (the so-called transmission losses). An estimation of evaporation is therefore necessary for practical water management, particularly during low flow periods.

In 1988 a study - the Orange River losses study - was commissioned by the Department of Water Affairs and Forestry to assess the current water resources of the Orange River system. In this study, carried out by the firm BKS, evaporation from the Orange River has been estimated indirectly using A-pan evaporation data. These data, multiplied by the appropriate pan factors, estimate that evaporation losses are very high (more than 800 cubic metres per annum) and therefore had to be verified if confident decisions on water resource allocations were to be made.

Routine estimates of open water evaporation are typically calculated by using simple energy budget methods, such as the Penman equation. These methods generally give good results if suitable meteorological data are available for use in the calculations. One possibility is to use land-based weather stations. However, if conditions at the land surface are different to those above the water, then large errors will occur. Because of these uncertainties, it is desirable to make direct measurements of evaporation over the water to enable the development and testing of suitable calculation methods.

WRC

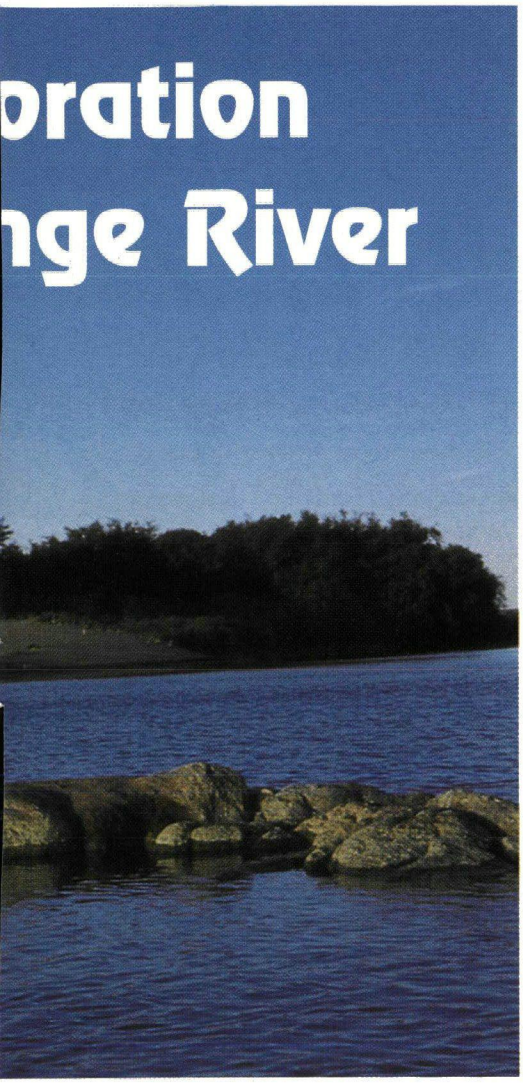
In a study funded by the Water Research Commission (WRC), researcher, CS Everson, from Environmentek at the CSIR in Pietermaritzburg, determined evaporation losses from the Orange River using the energy balance Bowen Ratio technique. A pilot study initiated in 1993, indicated that this technique provided accurate and reliable estimates of evaporation from a flowing water surface.

The study site was located approximately ten kilometres upstream from Upington in the Northern Cape. The Bowen ratio apparatus was sited on a small outcrop in the centre of the Orange River. During winter when the river was at its lowest, the area of exposed rock was approximately five metres long and two metres wide, providing an excellent platform from which to conduct the evaporation measurements. The water was deeper than 2.5 metres around the rock and the shortest distance from the site to each river bank was approximately 110 metres. Access to the study site was only by boat.

RESULTS

According to the final report presented to the Water Research Commission the primary objectives of this project were to determine evaporation rates from the Orange River using the Bowen ratio technique and to relate meteorological variables measured on land (radiation, temperature, vapour pressure deficit, wind speed) to actual evaporation from the river.

The evaporation monitoring using the Bowen ratio technique was successfully accomplished for a continuous period between June and December 1995. Although the intention was to continue until March 1996, the January 1996 floods necessitated the emergency removal of all the equipment from the river. At this point it was felt that sufficient data had been obtained to achieve the objectives of the project and monitoring was discontinued. The Bowen ratio evaporation data collected for the six month period from June to December 1995 were of a high quality and made the comparisons with land

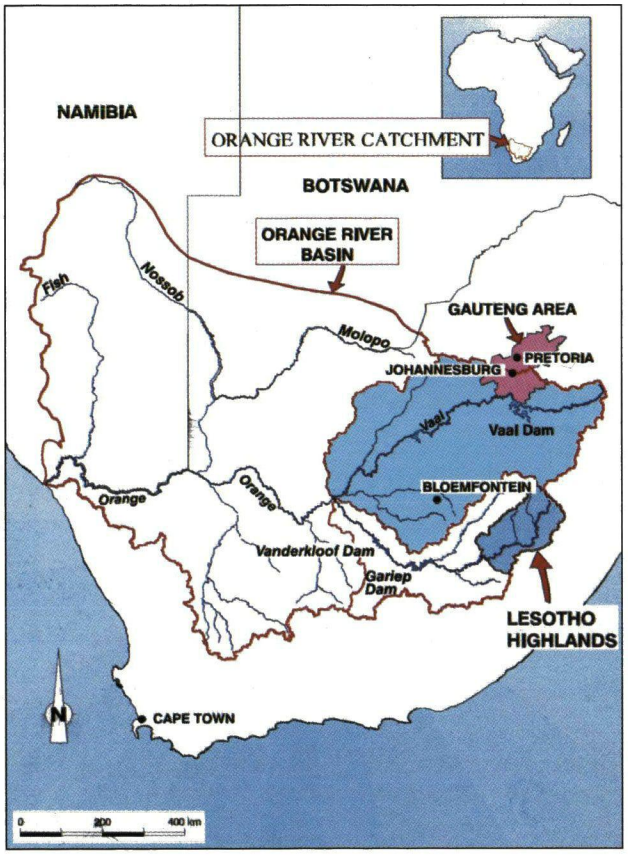


netres upstream from Upington, Northern Cape.

based weather stations easy to achieve. Comparison of the Priestley Taylor equation with direct measurements using the Bowen ratio energy balance approach showed small errors (approximately 3 per cent or 0.2 mm day per day), while the equilibrium evaporation rate underestimated the Bowen ratio seasonal total by 23 per cent. These differences therefore need to be accounted for when estimating river losses in arid environments.

The report says there is a climatic gradient down the Orange River which resulted in an increase in the evaporation by 380 mm over 1 000 km (or 0.3 mm per kilometre). The high annual evaporation measured from the Orange River (2 500 - 2 700 mm) in this study confirms that transmission losses are a major component of the water balance. These evaporation data translate into river losses that vary between 516 and 841 million cubic metres per annum for the low (60 cubic metres per second) and high (400cubic metres per second) flows respectively.

These findings are in agreement with A-pan based estimates of river losses determined by researchers in another WRC funded investigation.



General map of the Oranje River basin. (Courtesy of BKS Inc.)

Land-based A-pan evaporation data was used in a 1988 study to estimate the evaporation losses from the Orange River.

Copies of the final report entitled **Evaporation from the Orange River: Quantifying Open Water Resources** (WRC report 683/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

An assessment of drinking water disinfection at small rural supply schemes

Researchers from the Division of Water , Environment and Forestry Technology at the CSIR visited a number of small water supply schemes to evaluate the disinfection technologies currently in use in developing areas and to determine any problems associated with these systems.

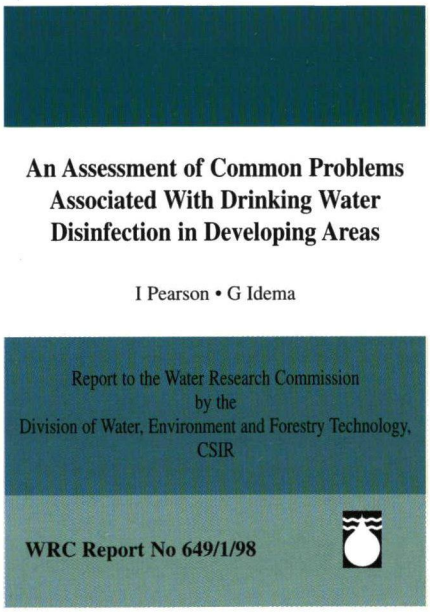
The study originated from an earlier project funded by the Water Research Commission (WRC) on the assessment of alternative disinfection systems for small water supply schemes.

According to the researchers, I Pearson and G Idema, the earlier project had identified and evaluated a number of promising alternative disinfection technologies which could be used to replace conventional chlorine disinfection systems in small, remote water supply schemes.

However, before these alternatives could be promoted, the WRC's project steering committee decided that "the actual situation with respect to the disinfection of small water schemes should first be assessed".

The researchers say the CSIR proposed to undertake a brief study, primarily making use of the long term water and sewage treatment plant monitoring records available at the CSIR. In addition a number of smaller schemes, not monitored as part of a government support programme, were visited and assessed.

Conclusions from the study show that manpower and training deficiencies often play major roles in the failure or rural disinfection systems. "Especially in KwaZulu-Natal, it is alarming to see how many of the small communities and community establishments (hospitals, schools, clinics, etc.) do not adequately disinfect their water treatment facilities."



OBJECTIVES

The main aim of the project was to assess the problems with present disinfection systems in the developing areas, most of which are chlorine based systems. The resulting health implications with respect to intermittent disinfection could be serious, and give rise to severe criticism of local authorities. The sub-aims may be summarised as follows:

- ❒ to establish to what extent drinking water supply systems are chemically disinfected in the rural and developing areas;
- ❒ to assess the efficiency and reliability of the system which have been installed for disinfection, and to identify the common problems;
- ❒ to propose revised design standards for disinfection systems, and to assess the value of alternative disinfection technologies for overcoming some of the problems encountered.

RESULTS

- ❒ In many of the water treatment plants and small water supply schemes existing disinfection practices are unreliable and often not monitored.
- ❒ In a number of systems no chlorination is practised at all. This is usual with borehole and spring water supply schemes, although in a few cases surface water schemes are not chlorinated.
- ❒ Failure of disinfection is essentially not due to technological problems with equipment (although where equipment did fail, the alternative of hand addition of chlorine was practised). The reasons for failure and unreliability of disinfection include:
  - ❍ lack of chlorine chemicals
  - ❍ lack of operator attention
  - ❍ no provision made for chlorine addition
  - ❍ lack of funds for purchasing chlorine
  - ❍ no monitoring of chlorine residual to detect chlorine levels
- ❒ It is very difficult to highlight which of the existing disinfection processes or disinfectant used is superior or inferior in these specific situations. The processes and chemicals in use include:

Place	No of samples tested	Range of Cl_2 residual in mg/ℓ	Range of Faecal coliform/100 mℓ	Problems/Comments
Glenmore	4	0,I - 0,2	0	Functioning well
Middeldrift	4	-	0	Gas chlorination
SADA	16	< <0,1	0 - 2	Only 1 Cl_2, reading: generally good quality
Zwelisha Town	9	<0,1-	-	Gas chlorination turbidity problems
Moantsane	58	> > 1,0	0 - > 1000	FC in ± 40% of samples and no Cl_2 present
Masincedame	21	<0,1 - 0.2	-	Gas chlorination; good quality water supplied
Tyefu	22	-	505 (once) 0	Acceptable water quality
Dubi	6	-	0 - 23	-
Seymore	41	0 - 0,3		Usually no Cl_2 added; HTH used occasionally;
		< < 0,1		no qualified people; chemicals not always available
			0 - 98	Equipment broken, HTH shock dosage occasionally
Upper Mnyameni	19	-	0 - 2	HTH shock dosage only
Upper Gxulu	20		(-) - 0	Irregular HTH dosing; FC tested occasionally:
Phlanduiwazi	52	(-) - <0,1		all were negative.
		(-) - 0,2	0 - 4	Generally poor quality; no Cl_2 dosage
St. Thomas School	24		(-) - 0	Hypochlorite addition not regular
Mpofu	18	0	-	No chlorination
St. Mathews Hospital	48	(-) - < 0,1	> 10 (twice)	Water quality fluctuations
Fish River Sun	57	-	-	-
Katberg Holiday Resort	1	< 0,1 (twice)		

An assesment of conventional drinking water treatment systems as encountered in the Eastern Cape (former Ciskei).

- chlorine gas addition
- dry chlorine addition (HTH) - usually by hand
- liquid chlorine addition (HTH in solution) by drip feed or special dispenser
- slow sand filtration

❒ Probably the most important aspect derived from this study is that the operators controlling the plant do not have the knowledge and understanding of the background of what they are doing, the importance thereof and the possible consequences to the community they are supposed to serve. Proper training is essential.

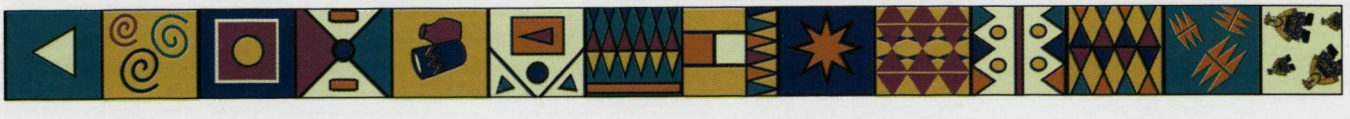
❒ In a number of cases disinfection is practised irregularly. This practise, unless based on scientific data, does not fulfil the purpose of disinfection and is a waste of time, disinfectant and money. It also creates a false sense of safety and peace of mind, whereas the community may be at considerable risk.

❒ In many cases there is a lack of adequate back-up available to operators in terms of consumables, repairs and back-up facilities.

❒ Generally the concentration of the disinfectant is not measured regularly or not at all. This lack of monitoring results in the operators not being aware of the situation of the water being supplied, and not knowing when there may be problems or shortcomings in the disinfection system.

❒ The prime objective of disinfection is to kill harmful micro-organisms which could be present in water. Generally there is no monitoring for such micro-organisms (e.g. faecal coliforms) to determine if the disinfection process is effective or not.

Copies of the final report entitled **An Assessment of Common Problems Associated With Drinking Water Disinfection in Developing Areas** (WRC report 649/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 15,00, via surface mail).



Researchers study novel enzymatic defouling on demand strategy

The Water Research Commission funded a project in which a novel capillary ultrafiltration membrane displaying high flux at low pressure characteristics was developed in a collaborative programme between the Department of Biochemistry and Microbiology at Rhodes University and the Institute for Polymer Science (Stellenbosch University). Besides its application for membrane bioreactors, this membrane offers the potential for small scale water purification in rural communities which do not have access to municipal water purification facilities.

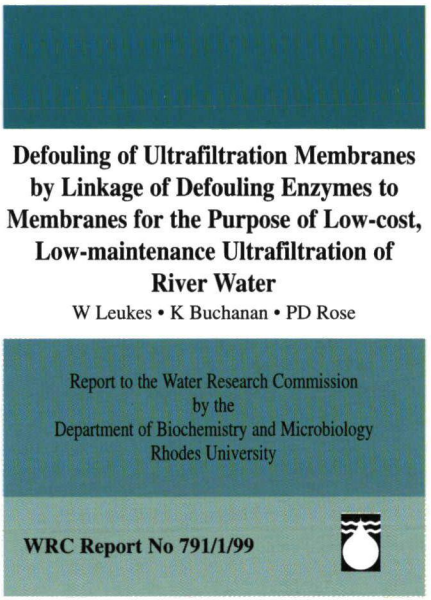
According to the researchers, W Leukes, K Buchanan and PD Rose, a major problem encountered in the use of this membrane, as well as in other pressure driven membrane processes (such as micro-, ultra- and nanofiltration as well as reverse osmosis) is fouling.

The consequences of fouling include the following:

- ❒ High cleaning costs, since large amounts of expensive cleaning agents are often required to restore the flux of fouled membranes.
- ❒ Harsh chemical cleaning agents damage the membrane leading to significantly shortened membrane life, and the cost of membrane replacement is often prohibitive.
- ❒ Lower-than-expected flux. This is often taken into account when plants are designed to handle a specific volume of liquid by increasing the membrane surface area. This incurs a significant cost.
- ❒ Reduced productivity due to down-time required for cleaning of fouled membranes.

SELF-CLEANING

In low-cost rural water purification, complex and highly engineered cleaning cannot be implemented due to the lack of skill and resources. The same applies to certain industrial environments. A need therefore exists for the development of self-cleaning membrane filtration systems. Such systems would involve the attachment of biodegradative enzymes to the active layer of membranes so that they may degrade the forming gel layer. The "self-cleaning" membranes generated in this way would have the following advantages over conventional cleaning regimes:



- ❒ No flux decline would be encountered since a gel layer is never allowed to form. This leads to higher efficiency of filtration plants. Therefore, lower membrane surface area would be required to handle the same volume, which would reduce the cost of setting up the plant.
- ❒ No down-time is needed for cleaning, which means that the membrane plant can be operated continuously, resulting in much better plant productivity.
- ❒ No harsh chemical cleaning agents would be required, which will lead to extended life expectancy of the membranes. The cost of membrane replacement would therefore also be reduced.
- ❒ The cost of expensive cleaning chemicals and enzymes would be avoided. The initial cost of the enzymes to be attached would be similar to that of a single enzymatic cleaning cycle. Because the enzymes are attached to the membrane, they can be re-used continuously without the added cost of recovery. Enzymes will be used that do not require frequent replacement.

RESULTS

In this project, enzymes capable of the transformation of humic substances, but which are inactive during the operation of the ultrafiltration process, were immobilised on the surface of the membranes. After normal fouling of the membranes which took place over time, it was shown that the fouling layer could be removed by activating the enzyme at will of the operator, using an oxidising activator. The enzymes manganese peroxidase and horseradish peroxidase showed the best results. Activating agents found to work best to activate these two enzymes were the manganous ion and hydrogen peroxide respectively.

Flux improvements over those of the control experiments of 20 per cent were achieved immediately after activation, and flux declined significantly slower over the longer term compared to the controls. Colour photographs of the membrane surfaces showed these improvements clearly.

Copies of the report entitled **Defouling of Ultrafiltration Membranes by Linkage of Defouling Enzymes to Membranes for the Purpose of Low-cost, Low-maintenance Ultrafiltration of River Water** (WRC report 791/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$15,00, via surface mail).

CCWR: strategic for integrated water research and management

The Computing Centre for Water Research (CCWR) which was established jointly by the Water Research Commission (WRC), IBM South Africa and the University of Natal in 1986, has been supported by the WRC since that time. The WRC views the CCWR as a strategic initiative to support the four key elements of the WRC's overall strategy, namely:

- ❒ to promote co-ordination, communication and co-operation in the field of water research
- ❒ to establish water research needs and priorities
- ❒ to fund water research on a priority basis
- ❒ to promote effective transfer of information and technological knowledge.

These strategic actions provide considerable support for the basic thrust of the new Water Law namely efficient, equitable and ecologically sound management of South Africa's water resources. Integrated water resources management is one of the key principles of the new Water Law. The WRC's continued support for the CCWR is testimony to its commitment to promote integrated water science as an essential foundation for integrated water resources management.

South Africa has a number of world class water scientists and supporting groups in water research. However, they are separated geographically, organisationally and in terms of their various disciplines. This separation has both advantages and disadvantages because these experts need to specialise and at the same time they also need to integrate their highly complex, multi-faceted and interdependent fields of water science. The CCWR's activities are one of the many actions which the WRC supports in order to creatively and cost effectively minimise the disadvantages and maximise the advantages of the geographic separation of our limited scientific intellect. The incredible growth in wide area computer networking technology has enabled the WRC to create a virtual centre, in the CCWR, where intellect from throughout southern Africa and indeed the world can interact to co-create new perspectives which in turn lead to more effective actions in the equitable and sustainable use of our water resources.

Effective actions are certainly required in the management of water issues in southern Africa. Seventy percent of the land area in the Southern African Development Community (SADC) comprises shared river basins. Therefore there is a need to broaden participation and thereby democratise the process of integrated water resources management for sustainable water resources development. Such participation and integrated management is fundamental to peaceful, holistic and equitable progress in southern Africa, a region traditionally racked with conflict and riven with inequalities which exacerbate the already complex situation surrounding the sustainable development of scarce water resources.

The region has come through the era's of "getting more water" and "using water more efficiently" and these issues are still important. However, we have now entered the "era of allocation" and allocation is a social process. The WRC's foresight in developing the CCWR is now really beginning to pay-off as communication, transparency, trust and relationships begin to be vital in underpinning the drive for equity and the smooth implementation of the new water law, particularly with regard to processes aimed at the upliftment of previously disadvantaged communities.

The CCWR's small staff of 6 professionals serves the on-line, medium and long term needs of more than 300 registered users who are based at no fewer than 103 departments within 68 institutions. In addition to the service role implied above the CCWR is also partnering several innovative and highly relevant endeavours to serve future Catchment Management Agencies and stakeholder groupings with systems software.

SANC IAHS

Southern African FRIEND programme - an update

The Southern African FRIEND (Flow Regimes from International, Experimental and Network Data) project was initiated in 1993 as a regional contribution to the UNESCO supported International FRIEND programme. The first phase of the Southern African FRIEND project culminated in the production of the final report (UNESCO IHP V, Technical Documents in Hydrology, No. 15) and a one day conference held at the University of Dar es Salaam (UDSM), Tanzania during July 1998. The second phase was launched immediately after the conference at the fourth Steering Committee meeting, but it was not until September 1999, at the next Steering Committee meeting held in Windhoek, Namibia, that clarity was obtained on the objectives of the second phase. Five themes were identified and implementation plans proposed :

- Drought assessment and climate variability, to be coordinated by the Institute of Hydrology (IH) in the UK and closely linked with the ARIDA project.
- Sediment transport, to be coordinated by UDSM.
- Water Resources assessment and streamflow modelling, to be coordinated by the Institute for Water Research (IWR) at Rhodes University.
- Water balance of Lakes, to be coordinated by UDSM.
- Internet communication to be improved through the UDSM website.

The research carried out under the first phase was funded by the Department for International Development (DFID) in the UK (support for the Institute of Hydrology and the University of Dar es Salaam), the Irish Government (support for the University of Dar es Salaam) and the Water Research Commission (support for the Institute for Water Research, Rhodes University). IH is currently in the process of seeking further funds from DFID to contribute to both the drought assessment and water resource assessment themes, while the WRC has accepted a proposal by the IWR and others to develop a 'Terms of Reference' during 2000 for a long term study of the water resources of the whole of the SADC region. This project will also address the Mobilisation Phase and Phase I (scope, design and finance) of the SADC Water Sector Round Table Priority Project on Integrated Water Resources Development and Management, PCN14 (Assessment of Surface Water Resources). The final group that will contribute to the terms of reference has yet to be decided but will certainly involve several South African groups who have been involved in similar studies (such as the successful WR90 project), the Institute of Hydrology, as well as representatives of the SADC Water Sector and the SA FRIEND Steering Committee. The aim is to develop a detailed proposal to carry out a surface water resource survey of the SADC region which will probably extend over a period of 10 years, cost up to £10 million and involve a multi-national and multi-disciplinary research team. Clearly, strong international support for such an ambitious project will be required.

CONFERENCE

Amongst the items raised at the Windhoek Steering Committee meeting was the organisation of the next FRIEND International Conference, at which all the regional FRIEND groups will come together and present their research results. The last one was held in Slovenia during 1997, while the FRIEND Inter-Group Coordination Committee (FIGCC) has decided to accept the offer by the IWR (on behalf of the Southern African group) to host the next conference in Cape Town from 18-22 March 2002. The local organising committee is made up of Prof. Denis Hughes and Mrs Juanita McLean (IWR), Prof. Andre Görgens and Mrs Julie Haarhoff (Stellenbosch University), as well as Mr Hugo Maaren (WRC). The theme of the conference will be 'Bridging the Gap between Research and Practice' and the first circular is expected to be distributed during April 2000.

Welcome to IAMSLIC !

Martha Pretorius, senior information specialist at the Water Research Commission, recently attended the annual conference of the International Association of Aquatic and Marine Science Libraries and Information Centers (IAMSLIC), and was elected as secretary for the organisation. This appointment is for a two year period from 1999-2001.

The 25th Annual IAMSLIC Conference was held in Woods Hole, Massachusetts, USA from 16-22 October 1999. The main focus of the conference programme always falls on aquatic information management, but also include presentations of a purely scientific nature. The topics addressed by keynote speakers from the Massachusetts Institute of Technology, the Marine Biological Laboratory, Scripps Institution of Oceanography, etc. at this year's conference included:

- The use of marine organisms in biomedical research
- Society's impact on coastal ecosystems: problems and solutions
- Trends in aquatic science research
- The history of cod fishing, etc.

Field trips included a memorable visit to the Museum of Comparative Zoology (MCZ) at Harvard University, says Martha Pretorius. The Museum has one of the best collections of biological specimens in the world: 80 000 mammals, 1 million fish, 7 million insects, and 10 million mollusc specimens. It also houses the Blaschka Glass Flower Collection. These life-size models include over 3000 models of 847 plant species, with remarkably accurate anatomical sections and enlarged flower parts and were created by the glass artisans Leopold and Rudolph Blaschka in Dresden, Germany. The commission began in 1886 and continued for five decades.

IAMSLIC

IAMSLIC is an international organisation of individuals and institutions involved with aquatic science information, which was begun in 1975 in Woods Hole, Massachusetts, USA. Presently IAMSLIC numbers just over 300 members with one third of the membership outside the USA and Canada. IAMSLIC, by virtue of its clearly defined focus, offers a unique opportunity to meet librarians and others interested in aquatic science information from all over the world in a professional context encouraging ongoing, close cooperation. IAMSLIC's purpose is to promote such cooperation and sharing of resources among libraries and information centres which specialise in any aspect of aquatic science - freshwater, brackish and marine. It is a formal non-profit organization providing an annual conference, continuing education workshops, a regular newsletter, membership directory, electronic mail conferencing, and special projects. Individuals representing all types and sizes of libraries and information centres participate, including marine and freshwater research and policy institutions, government agencies, colleges, universities, non-profit and for-profit organizations.

INTERNET DISCUSSION GROUP

IAMSLIC hosts an e-mail list server with more than 300 participants. Messages are posted to the address IAMSLIC@UCSD.EDU. Anyone may monitor and post messages to this group, including non-IAMSLIC members. Through this discussion group, IAMSLIC facilitates communication and sharing in the aquatic science information community and beyond IAMSLIC's membership.

MEMBERSHIP

Interested individuals or organisations are invited to join IAMSLIC. The organisation has a long history of cooperation with kindred international organisations and provides ample opportunities for international cooperation. The only requirement for membership is an interest in library and information science as it is applied to aquatic science. Membership is on an annual basis, from 1 October - 30 September.

For individuals and institutions in the "developed world", annual membership subscriptions are $35.00 (USA). For developing countries, membership fees are $20.00 (USA) per year and include voting privileges, membership directory, and a subscription to the newsletter.

IAMSLIC provides a "twinning" program of three year trial memberships to the organisation. There is no cost to the requesting institution, which must be from a developing country. However, the availability of twinships are very limited.

ENQUIRIES

Martha Pretorius
Tel. (012) 330 0340
Fax (012) 331 2565
E-mail: mpretorius@wrc.org.za
IAMSLIC web address:
http://siolibrary.ucsd.edu/iamslic/

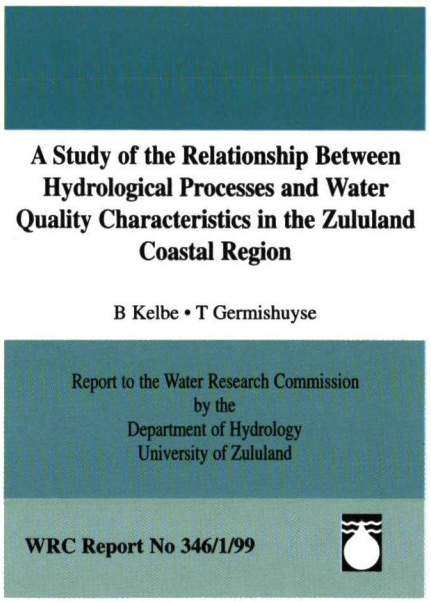
Hydrological processes and water quality characteristics

In many countries the rainfall and surface water resources have declined in quality to the extent that there is serious concern at all levels of management about the viability and sustainability of environmental systems. In South Africa, and particularly in the province of KwaZulu-Natal, the scarce freshwater resources are under extreme pressure to sustain a rapidly growing industrial and agricultural society that contributes to the problem of declining water quality in an ever increasing cycle. This is said in a report to the Water Research Commission (WRC) emanating from a research project on the relationship between selected water quality characteristics and specific hydrological processes in the Zululand coastal region. The research was carried out by two researchers from the Department of Hydrology at the University of Zululand, B Kelbe and T Germishuyse.

The main aim of the project was:

- To determine the relationship between water quality characteristics and hydrological processes for different rainfall types and antecedent conditions, and
- To develop a continuous monitoring system for selected water quality factors.

The study sites chosen were part of the paired and nested research catchments of the University of Zululand, situated in the Ngoye hills near the Empangeni and Richards Bay metropolitan areas.
The catchments are representative of a large proportion of the Natal Coastal Region and also of the Natal midlands. These regions are experiencing rapidly increasing pressure from the informal settlement and agricultural development and preliminary investigations of the water quality for selected run-off events show characteristics that may be linked to hydrological processes. An understanding of this relationship is important for future management of the water environment in this relatively water-rich region.



MONITORING

Previous studies of the hydrological response to land use changes in these catchments identified the need for high temporal resolution monitoring to achieve an understanding of the relationship between water quality characteristics and specific hydrological processes. A monitoring system was developed to measure specific water quality characteristics on a continuous basis. The physical and chemical characteristics included the rainfall rate, the stream discharge rate, electrical conductivity, pH, turbidity and temperature. The monitoring system was also developed to activate an automatic water sampler and to record the physical and chemical conditions of the system at the time of sampling.

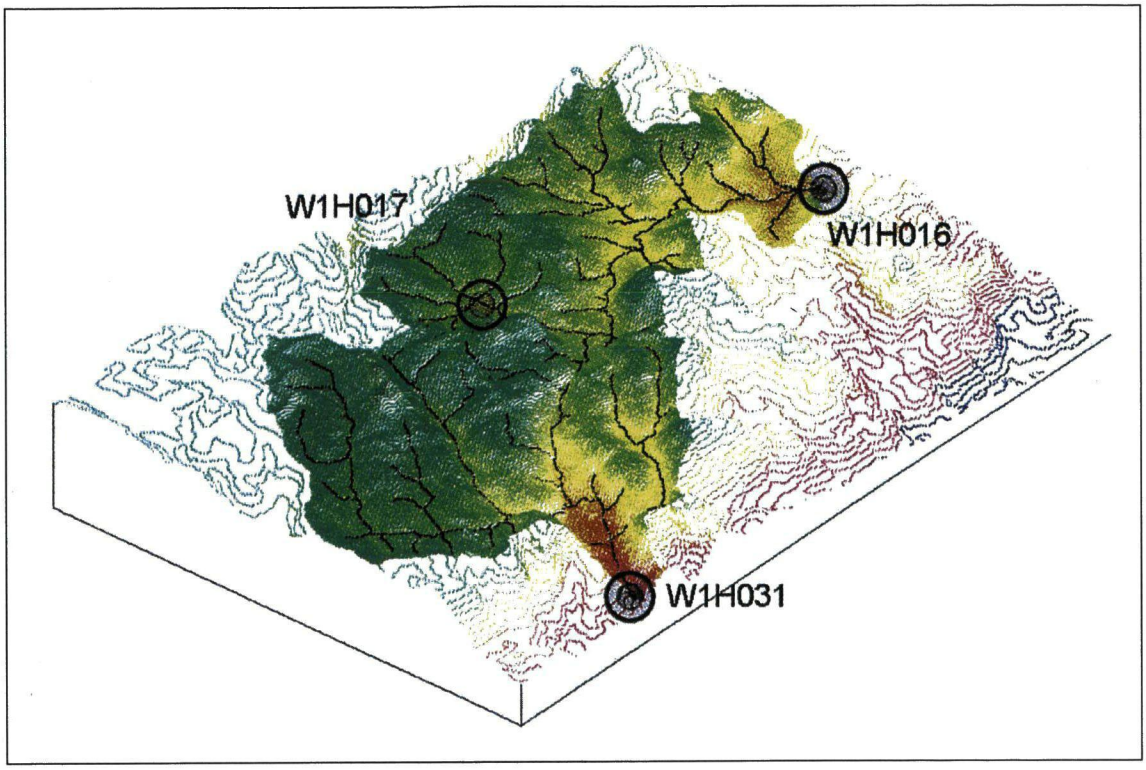
The researchers say the two catchments received very similar rainfall quantities and distribution during the study period but had significant differences in their discharge characteristics which resulted in different export loads of various substances. The export loads that were examined, indicated that the difference between the estimated loads were very dependent on the estimation techniques used in calculating the export loads.

The researchers say the individual storms have a major impact on the export loads of nutrients and sediment from the catchments and consequently selected storm analyses are presented in great detail in the report. These cover the main hydrological flow-paths that are likely to affect the selected water quality characteristics. The storms selected are those associated with short duration high intensity rainfall events that are assumed to produce runoff that can be associated with both surface and sub-surface flow-paths.

RESULTS

The study focussed on the comparison of two neighbouring catchments of equal size and natural conditions of soil, slope and rainfall. However, the one catchment remained rather undisturbed because of the domination by the Ngoye Nature Reserve. The other catchment is characterised by increasing population and dry-land agriculture (such as small scale sugar cane farming). The analysis of impact differences was limited to clearly identifiable rainfall and runoff events.

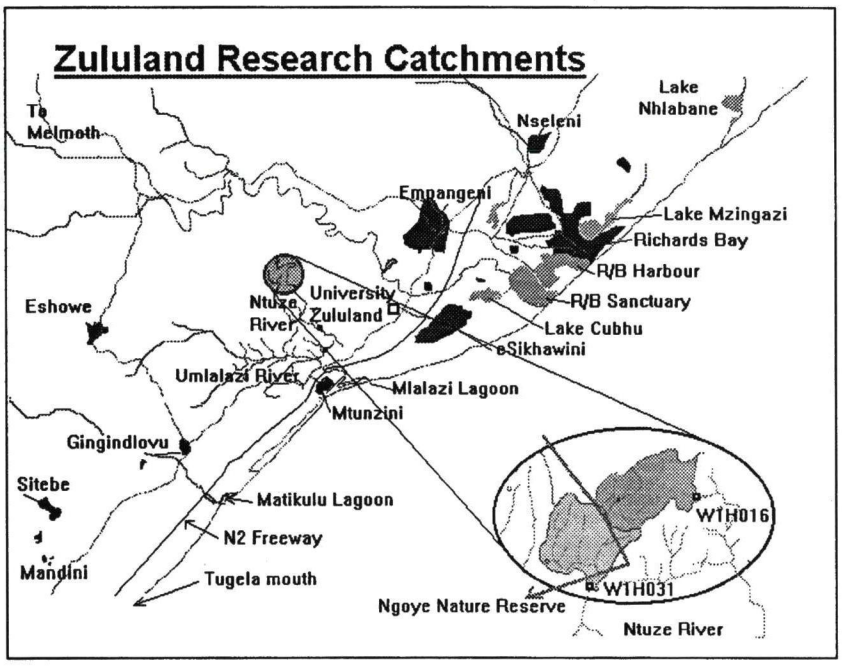
The researchers say the first three years of the project were hit by a severe



3-D view of the research catchments topography, streams and location of weirs.

drought in the region. For the first time in fifteen years of monitoring the rivers in the region dried up intermittently for a period of two years. This has been the main reason for the long time it took to obtain meaningful results (29 events) and to finalise this project.

The most consistent observation during a storm event was the immediate drop in electrical conductivity with the onset of the flow which is assumed to indicate a dilution effect on the total dissolved salts in the system. Many of the storm events showed the nitrate concentration rising with the discharge followed by a similar recession assumed to indicate an association with new rainfall and surface flow. However, in some cases the nitrate peak lagged several hours behind the flow peak, indicating that in some cases this is associated with older water or sub-surface flow. Sediment delivery from the two catchments was not consistently different which was somewhat of a surprise.

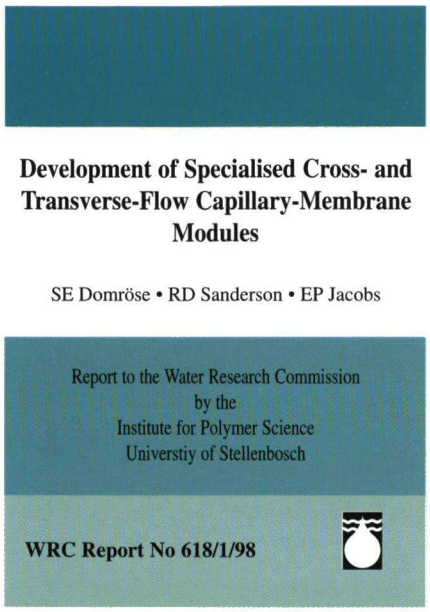


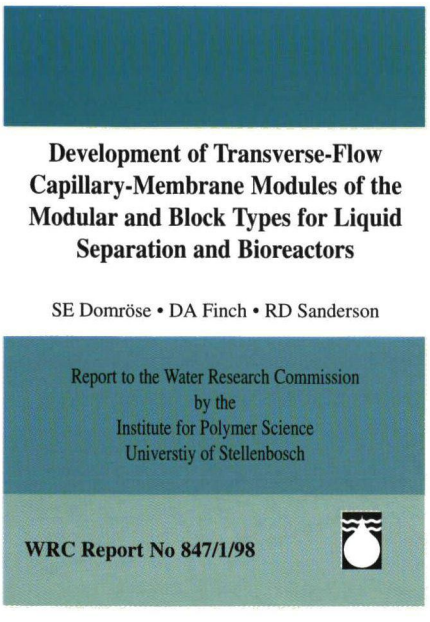
Location of the Ntuze Research Catchments at the University of Zululand.

The results confirm that conditions in a given stretch of river during a storm event can be very site specific and variable depending on the spatial and temporal characteristics of the rainfall event. The precise connectivity between certain source areas of pollutants and the river can play a major role and leads to a need to map such land uses rather accurately if water quality is a sensitive issue in that river.

Copies of the full report entitled **A Study of the Relationship Between Hydrological Processes and Water Quality Characteristics in the Zululand Coastal Region** (WRC report 346/1/99) are availalble free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25,00 - via surface mail).

Development of specialised transverse-flow membrane modules





Transverse-flow membrane modules are required for many research, laboratory, commercial and industrial applications. The reason for this is their higher mass-transfer coefficient (higher than the axial modules), modular design, individual stacking freedom and future possible uses as bioreactors. According to researchers from the Institute for Polymer Science at the University of Stellenbosch excellent progress has been made to date in the development of new transverse-flow membrane modules. This module is small in size, very adaptable and therefore easy to transport, install and operate. These factors make it accessible to institutions, training centres, technicons and universities for collaborative research efforts.

The researchers, SE Domröse, RD Sanderson, EP Jacobs and DA Finch, say there are currently numerous possible ways envisaged in which a module can be used.

"It is, however, only by pilot plant studies that the feasibility of the various possibilities can be explored. At present we only have feedback on the successful applications of the laboratory-type module in the laboratories of Rhodes and Stellenbosch universities."

The researchers say the working principles of the modules could be summarised as follows:

- A liquid feed stream enters the module through one of the feed channels. The permeate and concentrate are kept separate in case of internally-skinned capillary membranes, while in the case of externally-skinned membranes, the feed would enter through a main inlet port and the concentrate would exit from one of four secondary feed channels.
- As the liquid feed stream enters the module, a gas or secondary feed can be added to the feed stream or stripped from the feed stream, resulting, for instance, in a gas-enriched or gas-stripped liquid product.
- The module is capable of being used as a bio-reactor.
- Finally, the module could be used in any combination of the previous three configurations, either by feeding from the top or from the bottom, depending on the application.

For the successful application of the transverse-flow membrane modules, the researchers say it is essential that complete and reliable sealing between the various channels in the module and also of the module itself as a unit, is achieved.

To this end the Water Research Commission funded two projects at the University of Stellenbosch for the design and development of a transverse-flow capillary membrane module housing more than ten capillaries per template, built in a modular system consisting of stacks several layers high.

The researchers say emphasis was placed on designing a reliable robust and chemically-resistant module, suitable for mass production in a modular system.

"Scope for freedom of stacking, use of various capillary membrane types, the number of layers in a stack and the number of stacks or blocks in a module is required. It should be possible to

make a choice of internal or externally-skinned capillaries. Careful attention to detail had to be given to the locating, anchoring, support and protection of the membranes. The materials to be used in the construction of the module must fulfil the functional aspects of the module - these include being sterilizable and capable of meeting the manufacturing requirements."

MAIN RESULTS

- A locating spacer frame, which fully locates and encloses the capillaries, has been successfully designed. This spacer frame prevents encapsulating material blocking capillary membrane surface areas, and also provides a support lattice which counteracts the forces generated by the product feed stream.
- The module was designed in such a way as to ensure hydraulic sealing of all the flow channels.
- The designs of the inlet and outlet manifolds were such that they ensured that the feed did not dislodge or damage the membranes. The feed was distributed over the entire membrane area.
- A modular model was designed in such a way which made possible the successful incorporation of an infinite number of geometrical and application combinations.
- A manufacturing method was established which included the bonding of a spacer frame and encapsulation with silicon rubbers of different shore (A) hardnesses, viscosities and densities. This has never before been achieved in the silicone field.
- A low-cost silicon-rubber casting plunger-type mould was developed for the spacer locating frame. This is suitable for Cottage Industries as no electricity is required and the clamping forces are generated by a number of tightening bolts. The cost of this mould is only one tenth of that of a conventional multi-gate, hot-runner, core-pulling mould.
- A reliable and novel encapsulation method was developed which prevents leakage between the templates. The overhanging transverse frames, once encapsulated, are interlocked into a tight structure. This is because the silicon rubber is able to be dispersed between the overhanging layers of the templates and not only on the outsides. This provides more available surface area for bonding and produces a stronger structure.
- Modules were developed which are chemically resistant to many solvents, as silicon resin is used. This makes them suitable for use in food and drug applications and the purification of harsh effluents and liquids.
- Industrial-size transverse-flow capillary membrane modules of membrane areas 17 m^2 and 24 m^2, of 1 m height, consisting of 333 template layers in the cases of the internally and externally skinned capillaries, were developed. Furthermore, these individual modules can be connected in series of parallel arrangements to form large units of 100 m^2 of membrane area or more.
- The very large modules with 200 capillary membranes per layer, 333 layers high (1 meter high) would have surface areas of 186 m^2 and 250 m^2 for internally and externally skinned membranes respectively, but can nevertheless be constructed using the same methods as those used for the present model.
- The silicon rubber spacer frames and the cured encapsulation resin were engineered to be used in temperature applications in excess of 200°C.

Copies of the two reports describing the research project and summarising the results are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. The reports are **Development of Specialised Cross- and Transverse-Flow Capillary-Membrane Modules** (WRC report 618/1/98) (Overseas price: US$ 20) and the **Development of Transverse-Flow Capillary-Membrane Modules of the Modular and Block Types for Liquid Separation and Bioreactors** (WRC report 847/1/98) (Overseas price: US$ 20, via surface mail).

SA WATERKALENDER

The Water Research Commission is placing this calender in order to assist with the co-ordinating of water events in South Africa.

You are invited to send information about conferences, symposia or workshops to the SA Waterbulletin.

Address:
The Editor,
SA Waterbulletin,
P.O. Box 824,
0001 Pretoria
Tel (012) 330-0340
Fax (012) 331-2565

Legend:
- ❍ An SA Water Event arranged for these dates.
- ❑ 2nd SA Water Event scheduled for these dates.
- × 3rd SA Water Event scheduled for these dates.

See conferences and symposia pages for events.

2000

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Die Waternavorsingskommissie plaas hierdie kalender om te help met die koördinering van watergebeurtenisse in Suid-Afrika.

Alle belanghebbendes word uitgenooi om inligting aan SA Waterbulletin te stuur.

Adres:
Die Redakteur
Posbus 824
0001 Pretoria
Tel: (012) 330-0340
Fax: (012) 331-2565

Gids:
- ❍ Een SA Watergeleentheid vir hierdie dae.
- ❑ 'n Tweede SA Watergeleentheid vir dié datums.
- × 'n Derde SA Watergeleentheid vir dié datums.

Sien Konferensies- en Simposiumbladsy vir aangeduide geleenthede.

2001

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SOUTHERN AFRICA

2000

IAWQ/IWSA
FEBRUARY 16 - 18
A joint specialised conference on particle removal from dams and reservoirs will be held in Durban.
Enquiries: Mr D Nozaic, Umgeni Water, PO Box 9, Pietermaritzburg 3200. Tel: (033) 341 1111. Fax: (033) 341 1084.

WATER SUPPLY & SANITATION
FEBRUARY 21 - 25
The 10th UADE/UAWS congress with the theme "Partnerships and sustainable development in the water supply and sanitation sector" will be held in Durban.
Enquiries: UAWS Administrative Secretary, 01 BP 1843 Abidjan, Cote d'Ivoire. Tel: +225 241443. Fax: +225 242629. E-mail: uadewup@africaonline.co.ci (or in South Africa - e-mail address: ci@dbn.lia.net Tel: (031)-303 5875. Fax: (031)-312 3494.

WATER WEEK
MARCH 20 - 26
The South African Water Week will be held throughout the country during the third week of March 2000.
Enquiries: Department of Water Affairs and Forestry, Communication Services Division, Private Bag X313, Pretoria 0001. Tel (012) 336-7500. Fax: (012) 324-6592.

CEMSA 2000
MARCH 27 - 29
The 2nd international conference and exhibition on integrated environmental management in South Africa will be held in East London.
Enquiries: Creative Public Relations, PO Box 18227 Quigney, East London 5211. Tel: 0431 437267. Fax: 0431 26914.

GEOCHEMISTRY
APRIL 24 - 29
The 5th international symposium on environmental geochemistry will be held in Cape Town
Enquiries: Ms Jodi Fyfe, Postgraduate Conference Division, UCT Medical School, Anzio Road, Observatory 7925. Tel:(021) 406 6407. Fax: (021) 448-6263. E-mail address: jfyfe@medicine.uct.ac.za

WATER & WASTE
MAY 23 - 26
A specialist conference on managing water and waste in the new millennium - the challenges for developing areas - will be held in Midrand.
Enquiries: Roelien-M Bakker, IWA Conference, PO Box 6011, Halfway House 1685. Tel: (011) 805-6368. Fax: (011) 315-1258. E-mail: conference@wisa.co.za

WISA
MAY 28 - JUNE 1
The Water Institute of Southern Africa (WISA) will hold its biennial conference and exhibition at Sun City.
Enquiries: Roelien-M Bakker, WISA, PO Box 6011, Halfway House 1685. Tel: (011) 805 6368. Fax: (011) 315 1258. E-mail: conference@wisa.co.za

WATER RESOURCES
JUNE 7 - 9
The 4th biennial congress of the African division of the International Association of Hydraulic Research (IAHR) on conserving and sharing water resources in a water scarce environment will be held in Windhoek, Namibia.
Enquiries: Congress Secretariat, Ms Marelise Serfontein, PO Box 9870, Windhoek, Namibia.
Tel: +264-61-251014/272031/ 254281.
Fax: +264-61-272032/ 251014.
E-mail: namlink@iwwn.com.na

IRRIGATION
OCTOBER 22 - 27
The 6th international micro-irrigation congress together with the 51st IEC meeting of the International Commission on Irrigation and Drainage (ICID) will be held in Cape Town..
Enquiries: The Congress Secretariat, PO Box 36815, Menlo Park 0102. Tel: (012) 344 0390. Fax: (012) 344 5643.
E-mail address: reservations@parkgables.co.za.

AGROCHEMICALS
OCTOBER 25 - 26
A workshop on the control of adverse impacts of fertilizers and agrochemicals will take place in Cape Town, South Africa.
Enquiries: Prof A Mermoud, Institute of Soil and Water Management (IATE), Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland. Tel: +41-21-693-3726. Fax: +41-21-693-3739. E-mail address: andre.mermoud@epfl.ch

HYDROGEOLOGY
NOVEMBER 26 - DECEMBER 1
The International Association of Hydrogeologists' (IAH) XXX Congress 2000 with the theme Groundwater: Past achievements and Future challenges will be held at the University of Cape Town.
Enquiries: Conference Secretariat, IAH 2000, Conferences et al, PO Box 452, Stellenbosch 7599. Tel: (021) 886-4496. Fax: (021) 883-8177. E-mail address: deidre@iafrica.com. Web adress: http://fred.csir.co.za/conferences/iah/

OVERSEAS

2000

DIFFUSE POLLUTION
JANUARY 16 - 20
The 4th international conference on diffuse pollution will be held in Bangkok, Thailand.
Enquiries: Ms Nitayaporn Tonmanee, Department of Land Development, Phaholoyothin Road, Chatuchak, Bangkok 10900, Thailand. E-mail: ldd@mozart.inet.co.th Tel: +662 579 0111. Fax: +662 562 0732. Web: http://www.ldd.go.th/iawq

AWWA/WEF
JANUARY 30 - FEBRUARY 2
An AWWA/WEF conference on water reuse will be held in San Antonio, TX, USA.
Enquiries: Susan Miller, AWWA, USA. E-mail: smiller@awwa.org Tel:+303-3476181. Web address: http://www.awwa.org/tande/awwaconf.htm

IRRIGATION SYSTEMS
FEBRUARY 8 - 10
An international conference on micro and sprinkler irrigation systems will be held in Jalgoan, India. Enquiries: CVJ Varma, Central Board of Irrigation, Malcha Marg, Chanakyapuri, New Delhi 110021, India. Tel: 91-11611-5984/611-6567. Fax: 91-11611-6347. E-mail: cbip@nda.vsnl.net.in. Website: www.cbip. org

NATURAL RESOURCES
FEBRUARY 14 - 18
An international conference on managing natural resources for sustainable agricultural production in the 21st century will be held in New Delhi, India. Call for papers.
Enquiries: Dr AK Singh, Secretary-General, Indian Society of Soil Science, Indian Agricultural Research Institute, New Delhi-110 012, India. Tel: 91-11-5731494. E-mail address: icmnr@bic-iari.ren.nic.in Fax: 91-11-5755529. Internet site: http://www.nic.in/icar/nrm

WATER
MARCH 11 - 17
The 10th world water congress is to be held at the Melbourne Convention Centre, Melbourne, Australia.
Enquiries: Lisa McNaught, ICMS Pty Ltd, 84 Queensbridge Street, Southbank, Victoria, Australia 3006. Tel: +61 3 9682 0244. Fax: +61 3 9682 0288. E-mail address: worldwater@icms.com.au

WATER FORUM
MARCH 17 - 22
The second world water forum and ministerial conference will be held in the Hague, the Netherlands.
Enquiries: E-mail address: secretariat@worldwaterforum.org Fax: +31 70348 6792.

GLOBAL RESOURCES
MARCH 19 - 23
Water 2000 conference and expo with the theme - Guarding the global resources - will be held in Auckland, New Zealand.
Enquiries: E-mail address: water@nzwwa.org.za Tel: +64 9636 3636. Fax: +64 9636 1234. Web: http://www.nzwwa.org.nz/w2000.htm

REMOTE SENSING
APRIL 3 - 7
A symposium titled Remote Sensing 2000 will be held in Santa Fe, NM, USA.
Enquiries: Dr Jerry C Ritchie, Hydrology Laboratory, Room 104, Building 007, USDA/ARS/BARC-West, Beltsville, Maryland 20705-2350, USA. E-mail: jritchie@hydrolab.arsusda.gov Tel: +301 5047490. Fax: +301 5048931.

METEOROLOGY
APRIL 3 - 7
The 6th international conference on southern hemisphere meteorology and oceanography will be held in Santiago, Chile.
Enquiries: Patricio Aceituno, University of Chile, Casilla 2777,

Santiago, 6511227, Chile.
E-mail: aceituno@shmo.chile 2000.cl

WASTEWATER
APRIL 4 - 7
A CIWEM millennium conference - wastewater treatment: standards and technologies to meet the challenges of the 21st century will be held in Leeds, England.
Enquiries: Zena Hickinson, AE Technology Transfer, School of Civil Engineering, University of Leeds, Leeds LS2 9JT, UK. E-mail: z.hickinson@leeds.ac.uk Tel: +44 113 2332308. Fax: +44 113 2332243.

WATER RESOURCES
APRIL 9 - 12
An international symposium on integrated water resources management will be held in California, USA. Enquiries: Prof Miguel A Marino. Tel: +1 530 752 0684. Fax: +1 530 752 5262 Web address: http://www.conferences.ucdavis.edu

WATER RESOURCES
APRIL 30 - MAY 4
An international conference on water resources in extreme environments will be held in Anchorage, AL, USA.
Enquiries: Douglas Kane, University of Alaska, Fairbanks AK99775,USA. E-mail address: ffdlk@aurora.alaska.edu Fax: +907 474 7979. Web address: http://www.awra.org

WATER SERVICES
MAY 3 - 5
An international conference on the global marketing of water services - comparing quality service characteristics and customer satisfaction - will be held in Torino, Italy.
Enquiries: Noema srl, Via Orefici 4, 40124 Bologna, Italy. E-mail: noema1@alinet.it Tel: +39 051 230385. Fax: +39 051 221894.

GROUNDWATER
MAY 8 - 10
The International Association for Hydraulic Research will hold an international symposium on groundwater in Saitama, Japan.
Enquiries: Dr H Kazama, Saitama University, 255 Shimo-ohkubo, Urawa, Saitama 338-8570, Japan. Tel: +81 48 858 3568. Fax: +81 48 855 1378. Web: http://www.hgl.saitama-u. ac.jp

LAKE MANAGEMENT
MAY 17 - 21
The 8th international conference on the conservation and management of lakes will be held in Copenhagen, Denmark.
Enquiries: Conference Bureau, Herlev Ringveg 2C, DK-2730 Herlev, Denmark. Tel: +45 4492 4492. Fax: +45 4492 5050.

CHLORINATION
MAY 21 - 24
The 2nd international conference on the remediation of chlorinated and recalcitrant compounds will take place in Monterey, CA USA.
Enquiries: The Conference Group, 1989 West Fifth Avenue, Suite 5, Columbus, Ohio 43212-1912, USA. E-mail adress: 102632.3100@compuserve.com Tel: +800 783 6338. Fax: +614 488 5747.

ACHEMA 2000
MAY 22 - 27
The 26th exhibition-congress and international meeting on chemical engineering, environmental protection and biotechnology will be held in Frankfurt am Main, Germany.
Enquiries: Dechema. Tel: +49 (0) 697564-261. Fax: +49 (0) 697564201. Internet: http://www.woice.de E-mail: woice@dechema.de

IRRIGATION
MAY 23 - 25
A conference and exhibition - Irrigation Australia 2000 - will be held in Melbourne, Victoria, Australia.
Enquiries: Rodney Cox, Exhibitions and Trade Fairs, PO Box 232, Chatswood NSW 2057 Australia. Tel: +61 2 9413 3322. Fax: +61 2 9413 3303.
E-mail:syd@etf.com.au

WATER ECOLOGY
MAY 30 - JUNE 2
ECWATECH 2000 will hold the fourth international congress and exhibition with the theme "Water ecology and technology" in Moscow, Russia.
Enquiries: Exhibition Management and Congress Secretariat, PO Box 173, Moscow 107078 Russia. Tel: +7 0959 753 423. Web: http://www.sibico.com/ecwatech/

WATER SURFACES
JUNE 5 - 8
The 4th international symposium on gas transfer at water surfaces will be held in Miami Beach, Florida, USA.
Enquiries: Gayl van de Bogart, University of Miami, 4600 Rickenbacker Causeway, Miami FL 33149, USA. Web: http://cheyenne.rsmas.miami.edu/gas2000.html/

GROUNDWATER 2000
JUNE 6 - 8
A conference with the theme Groundwater 2000 will be held in Copenhagen, Denmark.
Enquiries: MiaCon Meeting and Conference Services, Helsingevej 23, DK-2830 Virum, Denmark. E-mail address: gw2000@isva.dtu.dk Tel: +45 45 859727. Fax: +45 45 839727. Web: http://www.isva.dtu.dk/grc/gw2000/

AWWA
JUNE 11 - 15
The AWWA 2000 annual conference and exhibition will be held in Denver, Colorado, USA.
Enquiries: David Rossiter, AWWA, USA. E-mail: rossiter@awwa.org Tel: +303 3476209. Web: http://www.awwa.org/tande/awwaconf.html

GIS
JUNE 14 - 16
The 2nd international conference on GIS (Geographic Information Systems) for the 21st century will be held in Lisbon, Portugal.
Enquiries: Gabriella Cossutta, Ashurst Lodge, Ashurst, Southampton SO40 7AA, United Kingdom. E-mail: gcossutta@wessex.ac.uk Tel: +44 2380 293 223. Fax: +44 2380 292 853. Web: http://www.wessex.ac.uk

IRRIGATION
JUNE 20 - 24
An international conference on the challenges facing irrigation and drainage in the new millennium - meeting human and environmental needs through sustainability, rehabilitation and modernisation will be held in Fort Collins, CO, USA.
Enquiries: US Committee on Irrigation and Drainage, 1616 17th Street, 483 Denver, CO 80202, USA. E-mail: stephens@uscid.org Fax: +303 6285431. Web: http://www.uscid/org

FLOW ANALYSIS
JUNE 25 - 29
The 4th international conference on flow analysis will take place in Warsaw, Poland.
Enquiries: Prof Marek Trojanowicz, Department of Chemistry, University of Warsaw, Pateura 1, 02-093, Warsaw, Poland. E-mail: trojan@chem.uw.edu.pl Tel: +48 22 8223532. Web: http://www.congress.pbp.com.pl/flow/

OCEAN DYNAMICS
JULY 2 - 7
The international union of theoretical and applied mechanics symposium on the advances in mathematical modelling of atmosphere and ocean dynamics, will be held in Limerick, Ireland.
Enquiries: PF Hodnett, University of Limerick, Ireland. E-mail: iutamlim@ul.ie Web: http://www.ul.ie/~iutamlim/

WASTEWATER
JULY 3 - 6
The 3rd international symposium on wastewater reclamation, recycling and reuse will be held in Paris, France.
Enquiries: Ms Nicole Couesnon, GBE, Universite Montpellier II, cc057, 34095 Montpellier cedex 05, France. E-mail: wrrr.2000@dstu.univ-montp2.fr Tel: +33 4 6714 3310. Fax: +33 4 6714 4774.

IWA
JULY 3 - 7
The first world congress of the new International Water Association (IWA), formed by the merger of the International Association on Water Quality (IAWQ) and the International Water Services Association (IWSA), will be held in Paris, France.
Enquiries: Aghtm-cfrp, 83 Avenue Foch - B.P. 39.16, 75761 Paris - Cedex 16 - France. Tel: +33 (0)1 53701351 or 53. Fax: +33 (0)1 53701340. E-mail: aghtm@aghtm.org

AQUATIC ENVIRONMENTS
JULY 3 - 7
A conference on new trends in water and environmental engineering for safety and life: eco-compatible solutions for aquatic environments will be held in Capri, Italy.
Enquiries: Terr@A, Dept IIAR, Hydraulic Div, Politecnico di Milano, Italy. E-mail: terra@marina.iar.polimi.it Fax: +39 2 23996298.

METEOROLOGY
JULY 10 - 14
A conference with the theme "Meteorology at the Millennium" will be held in Cambridge, England.
Enquiries: Royal Meteorological Society, Executive Secretary. E-mail: execsec@royal-metsoc.org.uk Tel: +18 956 8500. Fax: +18 956 8571.

UNIVERSITY OF DURBAN-WESTVILLE

Department of Civil Engineering

MSc in Water and Environmental Management

The department has successfully been running an MSc degree course in *Water and Environmental Management* since 1995. The course content takes into account the multi-disciplinary nature of water and environmental management and has attracted **Civil** and **Chemical Engineering** graduates as well as **Honours graduates from Microbiology, Geography, Chemistry** and other related streams in the past.

Course Contents

This programme consists of two segments. In the first six months of study, each candidate is required to undertake six courses, three of which must be core courses and other three electives.

- The core courses are: Environmental Impact Assessment; Environmental Pollution and Control; Economics, Environment and Sustainable Development; Unit Operations and Processes, and Water Resources Planning and Management.
- The elective courses are: Earth and the Environment, Ecological and Biological Principles and Processes, Advanced Transport Phenomena, Convective Dispersion Modelling, Advanced Hydrology, Industrial Water and Wastewater Management, Land Drainage and Coastal Defence, Project Management, Rural Sanitation and Epidemiology, Applied Statistics and Operation Research, Water Chemistry and Microbiology, Water Distribution and Wastewater Collection Systems, and Principles of Water Quality and Legislation.

The remaining six months is devoted to an individual research project, which must be written up as a dissertation and submitted for examination. **Please note:** Classes usually commence in **February**.

The research work undertaken in this programme have been well-received and yielded publications in referred journals and conference proceedings. Graduates from this programme have a high marketability. Almost all of them have been absorbed into various governmental, semi-governmental agencies and the private sector.

This programme has special provision for serving engineers/scientists/consultants who wish to join. After completing the course work, they may undertake individual research project at their own work-place/organisation under the joint supervision of an academic staff member from the department and another person from their organisation (if available).

Most of the candidates admitted to this programme were supported through bursaries awarded by National Research Foundation (formerly Foundation for Research Development). A limited number of tutorship/laboratory assistantships may also be awarded depending upon the need and merit of the individual candidates.

For application and further enquiries, please contact:

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South Africa

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E-mail: otieno@pixie.udw.ac.za

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Strategic advantages

Empowering people to become key players in the management of one of South Africa's most limited natural resources

Course presenters

The course is presented by leaders in the field from the University of Pretoria, the CSIR and other industrial partners

Course content

The success of this course is based on a multidisciplinary approach, combining theory and research with real life team-building and project management experiences. Fields covered include:

- Environmental paradigms; - governance; - analysis, assessment and modelling
- Water quality management; water conservation and demand management; water supply and sanitation
- At least one of the following elective course modules: International Environmental Law; Philosophy of the Environment; Ecotourism; Polar and Mountain Environments
- A practical group project
- Course duration: one year full time or two years part time

Admission requirements

Candidates must be in possession of a four-year degree qualification (BSc Hons) or equivalent and appropriate subjects in water-related issues. Final admission is subject to approval by the Director of the Centre for Environmental Studies and the Head of the Department of Microbiology and Plant Pathology.

Contact details:

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University of Pretoria
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