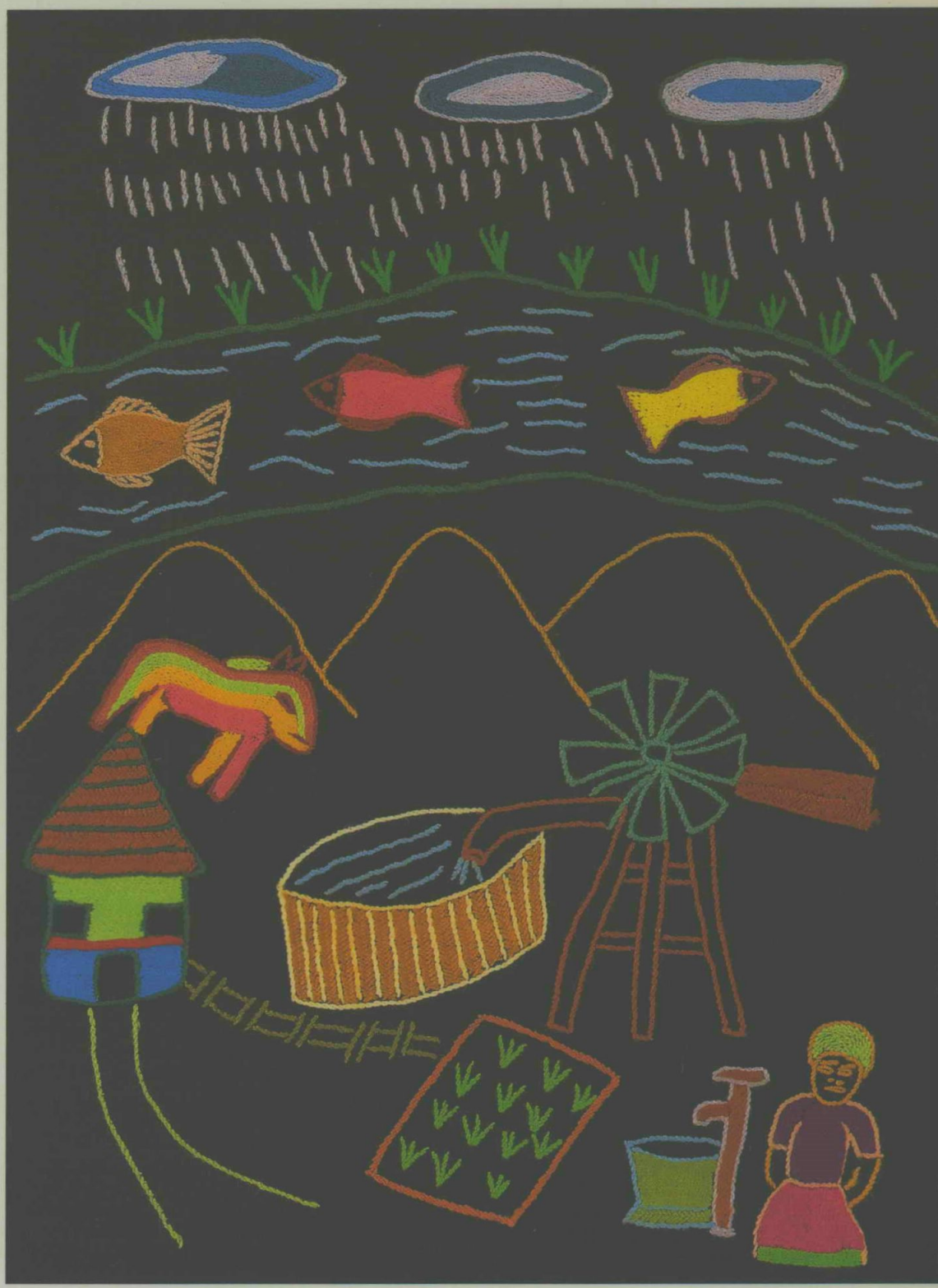
Water Research Commission



'95 TECHNICAL REPORT

1995

Technical Report

Water Research Commission

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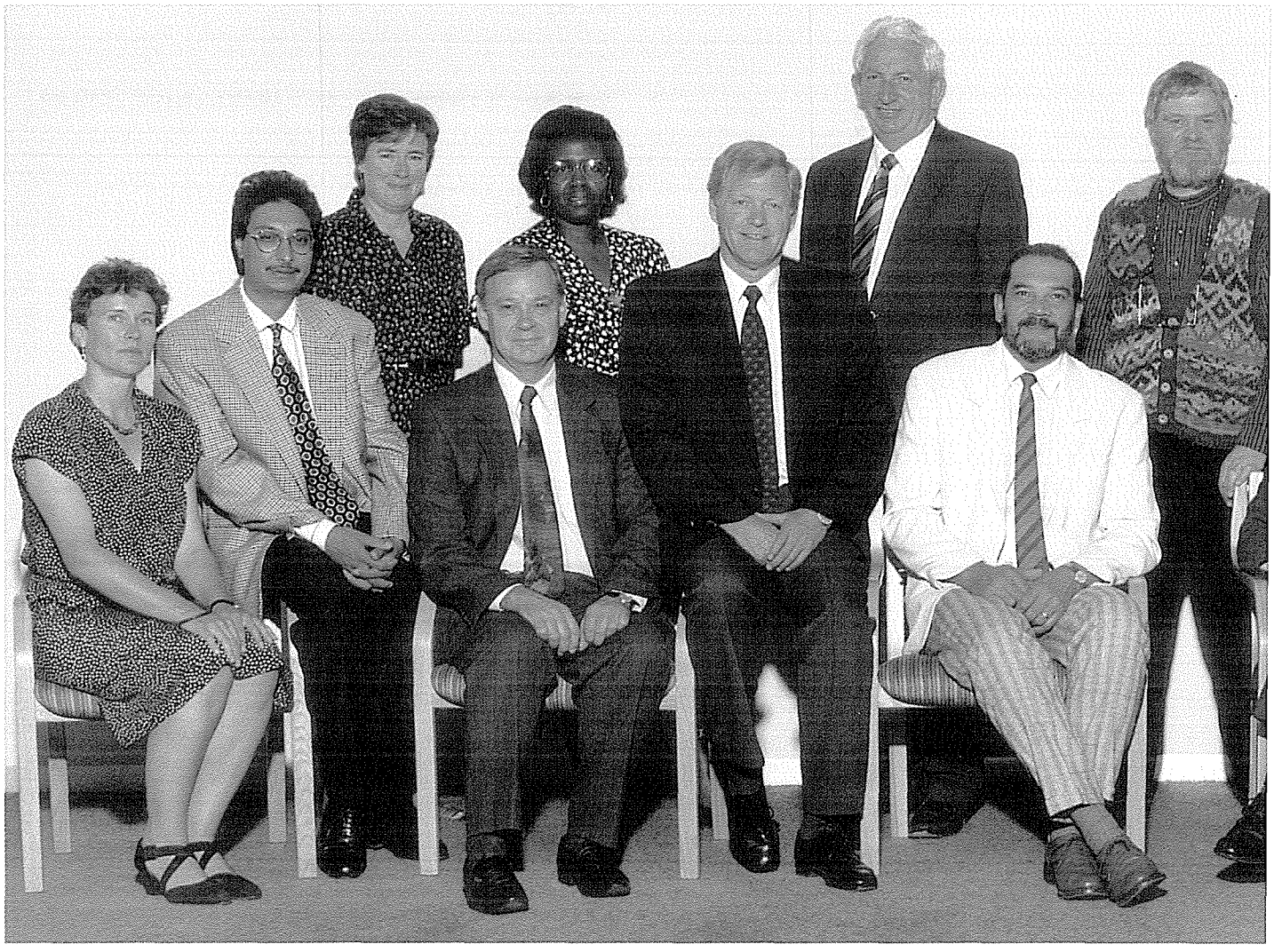
Members of the Water Research Commission
as on 31 December 1995



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Dean: Science Faculty, University of the Western Cape

Prof Peter Tyson (Vice-Chairman)
Director: Climatology Research Group, University of the Witwatersrand

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An agricultural economist and Rural Development Research Manager: Land and Agriculture Policy Centre

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Mr Bhekuyise Langa
Executive Official: E-Bank Division at Standard Bank

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Professional

Deputy Executive Director

Mr DS van der Merwe

(Municipal effluents; industrial water and waste water; urban water reticulation; water and sanitation for developing communities; water utilisation for agricultural and ecological purposes; membrane technology)

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Mr PM van der Schyff

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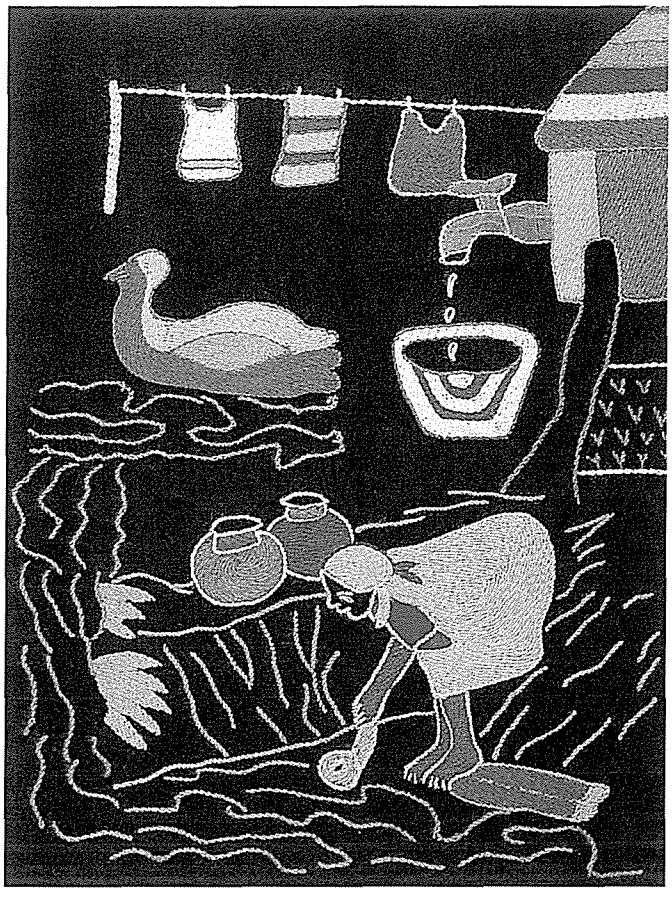

Martha Metlae

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The year under review

The diverse number of research fields supported by the Water Research Commission (WRC) bears testimony to its multidisciplinary approach to water research. The research fields and allocation of funds to the various fields for 1995 are indicated in the accompanying bar chart.

The WRC does not itself undertake research, but enters into agreements with other organisations to carry out the research. In the following table the research sectors which are responsible for the research, are listed, as well as the extent of their involvement:

Research sector	Number of times involved	%
Universities	134	53
CSIR	51	20
Consultants	26	10
Government departments	2	1
Local authorities	4	2
Water boards	15	6
Other organisations	19	8
Total	251	100

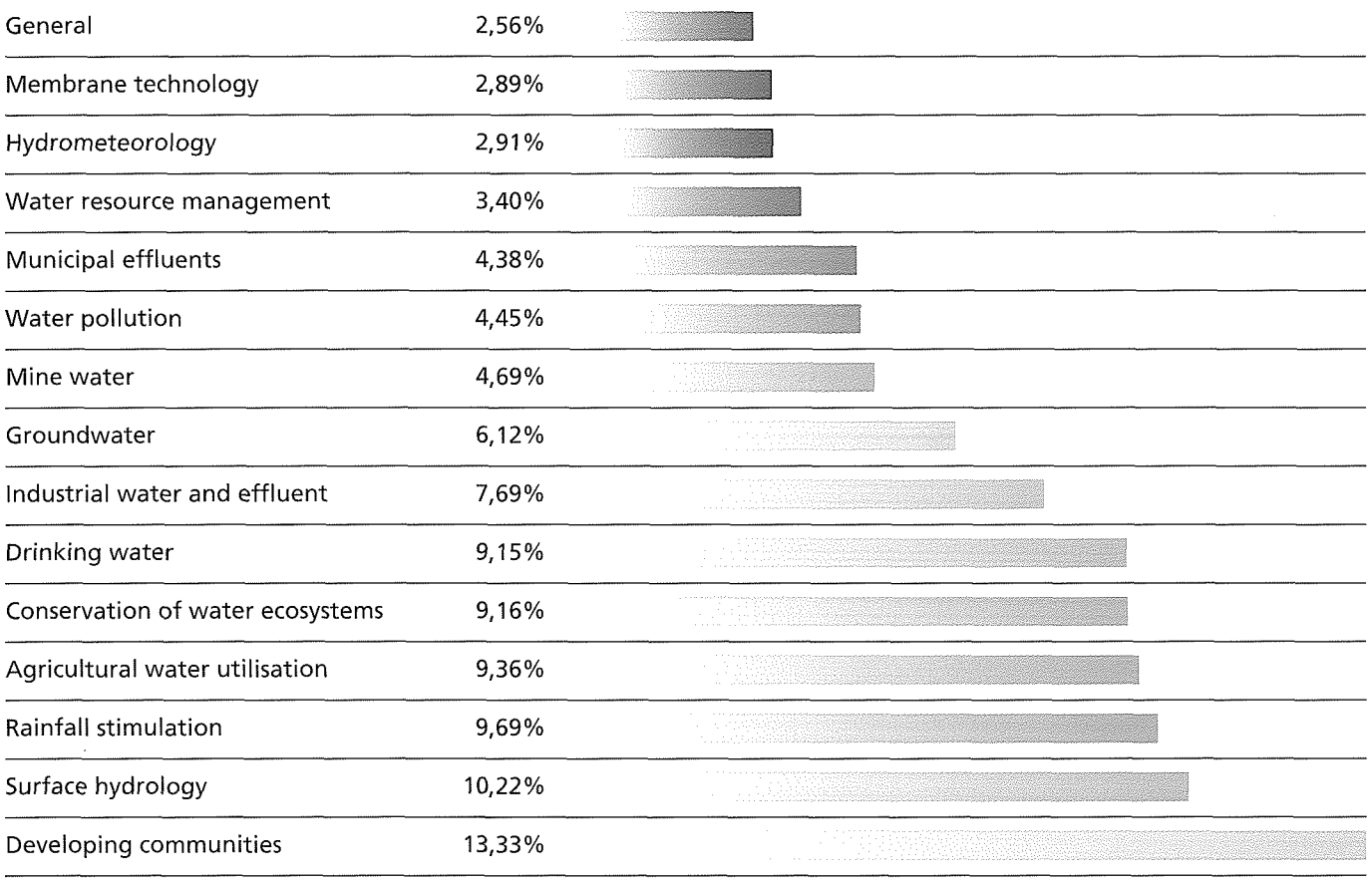
From the figures it is evident that universities are involved in 53% of the total number of contracts. The number of times that organisations are involved, namely 251, exceeds the number of projects supported, for the reason that more than one organisation is, in certain cases, involved in the execution of a project. In 1995 the WRC financially supported 244 projects at a budgeted amount of R37 779 200.

In addition to the direct funding of contractual research projects, the WRC also finances 2 research support services, namely:

- The SA Water Information Centre (SAWIC)
- The Computing Centre for Water Research (CCWR).

While the activities pertaining to the past year will be reported on in the various chapters, certain highlights will be singled out in this chapter.

ALLOCATION OF FUNDS (%) TO THE VARIOUS FIELDS DURING 1995



WRC reconstituted

The term of office of WRC members lapsed on 31 July 1995. After nominations for appointment had been invited through a press advertisement, the Minister of Water Affairs and Forestry appointed the following members to the Commission:

Prof Colin Johnson (Chairman), Dean of the Science Faculty, University of the Western Cape and Professor of Botany. He takes over from Mr Braam Raubenheimer, the former Minister of Water Affairs

Prof Peter Tyson (Vice-Chairman), Director of the Climatology Research Group, University of the Witwatersrand

Mr Vincent Bath, Chief Executive of Rand Water

Ms Diana Callear, an agricultural economist and Rural Development Research Manager at the Land and Agriculture Policy Centre

Mr Arthur Clayton, City Engineer of Cape Town

Prof Bryan Davies, Director of the Freshwater Research Institute at the University of Cape Town's Zoology Department

Mr Musa Furumele, a professional engineer at Goba Moahloli and Associates Inc., a consulting engineering and development management firm

Dr Ania Grobicki, Managing Director of the Environmental Consultancy Firm, Abbott Grobicki (Pty) Ltd

Dr Hamanth Kasan, Head of the Biotechnology Department at Natal Technikon

Mr Bhekuyise Langa, Executive Official of the E-Bank Division at Standard Bank

Prof Kingston Nyamaphene, Dean of the Faculty of Agriculture and Professor of Soil Science at the University of Fort Hare

Ms Angie Phaliso of ABA's Africa Growth Network and Treasurer of the Soweto Civic Association

Prof Albert Rooseboom, Head of the Water Engineering Section at Stellenbosch University's Department of Civil Engineering.

Mr Tinus Erasmus, Director-General of the Department of Water Affairs and Forestry, and

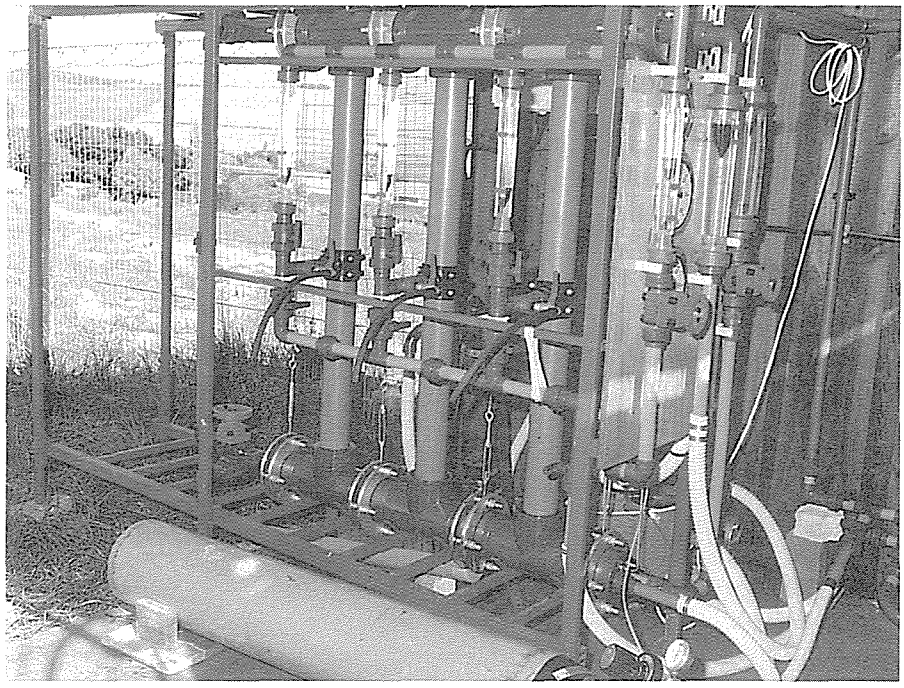
Mr Piet Odendaal, Executive Director of the WRC, are *ex officio* members of the Commission.

Novel membrane technology for rural water treatment

The WRC is funding the development of novel membrane technologies with the Institute for Polymer Science (IPS), University of Stellenbosch. The IPS has developed a low-pressure ultrafiltration membrane which already shows exceptional potential as a cost-effective process for providing potable water to small and medium-sized rural communities.

A first demonstration plant of 12 m^3/d has now been in operation near Stellenbosch for more than a year. The raw water intake to the system is derived from the Theewaterskloof scheme. The water has a high microbial and colour content and is also extremely corrosive, due to a low carbonate alkalinity. The demonstration plant has consistently produced high quality potable water at relatively low cost, and without any pretreatment.

As part of a technology transfer initiative, the technology will now be further evaluated at the M L Sultan Technikon in Durban with a view to training students in the application of the technology. Negotiations are also ongoing between the WRC, the IPS and the management of the Transkei Appropriate Technology Unit to evaluate the technology in remote rural villages in the former Transkei.



Cross-flow microfiltration unit for rural water supply.

UNESCO Mission to South Africa

During the period of 6 to 13 December 1995 four meetings were organised under UNESCO auspices by the WRC on different aspects of total interdisciplinary risk and crisis management (cindynics). The meetings involved:

- Representatives of universities, with a view to identifying their interest and needs regarding the introduction of new approaches to risk and crisis management at various levels of training (6 to 7 December).
- Decision-makers representing insurance companies, municipalities and government authorities with a view to discussing ways in which they could further develop risk and crisis management in their fields of interest, benefiting from the new approach to training, research, information and communication on this matter (8 December).
- Communication specialists with a view to clarifying their interest in developing risk-communication and improving access to relevant information resources (12 December).
- Institutions involved in the training of communication specialists, with a view to identifying the interest in and possibilities of introducing risk communication and information support components in the training program offered by them (13 December).

The UNESCO delegation consisted of Mr P Vasarhelyi of the Division of the General Information Programme, Prof L Faugêres from the University of Sorbonne, Paris and Mr C Collin, crisis manager for the city of Marseilles (France). They were later joined by Ms Susan Santos, communication specialist from the USA.

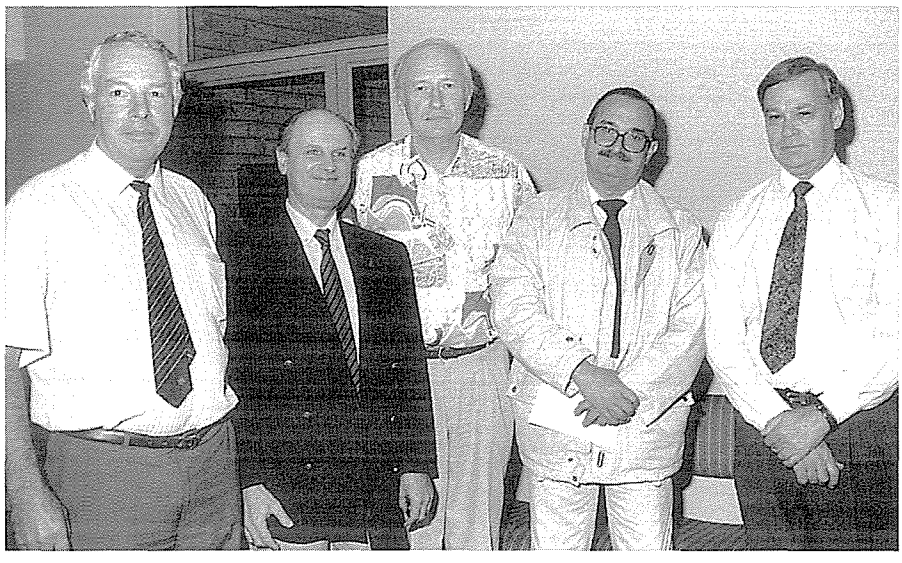
Internet information system for water supply and sanitation

The Pollution Research Group (PRG), University of Natal, developed an Internet information system for the WRC called EMILY (Electronic Membrane Information LibrarY), aimed at promoting free exchange of and access to information relating to membrane technology. Based on the success of this system (introduced in 1994), the International Association on Water Quality (IAWQ) charged the PRG to develop a similar system for the water supply and sanitation sector, called WENDY (Water Supply and Sanitation Electronic Network for Developing CountrY Needs). WENDY is now being developed jointly by the University of Natal and the University of Durban-Westville.

The WRC has been involved in the development of WENDY from the outset, in that WENDY will be based at the WRC-funded Computing Centre for Water Research (CCWR). Key partners who quickly joined the initiative in making their databases available and in collaborating in the development of the system are: IRC (International Reference Centre on Water and Sanitation), The Hague, Netherlands; the United Nations Centre for Human Settlements (Habitat), Nairobi, Kenya; EHP (Environmental Health Programme, USAID), Washington DC, USA; and WEDC (Water, Engineering and Development Centre), Loughborough University of Technology, UK. All these organisations are participating in a steering committee which has been set up for the WENDY initiative.

At the 3rd Global Forum of the Water Supply and Sanitation Collaborative Council, held in Barbados, 30 October to 3 November 1995, WENDY was accepted as a mandated activity of the Council, as a tool for information dissemination and for assisting in the co-ordination of the Council's activities. For this purpose WENDY will be attended to by an existing Working Group of the Council (Information and Communication) which is being co-ordinated by the IRC.

During the Barbados event, a number of representatives from developing countries, especially from Africa, expressed keen interest in the system, and these countries will be visited by members of the development team early in 1996 to provide training in the use of WENDY.



Photographed during a break in the UNESCO meeting on total interdisciplinary risk and crisis management held in Pretoria, December 1995, were from left, Mr H Maaren (WRC), Mr P Vasarhelyi (UNESCO), Prof L Faugêres (Sorbonne, Paris), Mr C Collin (City of Marseilles) and Mr PE Odendaal (WRC).

Planning of water supplies for rural development projects

A workshop on the planning of water supplies for rural development projects was held in East London, during May 1995. The workshop emanated from the project **Guidelines for the evaluation of water resources for rural developments with an emphasis on groundwater** which is being undertaken by the Institute for Water Research, Rhodes University.

The design of a rural water supply scheme is a complex procedure, requiring the consideration of a large number of different factors. The primary objective of the workshop was to list these factors and to develop a logical process for assessing them. The workshop highlighted the importance of issues related to community participation in the provision of water supply, and the need to transfer responsibility to the community for ensuring the success of a supply scheme.

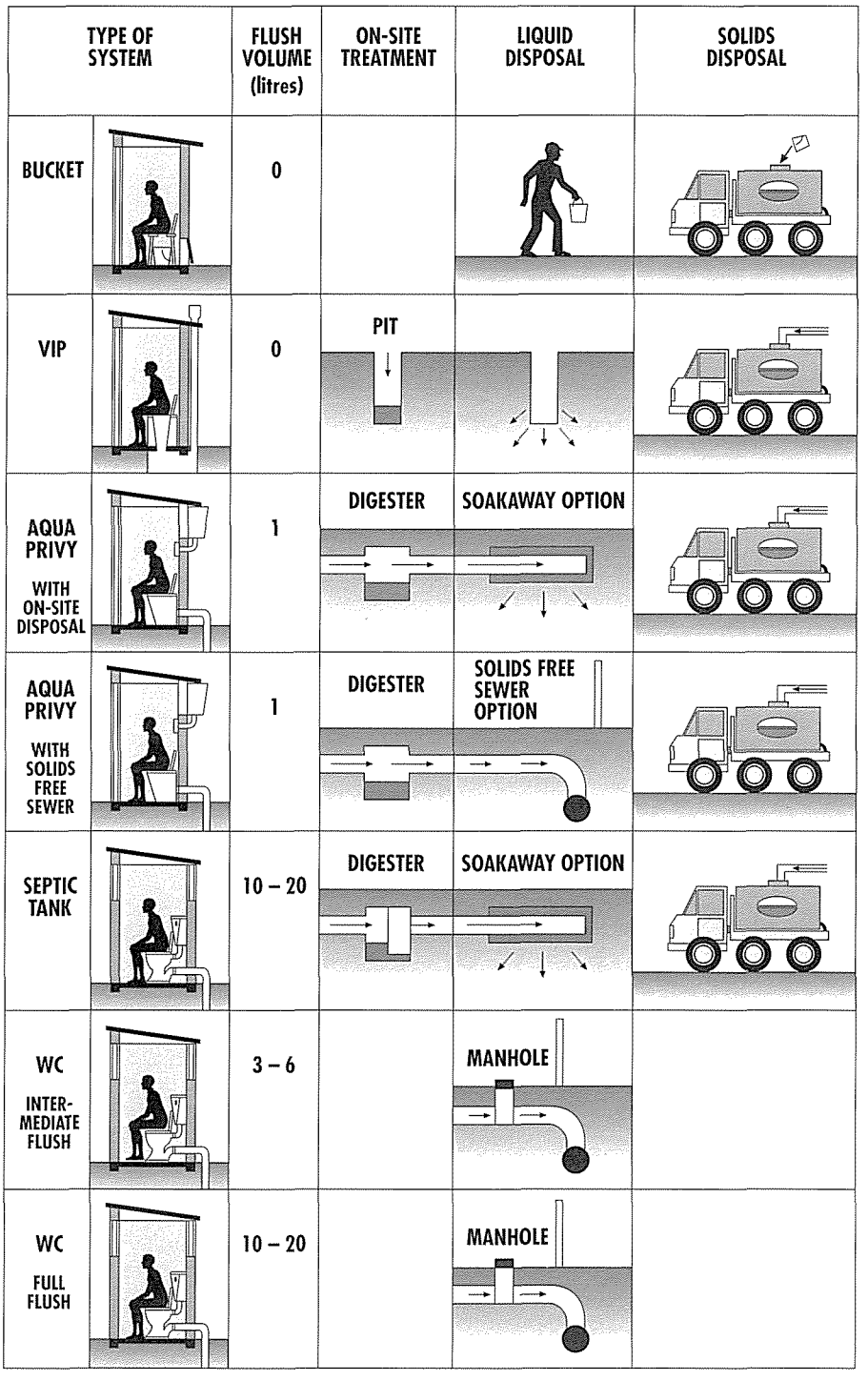
The need for a systematic and structured approach, incorporating the experience of practitioners in a decision-support system (DSS), will greatly assist those involved in the provision of rural water supplies. A preliminary DSS will be one of the outputs of the project.

Water and sanitation handbook for community leaders

A guide *Water and Sanitation Handbook for Community Leaders* was published by the WRC as an aid to ensure the successful involvement of community leaders in the provision of water and sanitation to developing areas. The guide was compiled for the WRC by the Palmer Development Group and applies specifically to urban and peri-urban situations.

The purpose of the guide is to empower leaders to improve their negotiation with developers and local authorities about the provision of water and sanitation services, to the benefit of their communities. The guide will hopefully contribute towards eliminating problems of the past when communities were frequently persuaded to choose systems which were unsuitable for their particular needs or which they could not afford to maintain effectively.

The guide not only provides community leaders with the basic knowledge they need to make informed decisions, but also gives important guidelines to be followed in the planning of water and sanitation services.



This chart shows the sanitation systems used in South Africa and illustrates how much water each system needs to operate.

Settlement upgrading: Application of computerised visualisation technology

The United Nations Centre for Human Settlements (Habitat), located in Nairobi, Kenya, developed a computerised visualisation technology, known as ViSP (Visual Settlements Planning) technology. ViSP is based on a combination of aerial photography and GIS software. It is not only intended to facilitate and expedite the planning of service development or upgrading programmes, but also to improve the involvement of communities in such programmes, through the visual presentation of different planning scenarios.

The WRC collaborated with Habitat in arranging a workshop in Pretoria in June 1995, in order to demonstrate the value and application of the technology in South Africa. The opportunity was also used to feature the CSIR's 3DVT (Three-dimensional Visualisation Technology), as it was perceived that the two technologies could beneficially complement each other. Much interest was generated at the workshop, which was followed up by a regional workshop in East London.

In order to promote the practical demonstration and implementation of the technology in South Africa, it was agreed that Habitat would assist in the mobilisation of funding one or more demonstration/monitoring projects through the WRC. The WRC is now negotiating with the CSIR and the University of Cape Town for the identification of appropriate sites and associated project formulations.

Although the initiative has been taken within the context of water supply and sanitation, the technology obviously holds great potential for facilitating the planning and implementation of projects in various other fields of land use, such as housing and transport.

Catchment rehabilitation

Many catchments in South Africa are already degraded to the extent that the quantity and quality of runoff to rivers are seriously affected. Therefore, urgent action is required to develop and implement strategies for the protection and rehabilitation of sensitive catchments. In the search for appropriate conservation and rehabilitation practices, the WRC held a successful workshop in November 1995. For the first time engineers and natural and human scientists were brought together to discuss a way forward. As a first step in integrated water management, a need to care for the catchment was confirmed. The most complex part of the problem concerns the socio-economic sphere.

One of the main conclusions of the workshop was that a key requisite for successful catchment protection and rehabilitation, is that scientists, policy-makers and people at grass-roots level find a common language and understanding of the problem. The workshop has laid the basis for developing a strategic research plan for catchment rehabilitation in South Africa.

Small-farmer irrigation scrutinised

Following the identification by the WRC's Co-ordinating Committee for Irrigation Research of a need for a thorough investigation of small-farmer irrigation, the WRC entered into an agreement with the consulting engineering firm MBB (CE) Inc. to scrutinise small-farmer irrigation in South Africa. The main objective of the investigation is that implementation of the research results should enable irrigation planners and designers to develop irrigation projects that are technically sound and cost-effective, and will promote small-farmer development.

In view of the possible growth in small-farmer irrigation that is expected to occur in South Africa, a recommendation was made to the WRC that the progress report on the project be published as an interim information paper. This recommendation culminated in the publication of a booklet entitled *Small-scale Irrigation in South Africa*.

This publication provides *inter alia* an overview of small-farmer irrigation farming in South Africa. An introduction to irrigation technologies – i.e. irrigation systems, currently in use under these conditions – is given, as well as a brief discussion of other issues in this field, e.g. appropriate technology, consultation with end-users, crop water requirements, sharing of infrastructure and equipment, need to organise farmers, management of these schemes, empowerment of farmers and training needs.

The final product of this project will be technical guidelines and procedures for the development of small-farmer irrigation schemes. Detailed recommendations for use by planners are envisaged, and it is expected that the guidelines will be released towards the end of 1996.

Participation in the Vulamehlo Agricultural Educational Exhibition

The first Vulamehlo Agricultural Educational Exhibition for small-scale farmers, hosted by the Witwatersrand Agricultural Society, coincided with the Rand Easter Show of 1995. The word "Vulamehlo" means "open your eyes". The exhibition was of an educational nature, aimed at advancing the productivity of small-scale farming, and was supported by a number of organisations and companies closely associated with agriculture.

During fieldwork the WRC-funded research project carried out by MBB (CE) Inc., entitled **Evaluation of irrigation techniques used by small-scale farmers**, identified a number of typical problems characteristic of small-scale irrigated agriculture in South Africa. In a follow-up to this facet of the project, the WRC and MBB participated in the Vulamehlo Exhibition with the intention to demonstrate solutions to problems mainly of a technical nature, e.g. correct installation of pumping equipment. In addition to the correct installations, the WRC/MBB display also explained the effect of incorrect installations on running and maintenance costs.

Funding and manpower for the irrigation part of the exhibition were provided respectively by the WRC and MBB, whilst a number of commercial concerns provided items used in the exhibits. Transport of small-scale farmers and their extension officers from distant rural areas to the Vulamehlo Exhibition was spon-

sored by a commercial bank.

This endeavour therefore was a joint undertaking involving commercial and government organisations, with attendance by small-scale farmers exceeding all expectations. The response of small-scale farmers to the exhibition clearly emphasised the need for and the value of this exercise.

Review of strategic plan for irrigation research

The present strategic plan for irrigation research, developed by the WRC's Co-ordinating Committee for Irrigation Research, dates back to 1992. It is recognised that, in view of the far-reaching changes that have taken place in the country since then, the strategic plan is now due for review. In particular cognisance has to be taken of the contents of the *White Paper on Water Supply and Sanitation* (1994) and the *White Paper on Agriculture* (1995).

The review process, which started in July 1995, will be inclusive and consultative. A draft discussion document was sent to the irrigation research community and to those making use of research findings. The strategic plan framework consists of 7 coherent and logically constructed points of discussion: water systems and subsystems; problem statements; objectives and goals; functions; focus areas; priorities; and projects. This framework enables the identification of linkages and interactions with other research fields, without losing sight of the main tasks.

The following considerations will be emphasised:

- A systems approach is to be followed with the empirical fields arranged in a hierarchy of complexity, to gain some idea of the present gaps in theoretical and applied knowledge
- Real-life problems of decision-makers and operators are of central concern
- Particular attention is to be given to smallholder agriculture and the problems of resource-poor farmers in rural areas
- As many researchers and extension officers as possible, involved in various specialist fields, must be accommodated and be able to continue appropriate work.

After receiving and processing comments, a number of regional workshops will be held, involving representatives from both the research and farming communities.

Research needs of rivers shared by South Africa and Mozambique

In January 1995, the WRC, in collaboration with the Kruger National Park and the Institute of Natural Resources, University of Natal, arranged a workshop involving Mozambican and South African researchers, in order to initiate a collaborative research programme on shared rivers. The specific aim of the programme is to determine what is necessary to sustain the natural environment associated with rivers and estuaries. Secondary aims are to:

- Promote collaborative research
- Exchange information
- Develop common methodologies for river research and management
- Build capacity amongst both Mozambicans and South Africans.

Additional products will be:

- A situation statement on the present state of the rivers
- An assessment of the in-stream flow requirements of the rivers.

Mozambique has requested that the first rivers to be researched be those that flow into Maputo Bay. The research will not be directed only at the water requirements of the rivers, but also of the estuaries and the in-shore areas of the Bay.

The workshop produced a draft proposal for collaboration between South Africa and Mozambique, which is currently being evaluated by policy-makers and researchers in both countries.

Southern African "FRIEND" meeting in Grahamstown

Southern African FRIEND (Flow Regime from International Experimental and Network Data) is a project in the SADC (Southern African Development Community) region, falling under the International Hydrological Programme of UNESCO. The second meeting of the FRIEND Steering Committee was held in Grahamstown in September 1995. The meeting was chaired by the WRC and, for the first time, all 11 SADC countries

Aerial view of the Sabie River, Kruger National Park, a river shared with Mozambique.

were represented.

The meeting was also attended by Dr A Szollosi-Nagy, Secretary of the Water Division of UNESCO; Dr John Rodda, President of the International Association for Hydrological Sciences; Mr Lenka Thama of SADC-ELMS; and Mr Jean-Marc Faures of FAO. Great enthusiasm was expressed for a possible next phase of the project, with emphasis to be placed on capacity-building for African hydrology.

South Africa's water resources reassessed

In a 5-year project, a consortium of engineers consisting of Watermeyer, Legge, Piesold and Uhlmann (CE) Inc.; SRK (CE) Inc. and Stewart Scott (CE) Inc., under the leadership of Prof DC Midgley, reassessed South Africa's water resources. The main objective of the project was to provide a basis for the preliminary planning of water resources development. The study also, in a single set of documents, made available valuable data and information for water resources planning such as rainfall, soils, geology and vegetation. Based on data available up to 1990, it appears that the total natural runoff in South Africa is now estimated at 51 000 x 10^6 m^3/a.

A set of GIS coverages, such as those depicting quaternary catchments, is now also available for other uses. South Africa has been divided into 6 regions, and for each region there is a book of maps at a scale of 1:1 000 000 and an appendix with data. Planning procedures are described in a *User's Manual*.

South African hydrology textbook

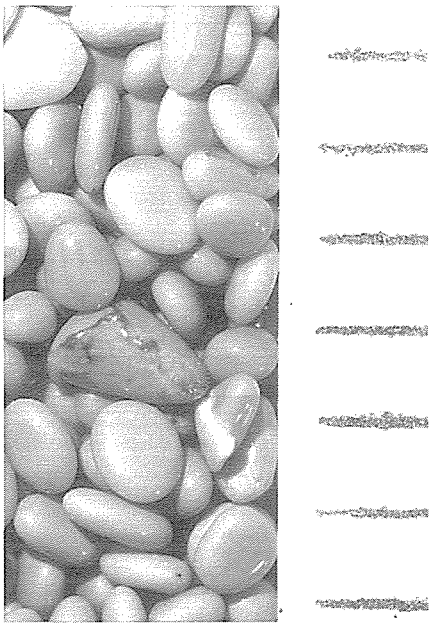
As a product of ongoing research, the following book was produced by Prof R E Schulze, head of the Agricultural Catchment Research Unit, University of Natal: *Hydrology and Agrohydrology: A Text to Accompany the ACRU 3.00 Agrohydrological Modelling System*.

This text is rapidly gaining status as an authoritative review of South African hydrology. Although largely based on theory and practice in other countries, the adaptation to typical South African conditions is effectively presented. The book contains a wealth of factual information and theoretical background to many of South Africa's water management problems.

Specifications for South African sand filtration media

Tentative requirements and specifications for the correct filter media to use in the production of an acceptable quality of drinking water, were set by the Water Research Group of the Rand Afrikaans University. No uniform and generally accepted method of media specification for rapid gravity sand filtration yet exists in South Africa. Such specifications do exist in many other countries.

Local, commercial filter-sand and anthracite were characterised and guidelines set for properties such as effective size, density, surface ratio sphericity, durability and solubility under acid and alkaline conditions. Mathematical prediction of the hydraulic behaviour of local filter media was incorporated into these guidelines.



Typical filter media used for rapid gravity sand filtration.

Power station cooling systems

South Africa, being a relatively arid country, is fortunate in having three of the world's largest dry-cooled power stations. As each of these is more than an order of magnitude larger than any similar station elsewhere in the world, Eskom is clearly the international leader in the field. To enable Eskom to improve the efficacy of such large systems, the WRC commissioned the Mechanical Engineering Department, University of Stellenbosch, to study the impact of system and environmental parameters on the performance of dry-cooling systems. The research led to the development of computer programs to evaluate and improve the performance of dry-cooling systems. The expertise developed is also applicable to wet-cooling systems.

The following 3 menu-driven computer programs were developed:

- Natural draft wet-cooling tower analysis program
- Forced draft, direct condensing, air-cooled heat exchanger analysis program
- Natural convection dry-cooling tower analysis program.

Marine disposal of effluents

The marine discharge of effluents offers an economically attractive disposal alternative for coastal centres, and 12 offshore pipelines are operating along the South African coastline. It is, however, essential to ensure adequate protection of marine fauna and flora, the sea bed and the sea water itself.

The efficiency of an offshore pipeline is largely governed by initial dilution and, to a lesser extent, by the secondary dilution caused by ocean currents. Initial dilution is effected through the entrainment of sea water during the rising of the buoyant effluent from the bedded pipeline's diffuser to the surface. The underestimation of initial dilution will result in over-design and hence excessive capital expenditure, while overestimation will adversely affect the marine environment.

Four models, developed abroad, are

available to predict the extent of initial dilution, and EMATEK, CSIR, was commissioned to evaluate the applicability of these models under the diverse South African marine conditions. This was done by studying the performance of the pipelines at Richards Bay, Mossgas and Hout Bay.

It was found that the relatively simple model developed by the Water Research Centre in the UK, can be applied with confidence, as it predicted achievable initial dilutions as accurately as the more sophisticated models.

Further applications of a novel waste-water treatment process – PETRO

In the previous annual report, mention was made of the novel PETRO (Pond Enhanced TREatment Operation) process which, in a unique manner, combines trickling filters and oxidation pond technology to produce an effluent which compares well with that from a well-operated activated sludge plant. This is a sturdy process, easy to operate and with low capital and operating costs. Of particular interest is the ability of the process to remove micro-algae, which become fixed in the biofilter film and contribute significantly to the production of the high quality effluent.

The reliability of the process has been accepted by design engineers, and there are currently 10 full-scale plants in operation and a further 5 under construction using the process. Effluent streams range from 2 to 5 Ml/d.

Further research is now aimed at fully understanding the biological aspects in order to optimise the process.

Membrane-based bioreactors

Joint research being conducted by the Department of Biochemistry and Microbiology, Rhodes University, and the Institute for Polymer Science, University of Stellenbosch, already demonstrated the applicability of capillary membrane technology in the bioremediation of industrial waste waters.

The research is aimed at the development of suitable enzymic and microbial systems for application in bioreactors for the removal of aromatic organic materials. Hollow-fibre membranes are used in the construction of biocatalytic reactors which have the ability to cultivate peroxidase-producing white rot fungus in aqueous medium inside specially developed skinless capillary membranes.

Intractable phenolic materials, polychlorinated biphenyls and other aromatic pollutants may be removed by immobilising a polyphenol oxidase enzyme on the membrane. Through secondary metabolite production, this enzyme is able to degrade many different intractable organic species. First results indicate the possibility of sustaining continuous enzyme production for up to 10 days. The high flux rates of the newly-developed ultrafiltration membranes improved the operation of the bioreactors and excellent organic removal rates were obtained.

A provisional patent on the production of secondary metabolites has already been registered. It is expected that the research findings will open up many novel applications in the fields of bioremediation and bioprocessing.

Earthworm technology for waste management

A recent country-wide survey, funded by the WRC, revealed that water and waste management at small- and medium-sized abattoirs is poor and cause for a great deal of concern. This points to a singular lack of robust low-cost treatment technologies, appropriate for small- and medium-sized abattoirs, poultry processing plants and other food processing industries. Amongst the problems identified are the handling of blood and its associated effluent, the management of paunch contents and the disposal of condemned carcasses.

Literature reviews have shown that long-term research by Indian scientists at the Bhawalkar Earthworm Research Institute (BERI), led to the development of a robust treatment system, based on earthworms (*Pheretima elongata*), for the processing of poultry offal and the conversion of bones, feathers, blood, intestines and dead birds into useful by-products. In South Africa, the earthworm *Eisenia foetida* has been extensively researched by the CSIR and the University of Potchefstroom. From the available information, it would appear that the adaptation of the BERI technology, using *Eisenia foetida*, to South African conditions could offer a cost-effective solution as well as holistic waste management in small- and medium-sized abattoirs, and in the food processing industry generally. Preparatory to a pilot investigation, BERI had been visited in late 1995, involving discussions with relevant researchers and visits to demonstration and full-scale facilities.

Advanced integrated waste-water ponding system (AIWPS) treatment

AIWPS technology was developed at the University of California, Berkeley, under the leadership of Prof W Oswald. Research at Rhodes University, with input from Prof Oswald and his group, led to the incorporation of AIWPS technology in various pilot-scale, demonstration and full-scale plants:

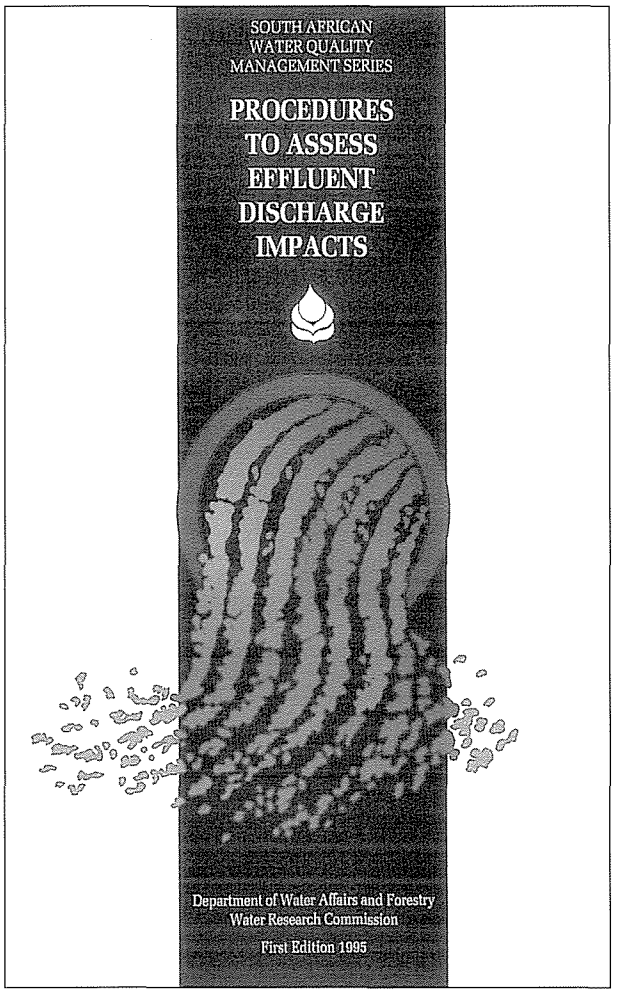
- A demonstration plant to treat wastes from a population of 500 people was constructed at the Grahamstown Sewage Works.
- Laboratory studies indicated that AIWPS technology could remove 91 to 94% of COD from abattoir effluent, while at the same time producing valuable *Spirulina* biomass. The laboratory work was followed by the operation of a 5 m^3/d pilot plant, while the construction of a 500 m^3 demonstration plant at Cato Ridge has recently been completed.
- The implementation of laboratory-, pilot- and demonstration-plant research at Rhodes University, spawned a collaborative project with the Department of Ichthyology and Fisheries Science in which treated water from the high-rate ponds will be used to raise exotic tropical fish. Methane gas from the primary pond will be used to heat the water. This initiative could form the basis of an export industry to the Far East.

- Western Tanning Co, Wellington, has taken the decision to go ahead with the construction of a full-scale AIWPS system for the treatment of its wastes and for the recovery and sale of algal by-products (*Spirulina* high protein animal feed). This follows on-site pilot-scale studies conducted by Rhodes University.

Procedures to assess effluent discharge impacts

The WRC and the Department of Water Affairs and Forestry (DWAF) jointly published a manual, prepared by the CSIR, which describes the procedures which must be followed to assess the impacts of effluent discharges on the quality, and therefore the fitness for use, of receiving water bodies. These impact assessments are now being used by the Department to decide whether an application to discharge an effluent will be granted or not and, if granted, what the requirements should be that the discharger must comply with. The manual therefore forms one of the cornerstones of the Department's current approach to the management of effluent discharges. The project which culminated in the publishing of the manual was funded jointly by the WRC and the DWAF and was undertaken in recognition of the need to develop the necessary management tools and information to support the implementation of the Department's current approach to water quality management.

The DWAF's current approach to control the impacts of effluents on the quality of receiving water bodies was adopted and published in 1991. This new approach became necessary when it was recognised that the hitherto reliance on the enforcement of uniform effluent standards would not offer sufficient protection of water quality in future. The new approach, *inter alia*, recognised that the capacity of water bodies to assimilate waste is limited and must be managed in a sustainable way.



Research on mine-water pollution

Mining remains the single most important industry in South Africa. From a national perspective it is a relatively small water user, but it is being implicated as a significant contributor to water pollution. Most of the geological formations that are mined in South Africa contain pyrites, which oxidise to form sulphuric acid when exposed to air and humidity. Acid generated underground in gold and coal mines, and above-ground in various waste deposits, is the main cause of water pollution originating from mining.

In 1995 the WRC started funding two new projects, the findings of which are expected to reduce the long-term impact of mining on water quality, viz. the investigation of prediction techniques and preventative measures relating to the post-operational impact of underground mines, and the pilot-scale development of integrated passive water treatment systems for mine-effluent streams.

Biotopes defined

Early in the year, Professor Malcolm Newson, a geomorphologist/hydrologist from the University of Newcastle-on-Tyne, UK, visited South Africa. Part of his visit was spent at a workshop during which significant progress was made in defining the common ground between fluvial geomorphologists, ecologists and hydraulics engineers.

Two useful tools were accepted by the multidisciplinary workshop for application in areas of common interest. These were, firstly, the physical biotope which is the basic habitat unit within a river and, secondly, a biotope matrix, which defines the different biotopes occurring within rivers.

Manual on quantitative estimation of groundwater recharge and aquifer storativity

A significant milestone in groundwater research was attained during the year, with the publication of a manual on quantitative estimation of groundwater recharge and aquifer storativity. The manual is based on a collaborative project between the WRC and the DWAF. A wide range of methods for the estimation of recharge was examined during the course of the study. The methods are documented in the manual, together with a selection of case studies where one or more of the techniques have been employed.

Not only does the manual provide a thorough examination of recharge in South Africa, but will also serve as an important foundation for future research into this topic.

National hydrogeological map of South Africa

The increasing importance of groundwater in South Africa, particularly as a source of domestic water supply for remote rural communities, small urban settlements, and farm-scale irrigation development, has created an urgent country-wide need for summarised and mapped hydrogeological information, in a synoptic and visual form.

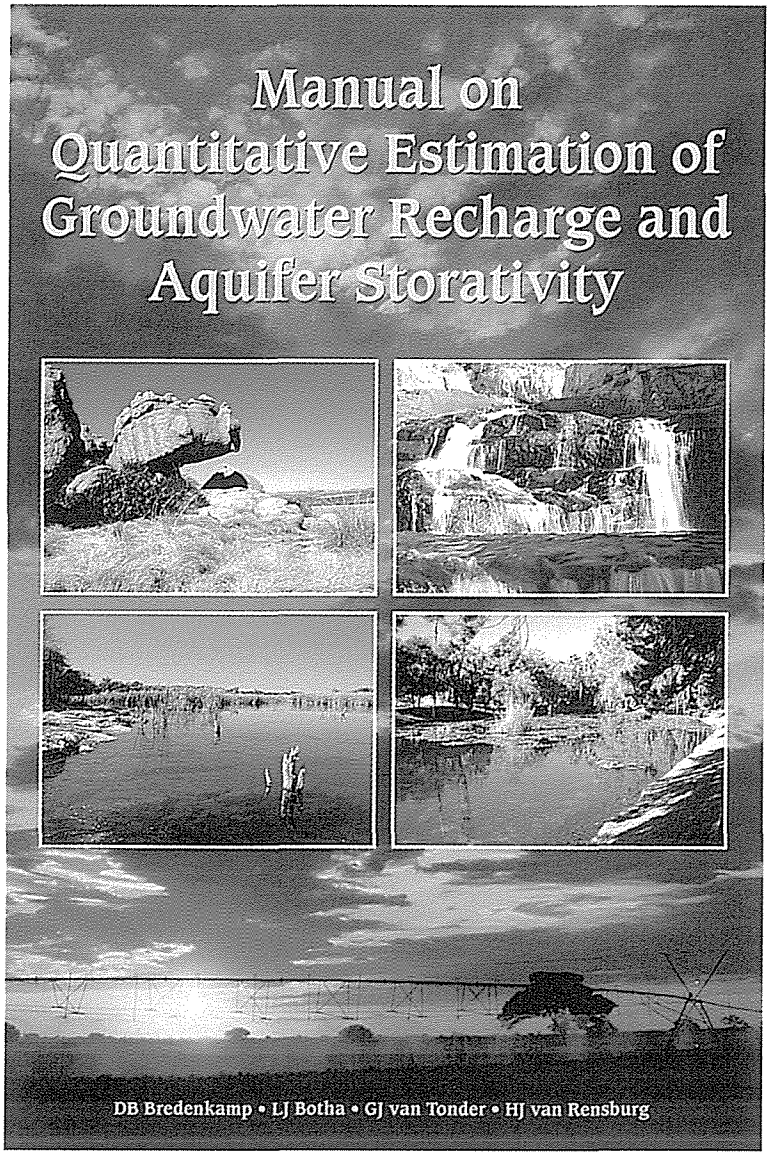
A national-scale hydrogeological map of South Africa has been compiled on 2 map sheets. The map depicts borehole prospects, optimal drilling conditions, groundwater quality and aspects such as recharge and water level depth. The preparation of the map represents the culmination of a 3-phased process, with contributions by many local and international experts. It commenced in 1990 with the preparation of a map of groundwater regions and subregions, followed the next year by the production of a document detailing the hydrogeological map legend and mapping protocol.

With groundwater being the preferred water supply source for many rural communities, the contribution of the maps to the water supply goals of the RDP will be evident for years to come.

One of the major benefits of the project is the dynamic digital database which resides "behind" the maps. Making this database available on, for example, ARC/VIEW will undoubtedly result in many derivative maps being produced in future.

Space-time characteristics of rainfall

Very often the hydrology of a catchment cannot be adequately modelled unless it is known how rainfall amounts produced by a single rainfall event, or a sequence of events, are distributed in space and time. Since most rainfall data in the past have been acquired with rain gauges read once daily, there is a serious lack of information on space-time



characteristics of rainfall. This is especially true in areas where convective systems produce most of the rain.

Workshops to assess the situation and accelerate progress towards possible solutions were held at the WRC in September 1995. These workshops brought together representatives of the following groups:

- Hydrologists in the best position to define information requirements with respect to the occurrence of rainfall
- Meteorologists in the process of developing skills in the quantitative measurement of areal rainfall using satellite- and radar-based techniques
- Statistical climatologists attempting to mathematically characterise and stochastically model rainfields in space and time, primarily with the object of providing engineering hydrologists with more adequate design tools.

The workshop not only clarified needs and provided better focus for researchers, but revealed that considerable progress is already being made in the provision of appropriate data sources (e.g. the Weather Bureau's network of weather radars) and the development of methodologies to make use of data from such sources. With regard to methodologies being developed, both facilities provided by the WRC (e.g. the MRL-5 dual wavelength research radar at Bethlehem) and several projects being financed by the WRC, are making significant contributions.

Rainfall enhancement technology under test in a drought-stricken area

Research, financed by the WRC and the Weather Bureau since 1983, has resulted in the development of a hygroscopic cloud-seeding methodology for the enhancement of rainfall from the warm-base convective cloud systems prevalent in the interior of South Africa during summer. The methodology has been well researched on semi-isolated cloud systems where, on average, a 30% increase in rainfall has been realised. This percentage may yet prove to be conservative in the light of potential improvements deriving from optimisation of the particle size distribution of the seeding material and the treatment of clouds at an earlier stage in their lifetimes.

What mainly remains to be done is to confirm, in practice, indications from modelling studies that the technology is capable of producing meaningful and cost-effective increases in areal rainfall and water resources when applied to a designated catchment area.

Acceptance of the challenge, late in the 1994/95 summer, to undertake emergency cloud seeding in order to assist in alleviating crippling drought conditions in the Northern Province, has in fact given impetus to the planning of a catchment-based areal rainfall enhancement experiment. In the process, much has been learnt about the needs and logistics of a semi-operational cloud-seeding programme. Ideas on how best to evaluate the results of semi-operational cloud seeding scientifically have been stimulated and are now being put to the test. On a practical note, the exercise appears also to have influenced rainfall positively in the region of highest concentration of treated storms. For instance, on 8 of the 9 operational days in March, treated storms yielded more radar-determined rainfall than any other storms within radar range on that day.

The emergency programme, together with its scientific components and objectives, was resumed at the start of 1995/96 rainy season.

Research centres: International peer-review operation (RECIPRO)

The WRC is participating with four other water research organisations in the RECIPRO international peer-review system. The other organisations are:

- The American Water Works Association Research Foundation (AWWARF) – USA
- Technologiezentrum Wasser (TZW) – Germany
- Keuringsinstituut van Waterleiding-Artikelen (KIWA) – Netherlands
- Compagnie Generale des Aux – France.

The objective of RECIPRO is to develop and implement a peer-review system directed at water research organisations throughout the world. The system is aimed at evaluating the operational processes and programmes within each organisation, and to suggest possible alternative approaches. The system is designed to be implemented at top managerial level and to provide external oversight of operational procedures and methods.

The WRC was the first organisation to undergo the RECIPRO review, during September 1995. AWWARF was reviewed in November 1995, and the other 3 organisations will be reviewed in May 1996. It is already clear that both the organisation being reviewed as well as those participating in the review process stand to gain valuable insights through the RECIPRO process.

Senior staff changes

Dr Nozibele Mjoli joined the WRC in January as Assistent Research Manager responsible for research projects on the provision of water and sanitation for unserved communities. She was previously employed as a Senior Lecturer in Microbiology at the University of Durban-Westville.

Dr Gerhard Backeberg, previously Deputy Director of the Directorate: Agricultural Economics of the Department of Agriculture, joined the WRC in July as a Research Manager mainly involved with irrigation research and agricultural water management.

2
Developing communities

There are many examples throughout the world where the relatively simple expedient of "throwing money at the problem" has been tried and has failed dismally. Virtually all of these failed examples relate back to a lack of involvement by the Community. Where communities have actively engaged in not only the "sweat" phase but also the decision-making stages, successes are far more common. Community participation not only results in acceptance of the scheme by the people being served by it, but it will also be better utilised and maintained. To top it all the total cost could be as little as only 10 per cent of the initial cost estimate.

The WRC strongly advocates the use of local resources when planning and undertaking water supply and sanitation projects, especially in rural and peri-urban areas. Such schemes have to be designed around the so-called 4M approach: Local men, local money (as little as it may be), local machines (picks and shovels), and local materials. Schemes designed this way are far more gratifying in the sense of achievement; in the sense of a better standard of living and in the sense of affordability. This is where ingenuity and innovative design are going to meet the challenge head-on and water research will be at the forefront of this challenge. Partly with this goal in mind the WRC is funding a project to develop guidelines to enable communities to operate and maintain certain sanitation systems (Project No 708).

To co-ordinate the players or stakeholders, the Co-ordinating Committee for Research into Water Supply and Sanitation for Rural and Urban Communities (CCRUC) was formed early in the year under review. A strategic research plan (SRP) for developing community research is currently being developed and will hopefully be finalised early in 1996. This SRP will serve to direct researchers and to focus research attention on priority areas, as identified in the plan.

Completed projects

Evaluation of water supply to developing urban communities in South Africa

(KV49/94 and KV73/95) Palmer Development Group in association with Department of Civil Engineering, University of Cape Town

The WRC was pro-active in 1992 in initiating this evaluation of the then current status of domestic water supply to developing communities in the urban sector. This consultancy project, together with its sister project on sanitation, proved to be one of the major sources of information for the RDP, in which connection the findings are frequently quoted. In this regard the project has admirably met its main aim of providing relevant and up-to-date information and analysis upon which rational policy and practice can be based.

The project was conceptually divided into 3 phases namely an overview, an evaluation phase and the development of strategies.

The first overview phase (WRC Report No KV 49/94) encompassed a review of the current status of water supply internationally and a survey of water supply to the urban areas of South Africa. It was then possible to determine who has access to adequate water supply, the systems being used and to obtain as much information on operating and costs as possible.

The evaluation phase considered water-supply systems from the point of view of acceptance by communities, health, cost, construction, operation and environmental impact.

From this a strategy was developed in the final phase to deal with water in developing urban areas over the next decade.

Guidelines for the selection, implementation, operation and maintenance of water supply systems were prepared.

Cost: R92 000
Term: 1992-1994

Prepayment water metering for South Africa

(KV56/94) Technology Research and Investigations, Eskom

Metering water supplies to individual consumers is fraught with problems. In dense (informal) settlements of low-income group people, these problems become almost insurmountable. In areas where people cannot or will not pay for services the presence of a meter reader

Angelina Moja

often generates animosity. The meters themselves, being of brass construction, have an intrinsic scrap value.

Householders have very little control over the amount of water consumed during the month and are then faced with a water account at the end of the month which the household just cannot pay (Getting the account to the householder is also a major problem, even if the address is known). The answer thus appeared to be prepayment. In this way the household could determine how much it could afford for water, purchase that amount of credit and through a dispenser in the house, monitor the rate of consumption to match the amount of credit purchased.

As such a budget energy controller (BEC) device had already been developed for the prepayment of electricity, the obvious course to follow was the development of a 2-channel BEC with a suitable interface to link the water meter and the electricity dispenser.

This consultancy project covered the initial exploratory work to establish the feasibility and specification for a combined prepayment water and electricity meter. Early BEC models were found wanting. Tamper control was inadequate and no suitable technical specification existed. External influences (lightning) also adversely affected the operation of some of the early BECs.

A follow-up project to develop a complete system from the end user, through the vending machine and all the way back to the supply authority is planned. The possibility exists that this would not be limited to water and electricity for developing communities only, but could also be extended to include: telephone, gas, rates and taxes, sanitation, solid waste removal and even banking, for all consumers.

Cost: R70 000
Term: 1992-1994

Environmental impact of on-site sanitation: A literature review with particular application to South Africa

(KV57/94) Department of Civil Engineering, University of the Witwatersrand

If the preferred option of waterborne sanitation for all South Africans is not feasible because of excessive, unaffordable cost to the country, then other adequate alternative sanitation options need to be pursued.

Against this background of concern, there appears to be limited understanding by the general public as well as many professional personnel in South Africa of the pollution risk from on-site sanitation. Allied to this is the probably erroneous assumption that there is no pollution risk associated with waterborne sewerage.

Thus, the project reviewed the current state of local and international knowledge of the topic and appraised existing guidelines. The research also addressed the objectives of guidelines for the environmental impact of on-site sanitation and proposed a means of disseminating this information. South Africa is unique in the world in that, in seeking to provide adequate sanitation for all, widespread use has been made of on-site sanitation in relatively high density urban areas. Because of these high densities, the researchers could not state categorically that: "Yes there is" or "no there isn't", pollution from on-site sanitation. But they do state emphatically that there is a risk of groundwater (and stream) contamination from these sources. Thus, the long-term effects are too significant to ignore, but difficult to determine.

Cost: R44 000
Term: 1993-1995

Review of rural sanitation in South Africa

(KV71/95) Palmer Development Group and Makhetha Development Consultants

This consultancy project was jointly funded by the WRC and the Mvula Trust. The research is aimed at supplementing a similar previous project, which evaluated the urban sanitation situation. The need for the work stems from the 21 m. rural and peri-urban residents (approximately 95%), who lack properly designed and constructed sanitation facilities.

Some 5 m. rural schoolchildren (90%) and half of the 1 100 rural clinics also lack adequate sanitation facilities.

In addition to reviewing the international experience and the current status of sanitation services in South Africa, the project also reports on sanitation priorities and household demand for sanitation and a participatory approach to understanding community needs and preference.

Four case studies were undertaken and these results were used to review rural sanitation technologies and to formulate proposals for optimal, affordable and appropriate sanitation options for the rural environment. Proposals are made for the financial, institutional and programme arrangements for facilitating sanitation provision. The establishment of a National Task Team to set up a National Sanitation Programme and to establish capacity at provincial and local level, is proposed and the policy framework to support this, described.

Cost: R100 000
Term: 1994-1995

New projects

Appropriate low-cost treatment of sewage reticulated in saline water, using the algal high-rate oxidation ponding (AHROP) system

(No 656) Department of Biochemistry and Microbiology, Rhodes University

The provision of waterborne sewerage for certain communities in South Africa remains difficult, given the poor availability of freshwater supplies. Many areas of the country, however, have copious volumes of brackish or saline water, including ground-, mine- and sea-water. The possibility of dual water reticulation systems for these communities has previously been suggested, where sewage is carried in a saline stream for treatment. The treatment options for saline sewage are, however, limited. Through other WRC projects Rhodes University has successfully investigated the application of the algal high-rate oxidation ponding (AHROP) system for the treatment of

saline tannery effluents.

The possibility of the application of the AHROP in small, disadvantaged communities such as Rietfontein (N. Cape) has arisen, where saline groundwater is the only available water source. It provides an opportunity for testing existing technology for the treatment of saline tannery effluents on the treatment of saline water sewage.

The aims of this 3-year project include the following:

- To evaluate the use of high-rate oxidation ponds for the treatment of sewage reticulated in saline water, in a laboratory-scale study
- To compare sources of saline water including sea-water and saline groundwater for the treatment of saline reticulated sewage effluent
- To evaluate the scale-up of the AHROP to a demonstration plant
- To evaluate the suitability of returning purified water to inland aquifers or the ocean, from which the reticulated waters were derived
- To investigate the recovery and value of the biomass obtained during the treatment of the above waste waters.

Estimated cost: R160 000
Estimated term: 1995-1997

Graded standards for landfilling in South Africa: Establishing appropriate affordable standards for disadvantaged communities

(No 670) Department of Civil Engineering, University of the Witwatersrand

Almost all of the research on the decomposition mechanisms, products, pollution potential and energy potential of refuse has been done on refuse from affluent societies. However, it has been established that the waste generated by a disadvantaged community differs considerably from that produced by an affluent community.

Therefore, the aims of this project include the following:

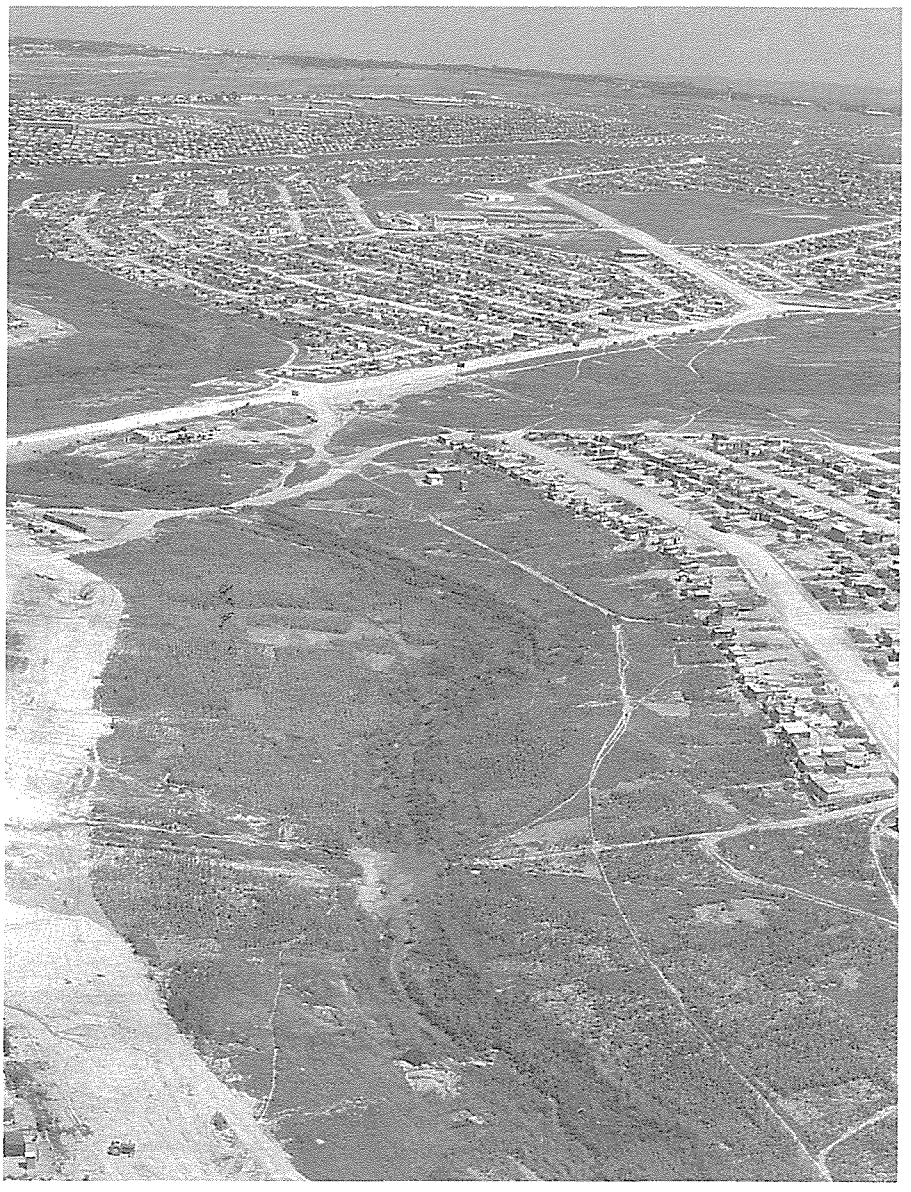
- To investigate and establish the surface- and groundwater pollution potential of household refuse from disadvantaged communities
- To study effective and affordable refuse disposal in these communities that will prevent surface- and groundwater pollution
- To compare the process and products of decomposition of refuse from disadvantaged communities with refuse from developed "rich communities".

Estimated cost: R344 000
Expected term: 1995-1996

Fog collection as a supplementary water source for small rural communities

(No 671) Department of Geography, University of the North

Studies conducted in Chile, Ecuador and Oman have shown that fog droplets can be collected by appropriately designed collectors to provide substantial volumes of water for both domestic use and livestock consumption. If this method of



A beautiful example of development control exercised to keep the floodplain of the Kaalspruit in Gauteng unoccupied.

water supply proves to be economically feasible in South Africa, it would undoubtedly impact positively on various aspects of life in rural communities which are isolated from conventional water supply systems.

This project aims to:

- Determine the fog-water collection potential along the West Coast and the Escarpment of Mpumalanga and the Northern Province, respectively
- Identify the extent of water "poverty" in small rural communities within the above-mentioned areas
- Determine the efficiency of various materials and designs for the collection of fog water
- Design a cost-effective fog-water collection and distribution system for a suitable community
- Document the country-wide potential of fog-water collection.

Estimated cost: R305 800
Expected term: 1995-1997

Guidelines for the evaluation of water resources for rural development with an emphasis on groundwater

(No 677) Institute for Water Research, Rhodes University

The success of a development project is largely determined by the process through which it is initiated and implemented, and the appropriateness of the water scheme to be developed. The above project will look at the latter point whilst concentrating on groundwater aspects which affect the appropriateness of a rural water supply scheme.

Although diversity in the developmental process is healthy, in the approach to assessing the appropriateness of a project it can lead to important factors being overlooked during the feasibility stage of a study. There are countless examples of inappropriate rural water supply schemes which result from the planners having failed to take all the contributing factors into account.

This project proposes to address and provide guidance on correcting these issues through the attainment of the following aims:

(i) Developing guidelines for assessing the water supply alternatives for relatively small-scale rural development projects.
(ii) Establishing the factors which affect the type of water source and infrastructural system to be developed. These factors fall within the categories of water source quantity and quality, demand, infrastructure, economics and management.
(iii) Developing guidelines on how to evaluate or assess the factors identified in (ii) above, and how to address the issues which arise from these factors.
(iv) Carrying out the initial development of a "Decision Support System" that presents a methodical, holistic approach to assessing the most suitable water source and infrastructure for rural water supply projects.

Estimated cost: R205 000
Expected term: 1995-1996

Development of a community-based integrated catchment management programme with special reference to water supply and sanitation in the Ntshongweni catchment

(No 684) Farmer Support Group, University of Natal

The Ntshongweni catchment is a microcosm of rural South Africa. Virtually all of the typical problems encountered in the various communities are found here. There are severe pollution problems from the Hammarsdale industrial complex, soil erosion in the Cliffdale area, invasive exotics in the Peacevale area, agricultural pollution from Tara Valley and faecal contamination from informal settlements.

Ntshongweni Dam is 60% silted up and so polluted that Umgeni Water recently decommissioned the dam. The area's history of co-operation between Inkatha Freedom Party and African National Congress supporters since 1989 bodes well for the possibilities of achieving results. The particular objectives of the research are to:

- Develop a framework for community participation in catchment management
- Assist local people in implementing ecologically and economically sound land-use practices
- Help appropriate agencies to understand local people's current attitudes and help in the development of educational programmes.

Estimated cost: R570 000
Expected term: 1995-1996

Occurrence and survival of protozoan parasites in source water and drinking water used by unserved rural communities

(No 685) Division of Water Technology, CSIR

The protozoan parasites, *Giardia* and *Cryptosporidium*, are recognised causes of diarrhoea in man and could cause acute, sporadic gastroenteritis in otherwise healthy people.

Informal settlements with no infrastructure have become common practice, resulting in increased levels of sewage pollution of drinking-water sources which coincide with increased levels of parasites. These unserved communities use surface water and groundwater, directly or after limited treatment. No data are available on the occurrence of protozoan parasites in water sources used by these communities and what effect the limited treatment has on parasites.

The objectives of this study are to investigate the occurrence and survival of protozoan parasites in the water used by developing communities for drinking purposes, and to devise appropriate guidelines for the treatment of the water.

Estimated cost: R300 000
Expected term: 1995-1996

Land-based effluent disposal and use: Development of guidelines and expert-systems-based decision support

(No 698) Division of Water Technology, CSIR

The negative impact of effluent disposal to land can often be effectively ameliorated if controlled and managed properly. An expert system which is a computer program with stored knowledge in a

form suitable for practical decision support, would be a useful medium for providing much-needed assistance in this regard.

The general aim of this project is to develop an expert system to give advice on, and to present regulatory conditions for, effluent-disposal-to-land permitting purposes. The expert system will also be tailored to assist in the following needs and functions:

- Presentation of relevant guidelines for the beneficial use of effluent for agriculture and forestry
- Identification of a suitable Integrated Environmental Management strategy for effluent-disposal or effluent-use permitting purposes
- Selection of cost-effective sewage treatment and effluent-to-land disposal facilities for communal purposes (e.g. schools, day-care centres, clinics, shopping areas) in rural developing communities.

Estimated cost: R260 000
Expected term: 1995-1996

Guidelines for the operation and maintenance of septic tank effluent drainage (STED) systems by communities in South Africa

(No 708) Division of Building Technology, CSIR

A septic tank effluent drainage (STED) sanitation system can provide an alternative sanitation option that is very similar to a conventional waterborne system at a reduced cost. STED sanitation systems can provide a solution to handling sewage in areas with limited infrastructure.

The project aims to improve the design, installation, operation and maintenance requirements of STED systems. The main product of the project will be guidelines for local water and sanitation committees. These guidelines will explain the STED process and set out operation and maintenance procedures to ensure optimum performance of STED systems.

Estimated cost: R145 000
Expected term: 1995-1997

Preparation of standard engineering drawings, specifications and guidelines for ventilated improved pit latrines in South Africa

(No 709) Division of Building Technology, CSIR

The RDP aims to provide sanitation services for all South Africans. The ventilated improved pit (VIP) latrine, when constructed and maintained properly, provides an adequate basic level of sanitation service that meets the environmental health requirements.

The project aims to improve the standard of VIP latrines by providing guidelines that will assist those responsible for sanitation programmes in ensuring that the VIP latrines they install meet health and user requirements. The importance of selected construction materials, the slope and direction of the roof, the function and role of the vent pipe, etc., will all be assessed to determine the importance of each relating to the performance of a VIP toilet.

Estimated cost: R90 000
Expected term: 1995-1996

Pilot study for the development of a GIS database on water and sanitation in South Africa

(No 710) Division of Water Technology, CSIR

The project aims to develop a pilot geographical information system (GIS) database on water and sanitation provision and investment for Northern Province. This pilot study may then be used in the development of a National Water Supply and Sanitation Information Management system.

The database is being developed to assist:

- The DWAF to plan and prioritise the water and sanitation needs of the region
- The DWAF and other stakeholders to monitor implementation progress, implementation constraints and the effectiveness of different investment policies at National and Provincial levels.

Estimated cost: R451 000
Expected term: 1995-1997

Biological processes in on-site low-flush volume sanitation systems

(No 712) Division of Water Technology, CSIR

Recently large numbers of on-site low-flush volume sanitation systems have been installed in several developing urban communities. Unfortunately some users of these on-site systems have encountered problems of odour developments, total failure of the system causing complete blockage at the toilet pan, and failure of soakaways. This has led to the rejection of these low-flush volume toilets by the developing communities.

This project aims to evaluate the biological processes that take place in tanks and soakaways of on-site sanitation systems, as well as the physical design of the various components. The study will determine whether the size and shape of the tank has any effect on the quality of the final disposed effluent. The effect that the number of users and the addition of chemical disinfectants has on the performance of on-site sanitation systems, will also be assessed.

This project will involve all the known manufacturers of these systems to ensure that all possible considerations are taken into account.

Estimated cost: R296 200
Expected term: 1995-1996

Socio-biological study of the aquatic resources and their utilisation in an underdeveloped rural region, the Mutshindudi River catchment

(No 714) Department of Zoology, University of Venda

The research conducted within this broad project is aimed at providing a scientific basis for the implementation of the RDP while at the same time promoting the sustainable utilisation of water and associated organisms in the Northern Province. The project will address the socio-economic composition of the population, the effect of land-use patterns of the area on the water resource, factors responsible for the deterioration of water resources, health and hygiene aspects associated with water use and the importance of the aquatic plants,

animals and riverine vegetation to rural communities for food, and medicinal purposes.

Estimated cost: R359 000
Expected term: 1995-1998

Quantitative determination and removal of nitrogenous pollutants from natural waters

(No 715) University of Bophuthatswana

Some of the natural water resources of the Northwest Province have levels of nitrates (>10 mg/*l*) which are above the safe levels for drinking water, and are likely to cause methaemoglobinaemia in infants. In addition, when nitrates are reduced to nitrites, these react with amines in the environment to form nitrosamines. These compounds are not only carcinogenic, but also have mutagenic and teratogenic properties.

Using electrochemical analytical methods, the main nitrogenous pollutants in the water resources of the region will be identified. Improvements to existing analytical methods or new methods of analysis will be investigated for these compounds, and the water resources of the region will be surveyed to map the occurrence of the various nitrogenous compounds.

Estimated cost: R304 000
Expected term: 1995-1997

Pollution of domestic water supply and health-related problems in the rural areas of the Molopo region of the Northwest Province

(No 724) Department of Nursing Science, Chemistry and Agriculture, University of Bophuthatswana

Water-related problems have been identified and linked to health and quality of life in the rural areas of the Molopo District of the Northwest Province.

The aims of this project are to identify the sources of water used by a selected number of villages in the Molopo region and to determine the extent and nature of pollution. A survey of the perceptions of the residents with regard to water pollution and its prevention as well as the relationship between polluted water supply and ill-health will be made.

Intervention studies and self-help projects based on the results of the investigations will be undertaken. An education project to inform the village inhabitants on the utilisation of water sources for safe household usage will be performed.

Estimated cost: R587 800
Expected term: 1995-1997

Effects of water supplies, handling and usage on water quality and quantity in relation to health indices in the Eastern Cape Province (Prowater Health)

(No 727) Department of Development Studies, University of Fort Hare

The role of water as a vehicle for the spread of diseases is well known. The prevention of any communicable diseases requires that the cycle of disease transmission be interrupted. Depending on the prevailing transmission pathways, different interventions in water supply and sanitation, are required.

This project will examine the effects of water supply, handling and usage of drinking, farming and other household activities on water quality in the rural and peri-urban areas of the Eastern Cape region. The microbial and physio-chemical quality of the water provided to the communities in this area will be examined and related to health indices of the study population.

Estimated cost: R393 000
Expected term: 1995-1997

Research projects

Completed

- **KV49/94** and **KV73/95** Evaluation of water supply to developing urban communities in South Africa (Palmer Development Group in association with University of Cape Town – Department of Civil Engineering)
- **KV56/94** Prepayment water metering for South Africa (Eskom – Technology Research and Investigations)
- **KV57/94** Environmental impact of on-site sanitation: A literature review with particular application to South Africa (University of the Witwatersrand – Department of Civil Engineering)
- **KV71/95** Review of rural sanitation in South Africa (Palmer Development Group and Makhetha Development Consultants)

Current

- **346** Study of the relationship between hydrological processes and water quality characteristics in the developing Zululand coastal region (University of Zululand – Department of Hydrology)
- **384** Water resources and sanitation systems sourcebook with special reference to KwaZulu-Natal (University of Natal – Department of Economics)
- **386** Development of a cross-flow microfilter for rural water supply (University of Natal – Department of Chemical Engineering and Umgeni Water)
- **435** Development of a training programme on community water supply management for village water committees (CSIR – Division of Water Technology and Appropriate Technology Information)
- **480** *Per capita* water demand in developing communities (Water Systems Management)
- **514** Groundwater contamination as a result of Third-World type urbanisation (CSIR – Division of Water Technology)
- **519** Development of programmes to combat diffuse sources of water pollution in residential areas of developing communities (Afrosearch CC)

- **520** Guidelines on appropriate technologies for water supply and sanitation in developing communities (CSIR – Division of Water Technology)
- **521** Water scheme cost recovery (Umgeni Water)
- **539** Development of a dynamic cross-flow sand filter for rural water treatment (CSIR – Division of Water Technology)
- **544** Determination of sludge build-up rates in septic tanks, biological digesters and pit latrines in South Africa (CSIR – Division of Building Technology)
- **562** Effect of water supply, handling and usage on water quality in relation to health indices in developing communities (CSIR – Division of Water Technology)
- **586** Development of a decision support system for the selection of the most appropriate sanitation option for developing communities (Umgeni Water)
- **598** Appropriate management of urban runoff in South Africa (University of Witwatersrand – Water Systems Research Group and CSIR – Division of Water Technology)
- **599** Co-disposal and composting of septic tank and pit latrine sludges with municipal refuse (CSIR – Division of Water Technology and La Trobe Associates)
- **603** Development of effective community water supply systems using deep and shallow-well handpumps (CSIR – Division of Water Technology)
- **622** Rapid quantitative evaluation of water quality using a modified biological test (University of the Witwatersrand – Department of Microbiology)
- **629** Evaluation of solid waste practice in developing urban areas in South Africa (Palmer Development Group)
- **630** Community participation and education in water resources management and environmental awareness (Amanzi Esizwe)
- **631** Assignment of a financial cost to pollution from on-site sanitation, with particular reference to Gauteng (University of the Witwatersrand – Department of Civil Engineering)
- **649** Assessment of common problems associated with drinking water disinfection in the developing areas (CSIR – Division of Water Technology)
- **651** Appropriate low-cost sewage treatment using the advanced algal high-rate oxidation pond (Rhodes University – Department of Biochemistry and Microbiology)

New

- **656** Appropriate low-cost treatment of sewage reticulated in saline water, using the algal high-rate oxidation ponding (AHROP) system (Rhodes University – Department of Biochemistry and Microbiology)
- **670** Graded standards for landfilling in South Africa: Establishing appropriate affordable standards for disadvantaged communities (University of the Witwatersrand – Department of Civil Engineering)
- **671** Fog collection as a supplementary water source for small rural communities (University of the North – Department of Geography)
- **677** Guidelines for the evaluation of water resources for rural development with an emphasis on groundwater (Rhodes University – Institute for Water Research)
- **684** Development of a community-based integrated catchment management programme with special reference to water supply and sanitation in the Ntshongweni catchment (University of Natal – Farmer Support Group)
- **685** Occurrence and survival of protozoan parasites in source water and drinking water used by unserved rural communities (CSIR – Division of Water Technology)
- **698** Land-based effluent disposal and use: Development of guidelines and expert-systems-based decision support (CSIR – Division of Water Technology)
- **708** Guidelines for the operation and maintenance of septic tank effluent drainage (STED) systems by communities in South Africa (CSIR – Division of Building Technology)
- **709** Preparation of standard engineering drawings, specifications and guidelines for ventilated improved pit latrines in South Africa (CSIR – Division of Building Technology)
- **710** Pilot study for the development of a GIS database on water and sanitation in South Africa (CSIR – Division of Water Technology)
- **712** Biological processes in on-site low-flush volume sanitation systems (CSIR – Division of Water Technology)
- **714** Socio-biological study of the aquatic resources and their utilisation in an underdeveloped rural region, the Mutshindudi River catchment (University of Venda – Department of Zoology)
- **715** Quantitative determination and removal of nitrogenous pollutants from natural waters (University of Bophuthatswana)
- **724** Pollution of domestic water supply and health-related problems in the rural areas of the Molopo region of the North-west Province (University of Bophuthatswana – Department of Nursing Science, Chemistry and Agriculture)
- **727** Effects of water supplies, handling and usage on water quality and quantity in relation to health indices in the Eastern Cape Province (Prowater Health) (University of Fort Hare – Department of Development Studies)

CONTACT PERSONS

- **Mr HC Chapman** (Provision of Services)
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3

Drinking water

The production and supply of a potable water of acceptable quality at an affordable cost to all consumers are national priorities and pose special challenges to the whole of the water industry. In meeting these challenges and dynamic requirements, research support is indispensable. Such support is, *inter alia*, provided in the form of on-going WRC funded projects, under guidance of the Strategic Plan for Research on Potable Water Treatment. The 2 main challenges in the treatment and supply of a potable water, requiring research support, are the following:

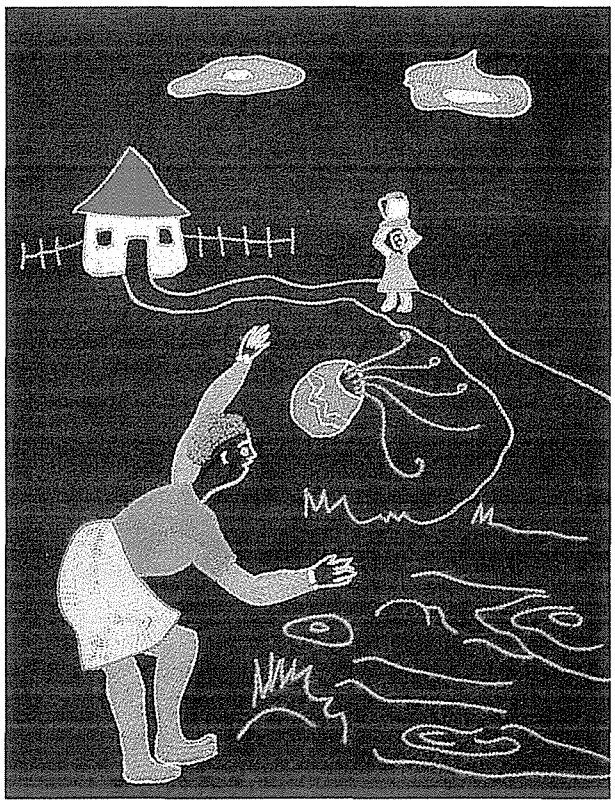
- **Ensuring acceptable water quality**

  Supplying a drinking water of acceptable microbiological and chemical quality to an increasingly critical consumer, from our increasingly polluted sources, poses special problems. These problems are aggravated by long distribution lines and high temperatures. Although research projects focus mainly on microbiological quality, chemical micropollutants and aesthetic aspects also receive due attention.

- **Cost-effectiveness**

  Urbanisation of South Africa's population is steadily on the increase, resulting in the influx of mainly lower-income families. Increased effort is being made under the RDP to provide safe drinking water to disadvantaged communities – including those in urban areas. The result is that great pressure is exerted on available funding and other resources. This in turn, demands increasing effort into research on more cost-effective water treatment and supply options.

The following main research areas, i.e. **Water Treatment and Reclamation, Drinking-water Quality and Health Aspects** and **Urban and Rural Water Supply** are addressed in this chapter.



Grace Makwana.

Water treatment and reclamation

Assisted by the Strategic Plan for Research on Potable Water Treatment, this research area focuses on the development, improvement and selection of cost-effective plant and processes to supply a safe drinking water which complies fully with the guidelines for treated water quality.

Because of increased pollution of the surface water resources, the purification of polluted and eutrophic water is receiving special attention. Another area of concern remains the effective treatment of soft, coloured waters, and a number of projects are addressing this issue. Two projects are currently directed at the selection and design of water treatment processes under South African conditions, while another concentrates on the selection of package water treatment plants.

Drinking-water quality and health aspects

It is of vital importance not only to provide people with water to within 200 m from their homes, but also to ensure that the water will be of good quality. The emphasis of new research in this area is shifting towards direct involvement in, and participation by, the developing communities.

The importance of this approach is stressed in an *Atlas of Potential Waterborne Diseases* that will become available early in 1996. The importance of educating people to store water safely in their homes and to prevent contamination of a good quality water is also accentuated.

Rapid microbiological detection methods that are applicable under South African conditions require urgent investigation. Pathogens responsible for specific waterborne diseases could then be identified in a short time and treatment started to prevent loss of life. Such rapid detection methods will be the focus of two of the projects which will commence in 1996.

Rural and urban water supply

Water restrictions have again been introduced in many areas of South Africa as a consequence of lower than average rainfall and increased demands on existing water supplies. Accelerated urbanisation has necessitated the urgent need to conserve water in all sectors.

To meet the challenge, the Minister of Water Affairs and Forestry, Prof Kader Asmal, has initiated a National Water Conservation Campaign which is set to run for one year after which it will be reviewed. The goal of this initiative is the sustainable, efficient and equitable supply and use of water in South Africa.

This concept forms the fundamental basis for future development of the nation, especially if one accepts that water is likely to become the single most crucial limiting factor to development; and within the shorter rather than the medium term.

The research component of this challenge is largely focused on people issues such as participation, payment, maintenance, capacity, responsibility, education and also training. From this appreciation was recognised the need for co-ordination, on a very wide front, of all of the activities and initiatives currently in vogue. This led to the birth of a Co-ordinating Committee specifically mandated to look after the water supply and sanitation research interests of the urban and rural communities. Obviously, this is an area which is not the exclusive domain of South Africa and, as such, we anticipate some new initiatives to interact with other African countries and also those active in Africa, with a view to sharing experiences, gathering data of mutual interest and building on work done by the host of people very active all over the world.

Completed projects

Occurrence of protozoan parasites in South African drinking water

(No 451) Division of Water Technology, CSIR

The recovery of *Giardia* cysts was compared using membrane filtration and ultrafiltration. Similar recoveries were obtained, but the ultrafiltration method has the advantage of co-processing the same water sample for the analysis of enteric viruses and protozoan parasites, thus reducing the cost of analysis significantly.

The occurrence of *Giardia* cysts and *Cryptosporidium* oocysts in South African raw and treated water was investigated by studying source and treated water obtained from several water purification works. The findings were that many South African untreated source waters were contaminated with both.

Raw water samples taken at the purification works under investigation, tested positive for cysts and oocysts and only a small percentage of raw water was free of protozoan parasites. The efficacy of 2 water treatment plants in removing protozoan parasites was evaluated at different stages of treatment and found to be effective.

The presence of protozoan parasites can only be detected directly since the microbial indicators of water quality cannot be used as an indication of the presence of protozoan parasites.

Cost: R363 500
Term: 1992-1994

Characterisation of South African media for sand filtration

(No 472) Department of Civil Engineering, Rand Afrikaans University

No uniform, generally accepted method of media specification exists for rapid gravity filtration in South Africa. This study characterised local, commercial filter-sand and anthracite with regard to durability, particle size distribution, sphericity, density and solubility under acid and alkaline conditions.

The study found that local silica sand fared well against foreign specifications, except for the (generally too high) uniformity coefficient. Tables with requirements and specifications for the correct filter sand, are included in the report as "tentative South African specifications". Models employed for the difficult design aspect of bed expansion were also evaluated, and it was found that some models could predict bed expansion to within an error of as low as ±3%.

Cost: R74 000
Term: 1992-1993

Evaluation of rapid methods for the detection of indicator organisms in water

(No 610) Division of Water Technology, CSIR

The time to perform a conventional membrane filter test to confirm the presence of indicator organisms in water is about 72 h. The Colisure and Colilert methods, described and tested during this project, reduced the time to 24 h. This is of great importance as the rapid detection of indicator organisms could prevent epidemiological outbreaks of waterborne diseases. These methods can be used for the early detection of sewage contamination of drinking water, as well as the possible pollution of surface water. Under South African circumstances, Colilert appeared to be the better of the 2 methods tested.

The major cost saving when using Colilert and Colisure lies in the decreased time and labour necessary to perform the tests and not in the cost of equipment and chemicals.

Cost: R93 700
Term: 1994

Education and training of watercare operators – Part 2

(KV66/94) MTI Manpower Consulting Services

This report documents the proceedings of a workshop in which the future direction of education and training of watercare operators was examined. The workshop began with a survey of the existing infrastructure and noted the problems experienced. Following this, the questions which the workshop was to be asked to address during strategic planning for the future direction of education

and training of personnel, were listed. The guidelines produced by the workshop participants concerned the following aspects of the education and training of personnel:

- The structuring and objectives of education and training of watercare personnel
- The content, delivery and scheduling system of future education and training programmes
- Guidelines for testing and examination, trainee certification, employment of staff and obtaining funds for the implementation of the national strategy.

The final part of the report makes proposals for the implementation of a national plan for the education and training of watercare personnel.

Cost: R38 500
Term: 1993

Development of a model for the projection of water demands in the supply area of the Bloemarea Water Board to the year 2020

(No KV52/94) Institute for Economic Research, University of the OFS

Accelerated urbanisation and the problems associated with it, place ever-increasing pressure on water authorities for dedicated planning to satisfy future water demands of communities.

For water boards and other large bulk water supply authorities, the only way of undertaking this planning exercise is through mathematical modelling. However, very few examples existed, necessitating the Board to approach the University of the OFS to develop the necessary model by acquiring all the relevant data concerning demography, ethnic, socio-economic, economic, techno-economic, natural and diverse factors as well as water restrictions. The model had to satisfy the following conditions:

- It should be able to reflect historical water consumption reasonably well by considering rainfall, price and population factors
- It must project water consumption by using predicted values of the relevant variables
- To enable the model to be applied in a specific town or supply area, it is essential that local available data can be used.

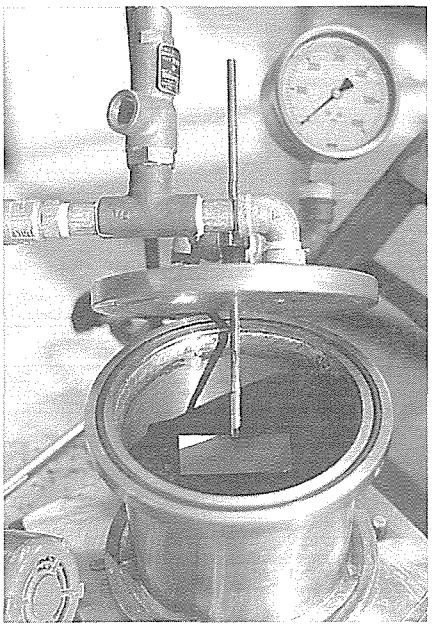
Two approaches for the model were tested. The structure-analysis method calculates water demand from expected future changes in the structure of the area such as population tendencies, expected rise in standards of living, and economic and development growth, while the regression-analysis method is based on available historical data and tendencies.

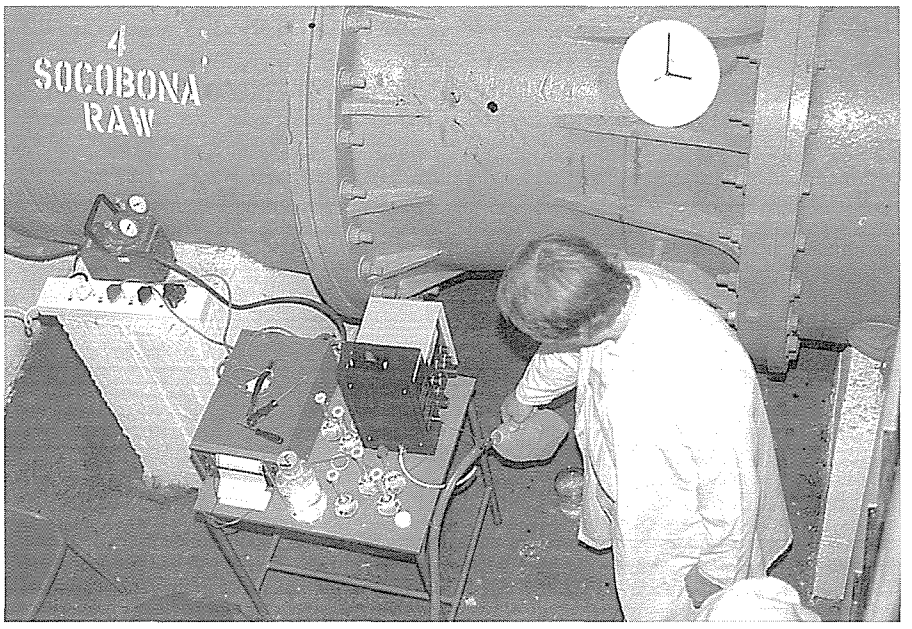
The former method predicted a growth from 50 x 10^6 k*l* to 76 x 10^6 k*l* by 2020, while the latter method predicted a change from 61 to 91 x 10^6 k*l* over the same period.

The models were also tested on data from Pretoria and Kimberley which showed that regression coefficients cannot be transferred, as is, from one area for use in another area. New coefficients will need to be determined in each application of the model.

Cost: R46 000
Term: 1993-1994

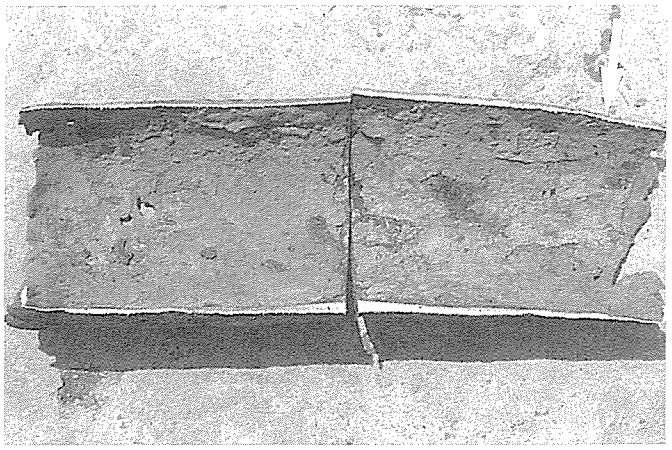
Below: Algal rupture simulation chamber – used to simulate the rupture of algae in the Inanda Dam to Wiggins Waterworks and Nagle Dam to Durban Heights Waterworks systems.



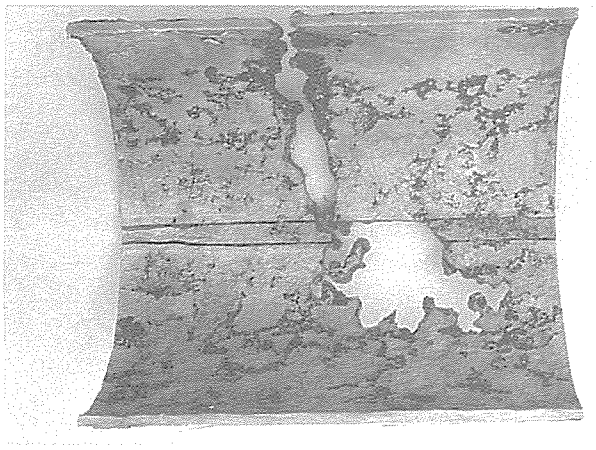


In situ sampling of lithium and algae at Durban Heights Waterworks.

Evaluation of water pipe leaks in the Johannesburg municipal area:



General type of corrosion (thinning wall arrowed).



Stray current on pipe samples after cleaning (note melted parts).

Occupational competencies for the occupation of watercare operator and watercare manager

(KV55/94) MTI Manpower Consulting Services

This consultancy addressed the need for a thorough knowledge of the occupational competencies required for each of the functional competencies defined in a previous report (KV35/92) as an essential step in the development of curricula. The report is presented as a series of tables, each listing the occupational competencies for a specific functional competency and, in addition, the levels at which both personnel in the industry and in educational institutions serving the industry would expect an employee to be able to perform each task.

Cost: R85 000
Term: 1991-1993

New projects

Evaluation and optimisation of a cross-flow microfilter for the production of potable water

(No 662) Pollution Research Group, University of Natal

The supply of potable water to rural and peri-urban areas is a national development priority. This may be effected by the installation of package microfiltration plants which can operate at full capacity within days of purchase. Cross-flow microfiltration has gained recognition as a technology which can produce a high quality water at an economically viable production rate. Certain modifications have to be implemented in existing equipment to render it robust, reliable, cost-effective and easy to clean. The dead-end mode of operation of the cross-flow microfilter appears to be a very attractive option – yielding a similar permeate production rate to the normal high-velocity cross-flow microfiltration, but at a significantly reduced energy consumption. Such a mode of operation may be ideal for use in rural areas.

Estimated cost: R383 000
Expected term: 1995-1996

Pricing water as an economic resource

(No 678) Palmer Development Group

Water is economically a scarce commodity with increasing and high marginal cost of supply. Currently price signals from the supply side are significantly distorted and arguably lead to inefficient and inequitable conservation and allocation decisions. The objectives of the research project are mainly to review international trends in water pricing theory and practice; propose pricing policy principles; and develop a pricing methodology. The proposed approach is a case study of residential and commercial water use in a highly urbanised and largely rural catchment. Secondary data will be used to determine, *inter alia*, short- and long-term price elasticities, marginal costs and tariff structures, and assess the effectiveness of the proposals. The information is expected to fulfil requirements of policy-makers, water resource and water utility managers.

Estimated cost: R571 300
Expected term: 1995-1998

Compilation of a computerised, diagnostic system for algal-related water purification problems

(No 679) Scientific Services, Rand Water

Certain algal species prevalent in South Africa's eutrophic waters are more problematic than others in that they are more difficult to remove, cause more taste and odour problems and generally increase the cost of water purification. A need exists at water treatment utilities to rapidly identify these problematic algal species and to take corrective action.

The aims of the project are therefore:

- To compile a diagnostic identification system, allowing treatment plant personnel to identify problematic algae from computerised photographs of these algae
- To provide plant personnel with an accompanying computerised decision-support system to subsequently assist them in taking the necessary and cost-effective corrective actions.

Estimated cost: R446 400
Expected term: 1995-1998

Treatment of eutrophic waters using pre- and intermediate ozonation, peroxone and Pica carbon

(No 694) Process Services, Umgeni Water

This project entails the first comprehensive study to provide guidelines for the treatment of South African eutrophic waters using advanced oxidation in conjunction with activated carbon filters. As surface waters become more organically polluted and eutrophic, water utilities will increasingly be compelled to implement this technology. Comparative studies on a new type of activated carbon to limit regeneration frequency could have a positive effect on limiting the costs of using activated carbon. These guidelines, and especially the test protocol to be incorporated into the guidelines, may be of value to all potential users of such processes.

Estimated cost: R600 000
Expected term: 1995-1997

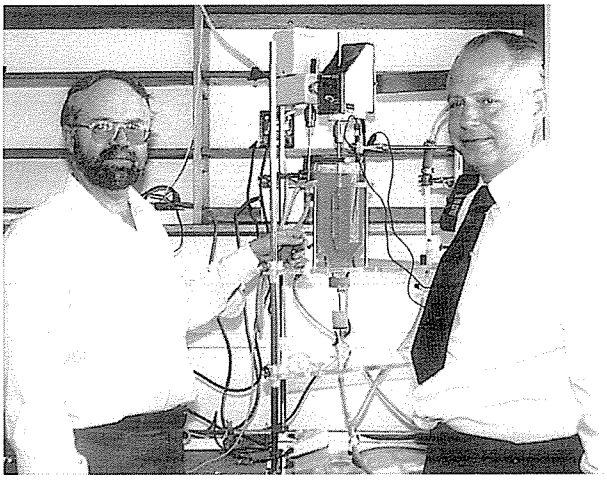
Prediction of chlorine losses from potable water in pipeline systems

(No 704) Scientific Services, Rand Water and Department of Civil Engineering, Rand Afrikaans University

Even though the effective disinfection of purified water right up to the consumer's tap is recognised as being of crucial importance, the prediction of chlorine losses in the distribution system remains very problematical. The aims of this project are to overcome these problems through:

- Determination of typical loss factors for various surfaces found in these distribution systems
- Compilation of a computerised model to allow more accurate prediction of initial chlorine dosage levels required for various distribution subsystems and operating conditions, to ensure adequate free chlorine at the consumer end.

Estimated cost: R99 000
Expected term: 1995-1996



Dr J Clasen (right), a visiting scientist of the Wahnbachtal Sperrenverband Siegburg, Germany, seen together with Prof AJH Pieterse (left) of the Potchefstroom University, South Africa. Both are involved in research on occurrence and distribution of algal species.

Re-evaluation of the existing guidelines for urban and industrial water supply, based on measured water uses. Phase 1: Pretoria supply area

(No 705) Department of Civil Engineering, University of Pretoria

Some 15 years' water consumption data, which can be related to factors such as the size of and the tax payable on premises, price elasticity, etc., are currently still available on the Pretoria City Council's computer network.

The project aims to extract and analyse the data to determine, *inter alia*, the effect of water restrictions, micro-climate and seasons on the water consumption of different water users. The results of the analysis will also serve to re-evaluate the guidelines pertaining to water provision for residential areas as currently embodied in the Guidelines for the Provision of Engineering Services in Residential Townships, which were published in 1982 by the Department of Community Development.

Estimated cost: R96 600
Expected term: 1995

CONTACT PERSONS

- **Mr G Offringa** (Water Treatment and Reclamation)
- **Mrs APM Oelofse** (Drinking-water Quality and Health Aspects)
- **Mr HC Chapman** (Water Supply, Water Loss Control and Corrosion)
- **Dr TC Erasmus** (Cross-flow Microfiltration)
- **Dr SA Mitchell** (Bioassaying)
- **Dr HM Saayman** (Membrane Applications)

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Research projects

Completed

- **451** Occurrence of protozoan parasites in South African drinking water (CSIR – Division of Water Technology)
- **472** Characterisation of South African media for sand filtration (Rand Afrikaans University – Department of Civil Engineering)
- **610** The evaluation of rapid methods for the detection of indicator organisms in water (CSIR – Division of Water Technology)
- **KV55/94** Occupational competencies for the occupation of watercare operator and watercare manager (MTI Manpower Consulting Services)

Completed continued

- **KV52/94** Development of a model for the projection of water demands in the supply area of the Bloemarea Water Board to the year 2020 (University of the OFS – Institute for Economic Research)
- **KV66/94** Education and training of watercare operators – Part 2 (MTI Manpower Consulting Services)

Current

- **259** Effect of water quality and chemical composition on the corrosivity in mild steel pipelines (Rand Water)
- **280** Evaluation of full-scale flotation-filtration and chlorine dioxide plants (OFS Gold Fields Water Board)
- **282** Development of a combination of sedimentation, flotation and sand filtration processes for water treatment (SEDIDAFF) (CSIR – Division of Water Technology)
- **354** Evaluation and development of deep-bed filtration for the treatment of South African surface waters (CSIR – Division of Water Technology and Local Government Affairs Council)
- **358** Development of guidelines for toxicity bioassaying of drinking and environmental waters in South Africa (CSIR – Division of Water Technology)
- **363** Development and evaluation of small-scale potable water treatment equipment (University of Natal – Department of Chemical Engineering and Umgeni Water)
- **381** Corrosion performance of various non-metallic piping materials and coatings in potable water (CSIR – Division of Materials, Sciences and Technology)
- **383** Holistic approach to affordable planning and maintenance of water and sewer systems (Water Management Services)
- **443** Compilation of guidelines for the use of peroxone and other oxidants in the treatment of eutrophic water (CSIR – Division of Water Technology)
- **446** Ozonation in the production of potable water from polluted surface water (University of Pretoria – Department of Chemical Engineering, Division of Water Utilisation Engineering and Rand Water)
- **449** Evaluation of non-conventional disinfection technologies for small water systems (CSIR – Division of Water Technology)
- **450** Performance criteria for package water treatment plants (Umgeni Water and University of Natal – Department of Chemical Engineering, Pollution Research Group)
- **470** Application of health risk assessment techniques to microbial monitoring data (CSIR – Division of Water Technology)
- **488** Optimisation of the Rand Water system (University of the Witwatersrand – Water Systems Research Group)
- **489** Development of procedures for the control of unaccounted-for water in water distribution systems and for the reduction of water loss (De Leuw Cather Inc.)
- **504** Guide for water purification and plant design: Phases 2 and 3 (Dr FA van Duuren)
- **534** Guidelines for the treatment of Eastern and Southern Cape coloured water (CSIR – Division of Water Technology)
- **537** Guidelines to coagulation and flocculation for South African waters (Pavel Polasek Association)
- **540** Evaluation of the use of bacteriophages as indicators for water quality (University of Pretoria – Department of Medical Virology)
- **541** Bio-degradable organic compounds and microbial regrowth in drinking water (Rand Water)
- **549** Algal toxins in drinking-water supplies (CSIR – Division of Water Technology and Umgeni Water)
- **557** Optimal operation of combined flotation/filtration of eutrophic surface water (Rand Afrikaans University – Laboratory for Energy)
- **558** Algal rupture – Further investigation (Umgeni Water)
- **567** Occurrence and distribution of algal species and related substances in a full-scale water purification plant (University of the OFS – Department of Botany and Genetics)
- **568** Development of an Exxpress unit for the production of potable water and the dewatering of waterworks sludges (Umgeni Water)
- **584** Atlas of potentially water-related disease in South Africa (University of Cape Town – Department of Community Health)
- **587** Evaluation of water pipe leaks in the Johannesburg municipal area (CSIR – Division of Materials, Sciences and Technology)
- **591** Study for the provision of point-source water by air-gap membrane distillation (University of Stellenbosch – Institute for Polymer Science)
- **611** Development of procedures for biodegradability testing of organic chemical compounds (CSIR – Division of Water Technology)
- **613** Stabilisation of aggressive and corrosive waters (CSIR – Division of Water Technology)
- **614** Expert system for water treatment plant design and analysis (Wates, Meiring and Barnard Inc., Sutherland and Ass.)
- **615** Modelling the causes of algal blooms in impoundments of the Umgeni catchment and the consequences for potable water treatment (Umgeni Water)
- **621** Balancing tank control application (Watson Edwards Inc.)
- **628** Leak detection from municipal mains water systems in the PWV area using environmental isotopes (University of the Witwatersrand – Schonland Research Centre for Nuclear Sciences)
- **648** Application of computational fluid dynamics to improving the design and operation of water and waste-water treatment plants (University of Natal – Department of Chemical Engineering)

New

- **662** Evaluation and optimisation of a cross-flow microfilter for the production of potable water (University of Natal – Pollution Research Group)
- **678** Pricing water as an economic resource (Palmer Development Group)
- **679** Compilation of a computerised diagnostic system for algal-related water purification problems (Scientific Services – Rand Water)
- **694** Treatment of eutrophic waters using pre- and intermediate ozonation, peroxone and Pica carbon (Umgeni Water)
- **704** Prediction of chlorine loss from potable water in pipeline systems (Rand Afrikaans University – Department of Civil Engineering)
- **705** Re-evaluation of the existing guidelines for urban and industrial water s upply, based on measured water uses Phase 1: Pretoria supply area (University of Pretoria – Department of Civil Engineering)

4

Municipal effluents

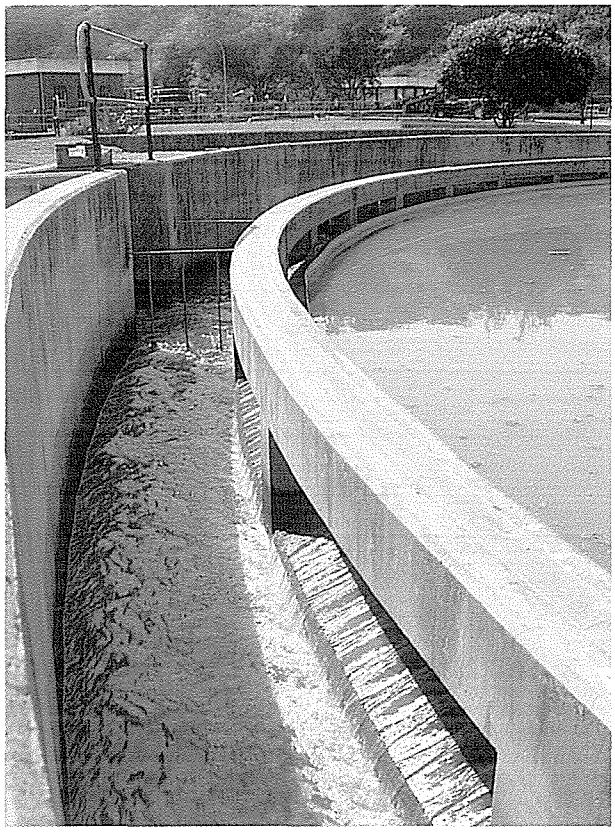
Research into the treatment of municipal effluents for the production of the best possible effluent concomitant with the available technology is important for South Africa. The prolonged drought which the country as a whole has been facing for the past few years continued during 1995, and this situation highlights our dependence on the discharge of high quality effluent into rivers for reuse downstream. Research is continuing on the optimisation of the large nutrient removal activated sludge plants as well as the upgrading (either mechanically or by management) of older works such as biofilter or oxidation ponds.

Research on nutrient removal from effluents high in nutrients (N and P) but low in organic matter (COD), long a problem in biological nutrient removal (BNR) plants, has been identified as having a high priority. Sludge dewatering liquors from BNR plants have often, in the past, been irrigated as a means of disposal. Some local authorities operating within the area affected by the special phosphate standard are now accepting septic tank effluent from some developments. This effluent cannot be kept separate from the mainstream, and the imbalance of nutrients to COD means that nutrients cannot be removed solely by biological means.

The PETRO process, which combines oxidation ponds with biofilters to produce a high quality effluent, continues to perform well. A follow-up project on this process was started during 1995 specifically researching the microbial processes such as the ability of the process to remove algae from oxidation pond effluent.

The Co-ordinating Committee for Municipal Waste Water met during the year and, in addition to giving guidance on proposals submitted for funding in 1996, also completed a review of the research plan for the field. This task had been made necessary by the transfer of the two most important goals to the Co-ordinating Committee for Research on Water and Sanitation in Developing Rural and Urban Communities. The new research plan is available from the WRC.

This field comprises **Sewage Purification, Sewage Sludge Treatment and Disposal**, and **Wetlands**.



Completed projects

Full-scale pilot-plant studies on phosphate crystallisation in biological systems

(No 366) Division of Water Technology, CSIR and City Council of Pretoria

To protect the environment the levels of phosphate in municipal discharges must be reduced. An alternative to conventional removal methods is phosphate crystallisation technology which exploits the best characteristics of the chemical, physical and biological driving forces in an integrated system.

Using a pilot-scale fluidised-bed crystalliser erected at Pretoria's Daspoort activated sludge plant, the study aimed to establish the critical design and operating requirements of the system.

The study revealed, *inter alia*, that:

- Suitable quartz sand can be used as crystallisation seed material in the fluidised bed
- The crystalliser influent Ca:P mass ratio should be as close as possible to the 2:1 stoichiometric requirement
- Water with a high alkalinity requires effective CO_2 degassing to prevent the precipitation of $CaCO_3$ in preference to hydroxyapatite
- Appropriate automated pH control is an absolute necessity for effective performance
- If CO_2 removal is necessary, the treatment costs amount to R2,11/m^3. This reduces to R1,02/m^3 if degassing is not essential.

Due to practical difficulties, no full-scale evaluation of the crystallisation system was undertaken.

Cost: R390 000
Term: 1991-1993

Development of electro-osmotic sludge dewatering technology

(No 427) Division of Water Technology, CSIR

During this project a pilot-scale electro-osmotic filter belt press for sludge dewatering was tested. The principle used by this method differs from that used by other electro-osmotic processes. The

small size of the pilot plant made direct comparisons with full-scale plants difficult for reasons such as the increased edge effect of the narrow belt used by the pilot plant. However, it was shown that, on certain sludges, the electro-osmotic filter belt press could achieve up to 45% solids with an energy consumption (in kWh/kg dry solids) of 0,08 to 0,13. This compares favourably with the power consumption of conventional dewatering devices. The process is currently being further developed by the Industrial Development Corporation and Steinmüller.

Cost: R396 500
Term: 1992-1993

Bio-augmentation technology for waste-water treatment in South Africa

(No 429) Division of Water Technology, CSIR

During this project recommendations were made for the development of guidelines for the application of this emerging technology in South Africa as it is already a major industry in the developed world. A standard protocol was also developed for the testing of various products so that their performance could be compared. Techniques for the isolation and storage of suitable micro-organisms are described, and a successful full-scale case study is described and priced.

Cost: R357 100
Term: 1992-1994

Bioremediation technology for the treatment of contaminated seepage water and soil in South Africa

(No 543) Division of Water Technology, CSIR

This project covers the bioremediation of contamination by petrochemical hydrocarbons. During laboratory studies it became apparent that existing methods for the recovery of phenol from soil were inadequate, so a new technique, giving improved recoveries, was developed.

A survey of the current use of bioremediation by South African industry is given. Various methods of applying bioremediation are also described, and the project closed with the analysis of a full-scale application of the technology.

Cost: R453 200
Term: 1993-1995

New projects

Determination of dissolved carbon load in raw and other sewage, and the determination of a relationship between COD and DOC (chemical oxygen demand and dissolved organic carbon)

(No 668) East Rand Water Care Company

Currently, chemical oxygen demand (COD), although being the standard for the discharge of waste waters, cannot be incorporated into sewage works automation. Dissolved organic carbon (DOC) can, on the other hand, be used for automating a plant.

The aims of this project, therefore, include: Finding the ratio between COD and DOC in various locations on an activated sludge plant; investigating the use of organic carbon loading in the control of aeration and investigating the effect of the various carbon ratios on aspects of micro-organism growth and electrical energy input into the activated sludge plant.

Estimated cost: R100 000
Expected term: 1995-1996

Laboratory and pilot-plant bioreactor development for remediation of metal-contaminated waste water using activated sludge as biosorbent

(No 688) Department of Biotechnology, Technikon Natal

In recent years the disposal of heavy metals to the environment has received much attention from environmentalists and legislators. Their concern stems from the toxicity and hazardous nature of many of these pollutants. Activated sludge is a biological adsorbent whose potential to remove heavy metals from industrial effluents has already been demonstrated in a laboratory-scale reactor. The present study will investigate the feasibility of developing a full-scale bioreactor for the treatment of industrial waste waters. It is envisaged that the process will be inexpensive (since the biosorbent is a waste material), efficient and reasonably flexible in operation.

Estimated cost: R256 000
Expected term: 1995-1996

Treatment of waste waters with high nutrients (N and P) but low organic (COD) contents

(No 692) Department of Civil Engineering, University of Cape Town

During this project, technologies for treating waste waters high in nutrients (N and P) but low in organic (COD) content will be investigated, developed and refined. The following waste waters will be investigated:

Septic tank effluents. Septic tank effluents cannot be satisfactorily treated in BNR activated sludge plants due to their nutrient imbalance.

Activated sludge dewatering liquors and anaerobic digester supernatants. If these are returned to the head of works, the plant will not achieve the results that it should.

Stabilised landfill leachates. These leachates are not only very concentrated, but the COD/N ratio is not always conducive to satisfactory treatment by conventional means.

Trickling filter effluents. There are many trickling filter plants in South Africa, and the effluents are high in nutrients.

Estimated cost: R306 000
Expected term: 1995-1997

Calibration of open channel flow measuring systems using laboratory calibrated velocity-head electronic measuring instruments, and by applying the continuity principle

(No 707) East Rand Water Care Company, through Sigma Beta (CE)

To date there is no reliable method to determine the accuracy of a flow meter installed in a flume that does not comply with the required standards of accuracy. Inaccurate readings can result in substantial over- or underpayment by the consumer.

The project aims to develop a calibration method for open channel flow meters by using the continuity principle. Although the study is being carried out on a sewage works, the outcome will be beneficial for the measurement of industrial effluents in particular, and all large-scale flow measurement in general.

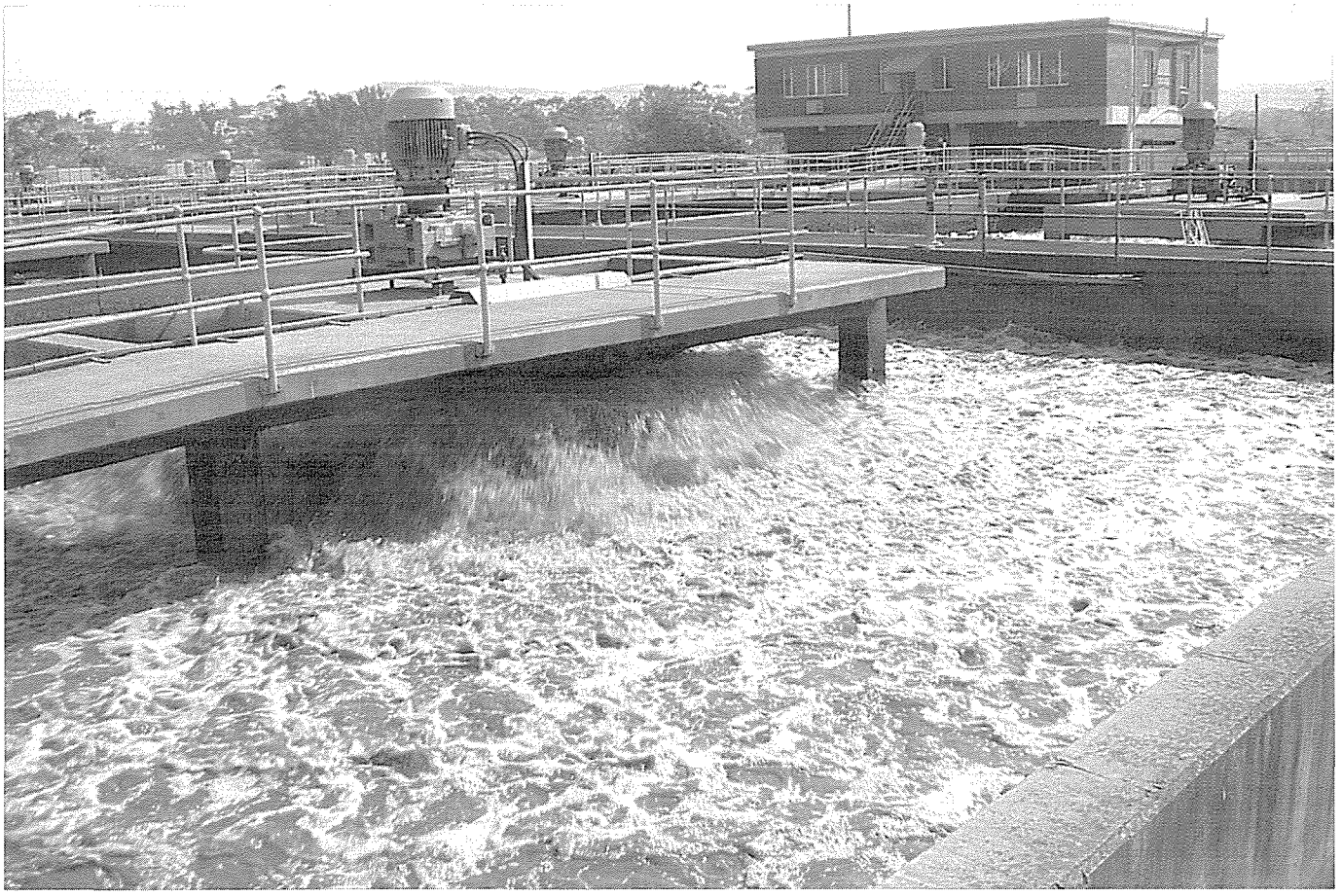
Estimated cost: *R86 600*
Expected term: *1995*

Removal of algal and other biomass from treated waste waters employing the PETRO process

(No 713) Wates, Meiring and Barnard (CE) Inc.

This follow-up project will investigate the optimisation of the PETRO process for the treatment of waste water. Work was done on the process itself during the first project (No 491), and during this project the research will concentrate on the microbiological aspects of the process, specifically the ability of the PETRO process to remove micro-algae from oxidation pond effluent. When properly optimised, the microbial diversity is greatly enhanced leading to enhanced treatment capacity. With fixed-film (biofilter) applications the micro-algae are retained in the film, and these metabolise heterotrophically in the dark, making an important contribution to the effluent treatment.

Estimated cost: *R489 000*
Expected term: *1995-1997*



Northern Waste-water Treatment Works at Sea Cow Lake, Durban.

Research projects

Completed

- **366** Full-scale pilot plant studies on phosphate crystallisation in biological systems (CSIR – Division of Water Technology and City Council of Pretoria)
- **427** Development of electro-osmotic sludge dewatering technology (CSIR – Division of Water Technology)
- **429** Bio-augmentation technology for waste-water treatment in South Africa (CSIR -Division of Water Technology)
- **543** Bioremediation technology for the treatment of contaminated seepage water and soil in South Africa (CSIR – Division of Water Technology)

Current

- **248** Chemical augmentation of biological phosphate removal (City Council of Johannesburg)
- **316** Aspects of sewage sludge treatment and disposal (City Council of Johannesburg)
- **328** Full-scale study of chemical sludge bulking control (University of Pretoria – Department of Chemical Engineering)
- **356** Consolidation of activated sludge research (University of Cape Town – Department of Civil Engineering)
- **391** Co-disposal of sewage sludge and refuse (City Council of Cape Town)
- **462** Activated fixed and suspended cultures for nitrification (University of Pretoria – Department of Chemical Engineering)
- **491** Pond-enhanced trickling filter operation (PETRO) (Wates, Meiring and Barnard Inc. and CSIR – Division of Water Technology)
- **496** Human viruses in diffuse effluents and related water environments (University of Pretoria – Department of Medical Virology)
- **542** Causes and control of low A/A filament bulking in nutrient removal activated sludge systems (University of Cape Town – Department of Civil Engineering)
- **554** Study of activated sludge microbial population dynamics for the optimisation of biological phosphorus removal (University of Pretoria – Department of Microbiology and Plant Pathology)
- **555** Limitation of convection currents in clarifiers (University of Pretoria – Department of Chemical Engineering)
- **556** Refinement of design parameters for sludge thickening by dissolved air flotation (Rand Afrikaans University – Energy Laboratory)
- **560** Development of a cross-flow microfiltration unit to improve the performance of anaerobic digesters at waste-water treatment works (University of Natal – Department of Chemical Engineering, Pollution Research Group)
- **569** High-rate recirculation and solids contact optimisation of biological filtration plants (Wates, Meiring and Barnard (CE) Inc.)
- **597** Technology adaption for successful application of septic tank systems in the coastal zone (CSIR – Division of Water Technology)
- **602** Application of chemical equilibrium to the control of struvite and calcite precipitation in waste-water treatment (University of Cape Town – Department of Civil Engineering)
- **604** Compilation of guidelines for the design and operation of sewage sludge drying beds (GFJ Inc.)
- **605** Municipal sewage sludge disposal: Development of guidelines and expert systems (CSIR – Division of Water Technology)
- **606** Practical application of special waste co-disposal with municipal refuse at the Coastal Park landfill bioreactor (Cape Town City Council – City Engineer's Department)
- **607** Compilation of an operating manual for biological nutrient removal waste-water treatment works (Stewart Scott (CE) Inc.)
- **620** Modelling, design and operation of secondary settling tanks (University of Cape Town – Department of Civil Engineering)
- **623** Bioremediation of a river system using the Alpha Biocatalyst (Alpha Biotech CC)

New

- **668** Determination of dissolved carbon load in raw and other sewage and the determination of a relationship between COD and DOC (chemical oxygen demand and dissolved organic carbon) (East Rand Water Care Company)
- **688** Laboratory and pilot-plant bio-reactor development for remediation of metal-contaminated waste water using activated sludge as biosorbent (Technikon Natal – Department of Biotechnology)
- **692** Treatment of waste waters with high nutrients (N and P) but low organic (COD) contents (University of Cape Town – Department of Civil Engineering)
- **707** Calibration of open channel flow measuring systems using laboratory calibrated velocity-head electronic measuring instruments, and by applying the continuity principle (East Rand Water Care Company, through Sigma Beta (CE))
- **713** Removal of algal and other biomass from treated waste waters employing the PETRO process (Wates, Meiring and Barnard (CE) Inc.)

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- **Mr HC Chapman**
  (Low-cost Sanitation)

☎ **(012) 330-0340**

5

Water pollution

Despite its efforts to contain water pollution through the enforcement of uniform effluent standards, the DWAF has found the quality of our water resources to be deteriorating in some parts of the country. This has led the Department to adopt a new approach to protect water quality. They now endeavour to manage the quality of water bodies in such a way that it remains fit for its users. Since the emphasis is now on the management of water quality, rather than on the more restricted activities to control the pollution originating from point sources, much more attention than earlier is being paid to quantifying and controlling pollution originating from non-point (diffuse) sources. Non-point sources are much more difficult to quantify and control. The WRC is consequently investing more in research on these aspects.

Pollution of water affects its suitability for all uses – thereby posing a threat to sustainable industrial, agricultural and other development. Since humans require fairly high quality water to fulfil their needs, the national aim to meet the basic water needs of the people of our country is likewise threatened by water pollution. The ability to provide users with water of an acceptable quality may prove to be more difficult to achieve than providing them merely with an adequate supply. Water-rich countries often have the luxury of solving some of their water pollution problems by making use of the dilution capacity of surplus water supplies but a water-scarce country such as South Africa has to concentrate on the control and prevention of pollution. In order to help meet the challenge of ensuring the supply of water of adequate quality for the different users, the WRC follows a two-pronged research strategy: on the one hand research is being conducted to eliminate pollution as far as possible, while on the other the levels of pollution which consumers could tolerate are being determined.

Water pollution often manifests itself as specific problems. The WRC has been funding projects that address pollution problems in the fields of salinity, eutrophication, other surface water quality studies and marine disposal.

Salinisation remains one of the consequences of water pollution which cause widespread problems in South Africa. However, most of these problems go unnoticed, or remain unconnected by consumers. Salinisation is the result of the addition of a variety of salts to the water environment which virtually inevitably results from the increasing use and reuse of water associated with development. With increasing salinity the water becomes less fit for most users, thereby incurring additional costs.

Eutrophication is the enrichment of the water environment with plant nutrients and the consequent abundant growth of algae and aquatic plants. Serious problems pertaining to the need to purify water and to combat defacement of the water environment arise, while certain algae also excrete toxins.

The gradual deterioration of water quality and the growing awareness of water quality as a factor which undermines the utilisation potential of water, have given rise to the identification of a number of research needs. **Water quality studies** are being conducted to address problems associated with microbial pollution, sediments and other water constituents, as well as to improve the means to cope with them.

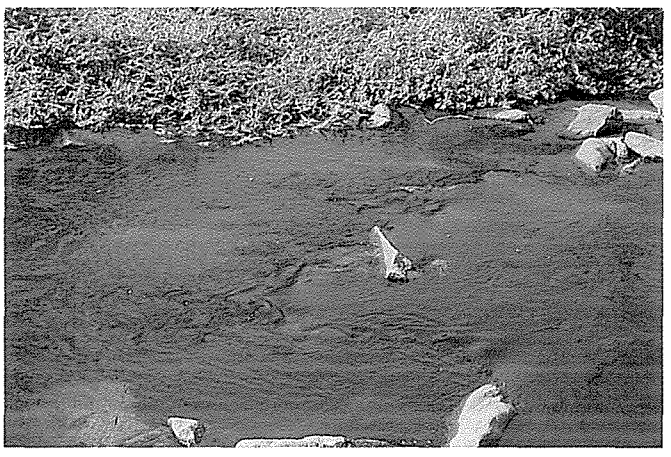
Marine disposal often is more economical than the land-based treatment of effluents. However, the sea's limited assimilation capacity is increasingly being recognised. Because marine disposal is sometimes used for the disposal of substances detrimental to the marine environment, and because of the unfavourable publicity associated with such abuses and with pipelines which are poorly designed or operated, public resistance to marine disposal is increasingly being experienced world-wide. It is nevertheless a practice which is widely (also in South Africa) adopted by coastal communities to dispose of their effluents. The WRC finances projects in order to enable the responsible consideration of marine disposal as an alternative to land-based disposal.

Completed projects

Field dilution studies on large off-shore pipelines

(No 364) Division of Earth, Marine and Atmospheric Science and Technology, CSIR

The efficacy of an off-shore pipeline is governed largely by the initial dilution and to a lesser extent by the subsequent



Textile effluents discolour river water below a sewage works.

secondary dilution caused by ocean currents. Initial dilution arises from the entrainment of sea water during the rise of the buoyant effluent from the pipeline's diffuser to the surface of the sea.

This project studied the performance of the pipelines at Richards Bay, Mossgas and Hout Bay. These are representative not only of various outfall designs and effluent types, but also cover the diverse physical conditions along the South African coastline. The data gathered served to assess which of the four available initial dilution models is suitable for the design of future long ocean outfalls.

It was found that the relatively simple model developed by the UK Water Research Centre can be applied with confidence, as it predicts achievable initial dilutions as accurately as that of the more sophisticated models. The more sophisticated models are useful when more details on the behaviour of a rising plume may be required.

Cost: R205 000
Term: 1991-1994

Preparation of a manual for waste load allocation in South Africa

(No 404) Environmental Services, CSIR and the DWAF

In recognition of the fact that the enforcement of uniform effluent standards would not offer sufficient protection of water quality in future, the DWAF adopted a more comprehensive approach towards controlling the impacts of effluents on the quality of receiving water bodies. This approach, *inter alia*, recognised that the capacity of water bodies to assimilate waste is limited and must be managed in a sustainable way.

This project was undertaken in order to formalise the assessment of the impact of effluent discharge on receiving water bodies and to ensure its consistent application in practice.

The manual which was developed, describes the procedures which must be followed to assess the impacts of effluent discharges on the quality, and therefore the fitness for use, of receiving water bodies. These assessments will be used by the Department to decide whether an application to discharge an effluent will be granted or not, and, if it is granted, which requirements the discharger should comply with. It therefore forms one of the corner-stones of the Department's current approach to the management of effluent discharges.

Cost: R685 441
Term: 1991-1995

Development of a rule model for the design of stream water quality monitoring strategies in the forestry industry

(No 524) Division of Forest Science and Technology, CSIR

As a result of the greater emphasis the DWAF is placing on water pollution originating from diffuse sources, there is an increasing need for information on the impact of different land-use practices on water quality. This project made use of data on water quality which were collected under a wide range of flow conditions, for a variety of forest management practices, in order to determine the effect of forest management on water quality and to identify water quality variables that could serve as indicators of forestry impacts.

Suspended sediment and plant nutrient content of flow provided good indications of the effects of most forest management practices. Results of the investigation were, furthermore, used to prepare guidelines to assist forest managers in designing cost-effective water quality monitoring systems for forested catchments.

Cost: R122 557
Term: 1991-1994

Demonstrating the potential of geographical information systems technology in hydrosalinity modelling by using the DISA-model

(No 588) Institute for Geographical Analysis, University of Stellenbosch

Most hydrological models require geographically based input data. Prior to the advent to geographic information systems (GIS) most of the required data were obtained by using labour-intensive methods to survey existing maps and by subjecting the survey results to arithmetic manipulations. Because of the time-consuming nature of this process, the full potential of hydrological models could often not be realised. Because of the need to combine the skills of divergent disciplines, the potential of GIS technology is even now mostly not fully utilised in hydrological modelling.

This project aimed to demonstrate the potential of GIS technology by integrating GIS with the DISA-model (a daily irrigation and salinisation systems model).

In spite of some problems being encountered, an interface between GIS and the DISA-model was successfully developed and implemented. It was concluded that the use of GIS offers a number of significant advantages in the application of the DISA-model, including faster spatial data capture, powerful visual tools for error detection and automated spatial data analysis.

Cost: R47 300
Term: 1993-1994

New projects

Comparison of predicted secondary dilutions of deep sea marine outfalls to measured field data and the determination of prototype diffusion coefficients

(No 675) Division of Earth, Marine and Atmospheric Science and Technology, CSIR

The efficacy of an off-shore pipeline is governed by both the initial dilution and the subsequent secondary dilution. Initial dilution arises from the entrainment of sea water during the rise of the buoyant effluent from the pipeline's diffuser to the surface of the sea. Sea currents transporting the surfaced effluent away from the "boil", i.e. the area where the effluent surfaces, cause further ingress of sea water into the effluent to effect the so-called secondary dilution.

The performance of the pipelines at Richards Bay, Mossgas and Hout Bay was used in a preceding study by the CSIR to evaluate existing initial dilution models. Models to predict the secondary dilution and the concomitant decay of microbial organisms are available, but have not been evaluated under actual South

African conditions. This project aims to effect this by means of the data generated in preceding studies.

Establishment of the most appropriate secondary dilution model would bridge the remaining knowledge gap to enable improved design and hence cost-effectivity of future deep-sea outfalls for the South African coast.

Estimated cost: R107 100
Expected term: 1995

Development of a guide to assess non-point source pollution of surface water resources in South Africa

(No 696) Sigma Beta (CE) and the DWAF

Non-point source pollution is more difficult to quantify and manage than point sources. Although local information is limited, it is increasingly realised that many catchments have zones where non-point (diffuse) sources contribute more to water quality deterioration than do point sources.

This project will develop a South African handbook for the characterisation and quantification of non-point sources. It will also develop a GIS-based set of information on current day non-point loadings in heavily impacted basins for selected water quality constituents.

Estimated cost: R840 000
Expected term: 1995 – 1998

Modelling the long-term effect of atmospheric deposition on the salinity of catchment runoff with special reference to the Vaal Dam catchment

(No 697) Stewart Scott (CE) Inc.

A gradual deterioration in the quality of runoff from the Vaal Dam catchment is being observed. Atmospheric deposition of pollutants emitted by the burning of fossil fuels has been identified as a possible indirect source of Vaal Dam salinity.

Preceding studies addressed some of the uncertainties which affected the validity of the calculated contributions by atmospheric deposition to Vaal Dam salinity. This project will study the processes controlling the lag time between atmospheric input and the resulting long-term change in both surface- and groundwater quality, and develop a computer model to simulate the long-term salt balance of Vaal Dam.

Estimated cost: R486 000
Expected term: 1995-1996

Guidelines for point-source pollution risk assessment as a decision-making tool for water quality management

(No 706) Corporate Risk Management (Pty) Ltd

Since past point-source pollution studies have not given adequate attention to the relative risks posed by various point sources in a given catchment area, this project aims to achieve the following:

- Development of guidelines for point-source pollution risk assessment to determine probability and severity of a particular occurrence, and to assist the water quality manager with the subsequent decision-making process
- Proving the applicability of the guidelines using the Vaal Barrage catchment area as a case study.

The product will be a practical, hands-on guideline, and lead the user into the decision-making process rather than simply quantifying the probability of occurrence of a particular event.

Estimated cost: R85 000
Expected term: 1995

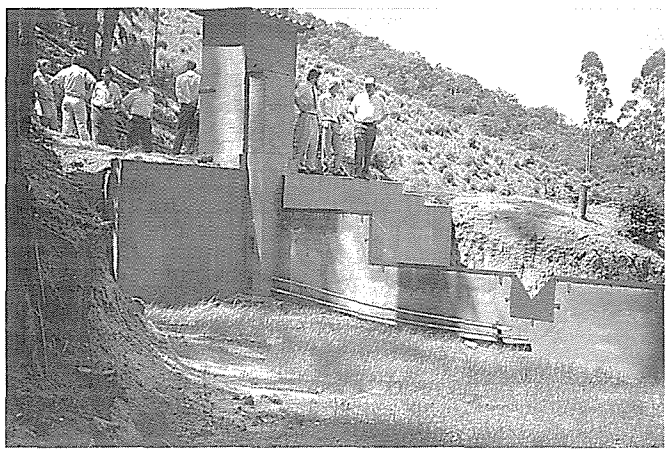
Impact of urbanisation and industrialisation on the environment

(No 717) Department of Chemistry, Vista University (Mamelodi Campus)

This project is being run in an urban context, and will investigate specific pollutants arising in an urban environment and affecting the quality of the runoff from urban areas.

An important spin-off from this project is that it will develop an awareness of the detrimental effects of urban pollution on runoff.

Estimated cost: R345 000
Expected term: 1995-1997



Weirs used to measure the impact of different land-use practices on water quality and quantity.

The adverse effect of using high-salinity water for the irrigation of vines is clearly visible.

Research projects

Completed

- **364** Field dilution studies on large offshore pipelines (CSIR – Division of Earth, Marine and Atmospheric Science and Technology)
- **404** Preparation of a manual for waste load allocations in South Africa (CSIR – Environmental Services)
- **524** Development of a rule model for the design of stream water quality monitoring strategies in the forestry industry (CSIR – Division of Forestry Science)
- **588** Demonstrating the potential of geographical information systems technology in hydrosalinity modelling by using the DISA-model (University of Stellenbosch – Institute for Geographical Information)

Current

- **195** Hydrosalinity studies in the Eastern Cape (Rhodes University – Institute for Water Research)
- **266** Extension of the management-orientated models for eutrophication control (CSIR – Division of Water Technology)
- **312** Occurrence and accumulation of selected heavy metals in freshwater ecosystems affected by mine and industrial polluted effluents (Rand Afrikaans University – Department of Zoology)
- **359** Phytoplankton blooms in the Vaal River and the environmental variables responsible for their development and decline (University of the OFS – Department of Botany)
- **369** Completion of research relating to the DISA model – A daily irrigation and salinity analysis system model (Ninham Shand (Cape) Inc.)
- **380** Investigation techniques for the determination of microbial aspects of water quality of South African rivers (CSIR – Division of Water Technology and Rand Water)
- **405** Situation analysis of water quality in the Buffalo River, Eastern Cape, with special emphasis on the impact of low-cost high-density urban development on water quality (CSIR – Division of Water Technology)
- **411** Coastal pollution: Pathogenic micro-organisms (University of Pretoria – Department of Medical Virology)
- **419** Water quality and quantity assessments in catchments with changing land uses in the Umzinto coastal area (SA Sugar Association Experiment Station)
- **420** Long-term salt balance of the Vaalharts irrigation scheme (Stewart Scott (CE) Inc.)
- **421** Relationship between atmospheric deposition and water quality in a small upland catchment (CSIR – Division of Water Technology)
- **447** Optimising diffuser design for offshore pipelines – Laboratory experiments (CSIR – Division of Earth, Marine and Atmospheric Science and Technology)
- **465** Detergent phosphorus in South Africa: Impact on eutrophication with specific reference to the Umgeni catchment (University of Natal – Department of Chemical Engineering and Umgeni Water)
- **498** Collection and evaluation of runoff water quality data from a disused feedlot in Natal (CSIR – Division of Water Technology)
- **522** Pilot study to investigate alternative management options to enhance the use of saline water for irrigation purposes (University of Stellenbosch – Department of Soil and Agricultural Water Science)
- **523** Lower Vet River water quality situation analysis with particular reference to the OFS gold-fields (Stewart Scott (CE) Inc.)
- **536** Development of a dynamic model for the growth and bloom of algae in the Vaal River (University of the OFS – Department of Applied Mathematics)
- **574** Potential for the use of economic instruments to protect the quality of water resources in South Africa (Economic Project Evaluation (Pty) Ltd)
- **583** Development of a laboratory river model to determine the environmental impacts of key xenobiotic compounds (University of Natal – International Centre for Waste Technology, and Umgeni Water)
- **633** Management of urban impoundments (Johannesburg City Council and Stewart Scott (CE) Inc.)
- **634** Quantifying the impact of the salinisation of South Africa's water resources with special reference to economic effects. Phase 1: Development of a generic model (DWAF and Urban-Econ, Development Economists)

New

- **675** Comparison of predicted secondary dilutions of deep sea marine outfalls to measured field data and the determination of prototype diffusion coefficients (CSIR – Division of Earth, Marine and Atmospheric Science and Technology)
- **696** Development of a guide to assess non-point source pollution of surface water resources in South Africa (Sigma Beta (CE) Inc. and the DWAF)
- **697** Modelling the long-term effect of atmospheric deposition on the salinity of catchment runoff with special reference to the Vaal Dam catchment (Stewart Scott (CE) Inc.)
- **706** Guidelines for point-source pollution risk assessment as a decision-making tool for water quality management (Corporate Risk Management (Pty) Ltd)
- **717** Impact of urbanisation and industrialisation on the environment (Vista University – Department of Chemistry (Mamelodi Campus))

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- **Dr HM Saayman** (Water Environment)
- **Mrs APM Oelofse** (Urban Runoff)
- **Mr G Offringa** (Eutrophication)
- **Dr TC Erasmus** (Marine Disposal)

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6
Groundwater

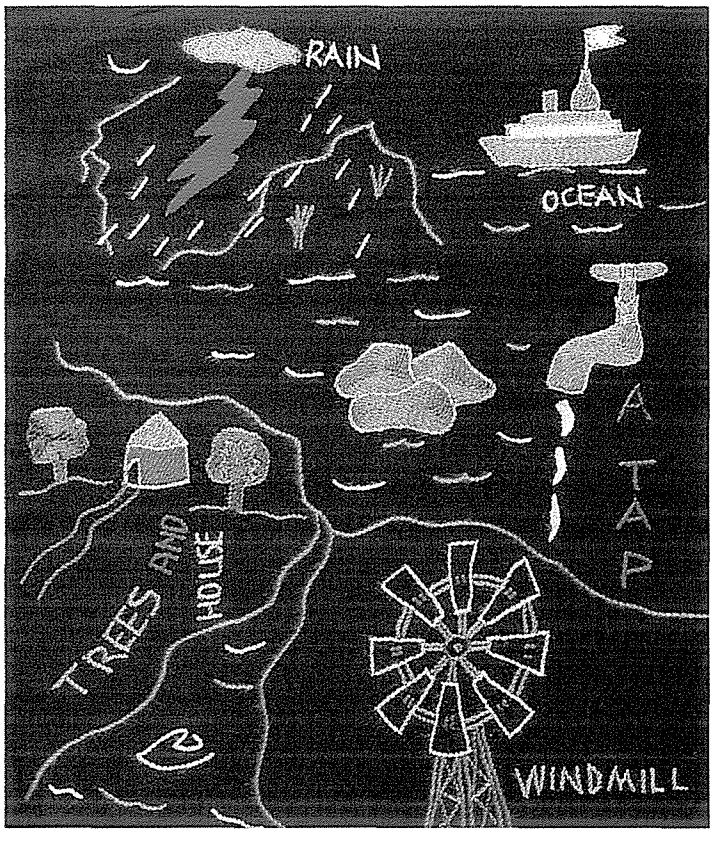
Two significant milestones in groundwater research were attained this year, the first being the publication of a manual on quantitative estimation of groundwater recharge and aquifer storativity. Our ability to provide accurate estimates of groundwater recharge and aquifer storativity is crucial for sustainable development and management of groundwater resources.

The second milestone took the form of 2 map sheets depicting the groundwater resources of South Africa on a national scale. These products formed the culmination of a 5-year national mapping programme with contributions by many local and international mapping experts. With groundwater being the preferred water supply source for many rural communities, the contribution of the maps to the water supply goals of the RDP will be evident for years to come.

The protection of South Africa's groundwater resources from the harmful effects of pollution was discussed at 2 workshops this year, under the topics: **The Preparation of an Aquifer Classification System for South Africa** and **An Assessment of the Impact of Agricultural Practices on the Quality of Groundwater Resources in South Africa**. Both these studies will contribute to the DWAF's groundwater quality management strategy currently in preparation.

Three international groundwater experts visited South Africa in 1995. All were exposed to groundwater research programmes and constructive contributions to the following current projects were made:

- Dr Warren Wood, USGS, Reston, USA: **Geochemistry and isotopes for resource evaluation in the fractured rock aquifers of the Table Mountain Group**
- Prof Wolfgang Kinzelbach, Heidelberg University, Germany: **Analysis and interpretation of aquifer tests in secondary aquifers; Extension and refinement of the Aquamod computer software package**
- Prof Arrie Issar, Desert Research Institute of the Negev, Israel: **Regional characterisation and mapping of Karoo fractured aquifer systems; Geochemistry and isotopes for resource evaluation in the fractured-rock aquifers of the Table Mountain Group; Isotopic and chemical signatures of water in the Transvaal dolomite springs**.



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Completed projects

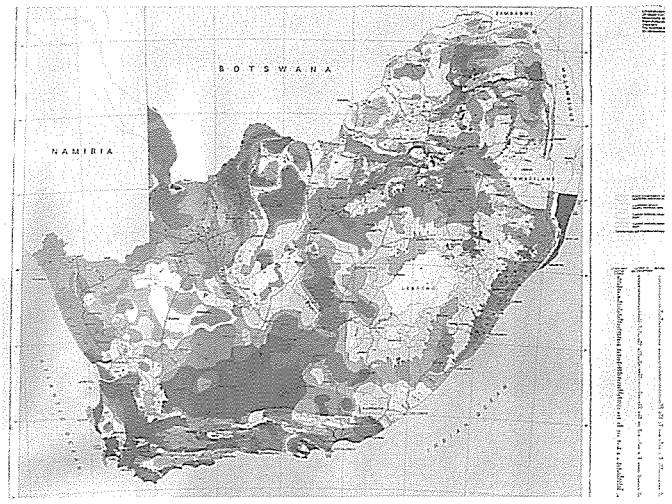
Preparation of a manual on quantitative estimation of groundwater recharge and aquifer storativity

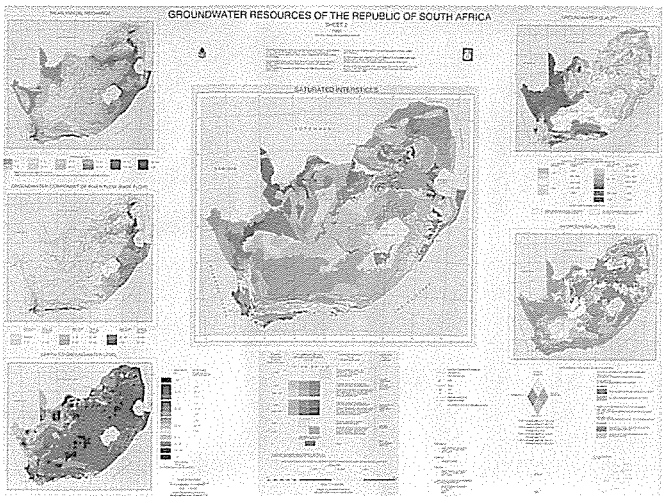
(No 353) Water Resources Evaluation and Management and the DWAF

Reliable estimation of groundwater recharge remains one of the major challenges in the assessment, effective utilisation and sustainable management of groundwater, especially in semi-arid to arid regions of the world. Although there are various well-established methods for the quantitative estimation of recharge, few can be applied successfully to these semi-arid environments. This has in many instances led to an over-exploitation of groundwater resources and the resultant failure of boreholes, particularly during drought conditions.

A significant milestone in groundwater research was attained this year with the publication of a manual on quantitative estimation of groundwater recharge and aquifer storativity. A wide range of methods for the estimation of recharge were examined during the course of the study and are documented in the manual, together with a selection of case studies, where one or more of the techniques have been employed. Not only does the manual provide a thorough examination of the subject of recharge in South Africa, but it will serve as an important foundation for future research into this topic.

Cost: R70 000
Term: 1991-1994





Maps depicting the groundwater resources of the Republic of SA.

Studies of dolomite aquifers in recharge evaluation.

Use of geographic information systems and other computer-aided drafting facilities for the production of geohydrological maps

(No 377) Institute for Groundwater Studies, University of the OFS

In the compilation of hydrogeological maps, particularly those which make up the 1:500 000 regional hydrogeological map series, it was deemed as essential to link facilities which store point data (such as the National Groundwater Database and HydroCom) with a geographic information system (such as ARC/INFO). In this manner the point data can be interrogated and displayed as a spatial coverage.

By combining the development of specialised programs to process point information with existing ARC/INFO routines, a system for assisting the map compiler in producing a hydrogeological map, termed Geographic Groundwater Interpretation System (GGIS) was created. This data interpretation system will be of considerable benefit to the compilers of the regional hydrogeological map series.

Cost: R876 000
Term: 1991-1994

Compilation of a hydrogeological map of South Africa

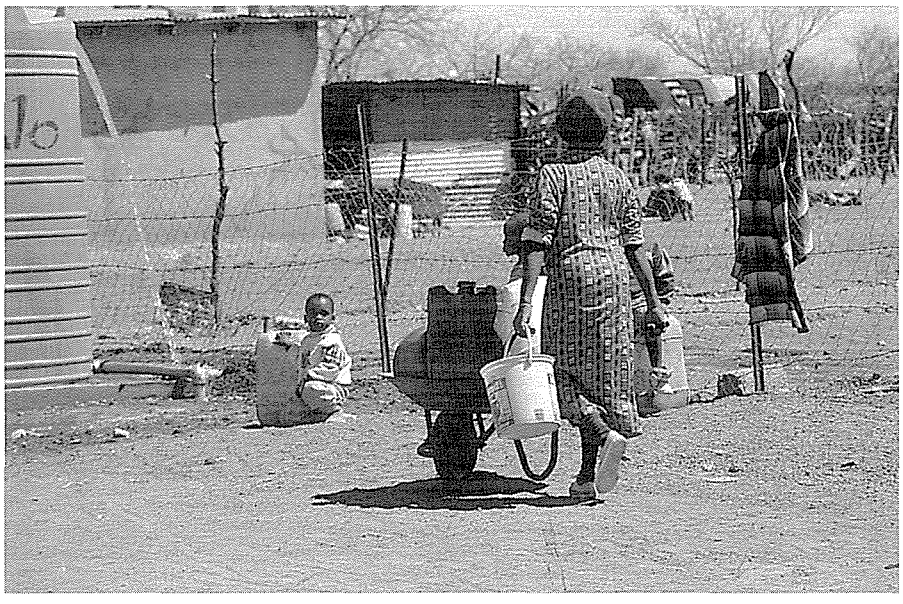
(No 483) JR Vegter Esq. and the DAWF

Advances in hydrogeology over the past years, and the increasing demand on groundwater resources, have given rise to the need to portray hydrogeological information in such a manner that planners and various groundwater users can make decisions by means of a quick and accurate overview of the most up-to-date information. Hydrogeological maps are seen as a powerful tool to meet this objective.

The preparation of a national-scale hydrogeological map of South Africa represents the culmination of a three-phased process, commencing in 1990 with the preparation of a map of groundwater regions and subregions, followed the next year by a document detailing the hydrogeological map legend and mapping protocol.

This map has been published on two sheets, the first depicting borehole prospects and the second saturated interstices, together with inset maps of mean annual recharge, groundwater component of river flow, depth to groundwater level, groundwater quality and hydrochemical types.

Cost: R466 000
Term: 1992-2995



Groundwater development in Northern Province.

Production of the Pietersburg 1:500 000 hydrogeological map sheet 2326

(No 517) Water Systems Management and the Directorate of Geohydrology, DWAF

The increasing importance of groundwater in South Africa, particularly as a source of supply of domestic water for remote rural communities and small urban settlements, and for farm-scale irrigation development, has created an urgent need for summarised and mapped hydrogeological information country-wide in a synoptic and visual form, at all planning levels.

Prior to initiating the production of a series of regional-scale hydrogeological maps covering South Africa, there was a need to produce a pilot map together with an explanatory document to serve as a blueprint for the entire 1:500 000 series, comprising some 23 sheets.

The result of this study is a high-quality hydrogeological map of the Pietersburg map sheet at a scale of 1:500 000 and a set of explanatory notes which provide guidelines as to the need for detailed groundwater investigations and what hydrogeological conditions are expected to occur. Although not fully appreciated at the commencement of the study, in this area of the Northern Province some 85 per cent of the population live in rural areas. These areas are highly dependent on groundwater for potable water supplies and in some cases for irrigation supplies. The impact of this map in terms of the RDP is likely to be significant.

Cost: R136 000
Term: 1993-1994

Review of approaches and methodologies for determining recharge and leachate generation rates at waste disposal sites

(No 564) Division of Water Technology, CSIR

Leachate is generated as a result of the percolation of water or other liquids through any waste pile and by the compaction of the waste due to its weight. The main objective of this research project was to evaluate approaches employed locally and internationally to determine **groundwater recharge** and

leachate generation in order to identify the more appropriate approach when siting sanitary landfills under the semi-arid conditions experienced over much of South Africa.

The researcher concluded that the processes of leachate generation and groundwater recharge, and consequently the methods used in their estimation, cannot be equated. Furthermore, a number of weaknesses in the water balance approach, which forms the basis for leachate estimation methods, were observed. In particular, the role of macropore flow which is now recognised as a major factor in groundwater recharge in arid and semi-arid areas will need to be addressed in the estimation of leachate generation.

Cost: R91 000
Term: 1993-1994

New projects

Monograph on South Africa's groundwater resources

(No 676) JR Vegter Esq. (Private Consultant)

The increasing significance of groundwater and emerging problems surrounding its utilisation, have resulted in the need for a reference work on the occurrence, availability and quality of groundwater that will extend the usefulness of the national hydrogeological map and to some extent also that of the regional hydrogeological maps series which are currently being prepared by the DWAF.

The preparation of such a handbook will add enormous value to all hydrogeological maps by documenting in detail the information that can be applied at a local level, for example appropriate groundwater exploration techniques and anticipated drilling conditions. Amongst the major beneficiaries will be those involved in developing rural groundwater supplies, by obviating the need for a detailed hydrocensus prior to the development phase. As no such handbook is currently available locally, significant resources can be wasted by amongst others relief agencies involved in rural groundwater development.

Estimated cost: R167 000
Expected term: 1995-1997

Relationship between the geotechnical and hydrogeological properties of residual soils and rocks in the vadose zone

(No 701) Department of Geology, University of Pretoria

While the rapid growth in population puts ever-increasing demands on groundwater as a source of urban, agricultural and rural water supply, it also causes a deterioration in groundwater quality, mainly due to waste disposal, mining and agricultural activities.

Geotechnical investigations and engineering geological mapping for civil engineering projects and infrastructure development in many parts of South Africa have generated a wealth of data on the geotechnical properties and distribution of residual soils and rocks which, in most cases, constitute a major portion of the unsaturated zone overlying the aquifers. Geotechnical data in the form of soil and rock profile descriptions, test results and maps, can most likely be adapted to provide information on the permeability and thickness of the vadose zone. Through the identification of these hydrogeological properties of soils and rocks in the vadose zone which affect aquifer recharge and contamination, and determining the relationship between them, a protocol for deriving relevant hydrogeological data for groundwater vulnerability assessments will be possible.

Estimated cost: R250 000
Expected term: 1995-1997

Development of a Windows-based interpretation system for hydrogeologists

(No 702) Institute for Groundwater Studies, University of the OFS and the DWAF

The creation and implementation of the existing groundwater database structure in South Africa has facilitated both the production of hydrogeological maps and the DWAF's regional groundwater characterisation programme. The National Groundwater Database, and its personal computer version *HydroCom*, have been accepted by the DWAF and many consultants as the national standard for data acquisition, storage and retrieval.

The fact that the National Groundwater Database and *HydroCom* were developed in the 1980s, together with the considerable progress in database software development over the past few years, has resulted in the need to revise and upgrade the present system to meet current and future requirements.

One aspect which is required in the short term is groundwater interpretation software for the emerging groundwater information system. This project proposes that this be developed under the most up-to-date Windows operating system. The Department as the major client for the interpretation software have given their full support to the project and are in fact going to be a full partner in the contract.

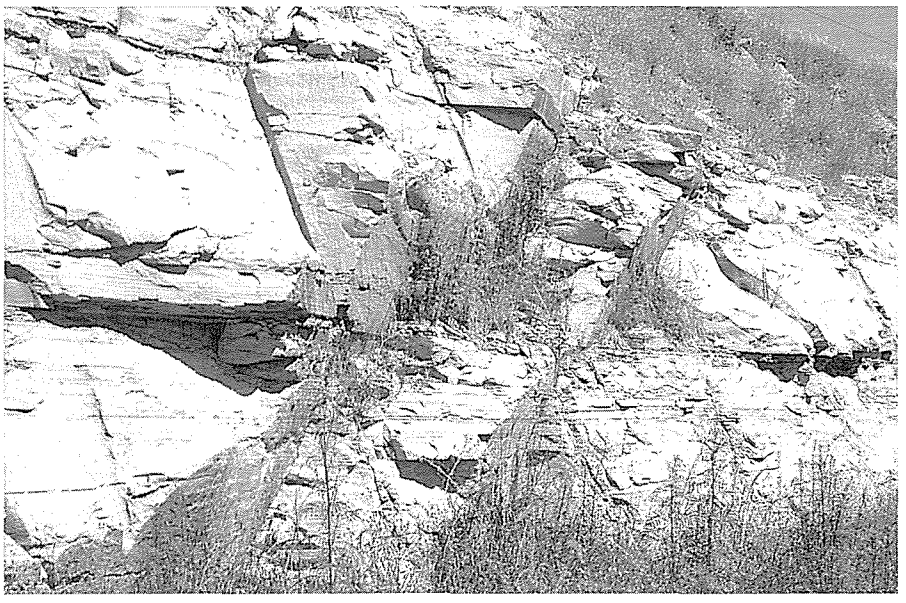
Estimated cost: R795 000
Expected term: 1995-1997

Geohydrological modelling of the Richards Bay area

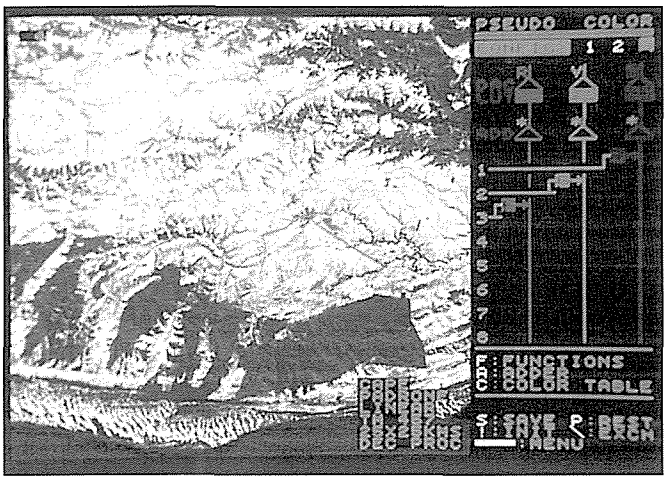
(No 720) Department of Hydrology, University of Zululand

The principal water resources of the Richards Bay metropolitan area are Lake Mzingazi and Lake Insese. The catchment area between Lake Insese and Lake Mzingazi comprises the main urban and industrial centre of the Richards Bay area. This area is expanding rapidly with the development of heavy industries and their support services and consequently could become a serious source of pollution to the water resources of Richards Bay. The rapidly expanding rural settlements in large sections of the surface

Table Mountain Group rock outcrops.



Above: Fractured rock aquifer studies.



Right: The use of satellite imagery in coastal aquifer exploration.

catchment could also have a substantial impact on surface- and groundwater pollution.

Suitable simulation modelling can be used as a relatively inexpensive educational and management tool in planning the development of the urban and rural sections of Richards Bay.

The objective of this research project is the development of a hydrogeological model of the Richards Bay area for use in numerical simulation studies of groundwater/surface water interaction, with the emphasis on determining the impact of pollution sources on the sensitive water resources of the Zululand Coastal Plain.

Estimated cost: R560 000
Expected term: 1995-1997

Groundwater supply assessment and strategy for the Western Karoo, Namaqualand and Bushmanland

(No 721) Department of Earth Sciences, University of the Western Cape

In terms of addressing the RDP goals for community water supply, attention is currently being focused on those regions most in need of water and sanitation, for example the Eastern Cape, Northern Transvaal and KwaZulu-Natal. There is, however, a long-term need to address the insufficiencies of the other regions. These are often as needy, but for various reasons possibly less visible. This is particularly true for the less populated, more arid western portion of South Africa.

The primary objective is to assess the water supply needs and identify the available groundwater resources in terms of quality and quantity in the Western Karoo, Bushmanland and Namaqualand regions in order to develop a water supply strategy for use in the overall RDP programme. Community involvement and consultation will be a key component of the study.

Estimated cost: R1 710 000
Expected term: 1995-1999

Research projects

Completed

- **353** Preparation of a manual on quantitative estimation of groundwater recharge and aquifer storativity (Water Resources Evaluation and Management and the DWAF)
- **377** Use of geographic information systems and other computer-aided drafting facilities for the production of geohydrological maps (University of the OFS – Institute for Groundwater Studies)
- **483** Compilation of a hydrogeological map of South Africa (JR Vegter Esq. and the DWAF)
- **517** Production of the Pietersburg 1:500 000 hydrogeological map sheet 2326 (Water Systems Management and the DWAF – Directorate of Geohydrology)
- **564** Review of approaches and methodologies for determining recharge and leachate generation rates at waste disposal sites (CSIR – Division of Water Technology)

Current

- **273** Investigation of the potential use of NOAA satellite remotely sensed data for identification of regional-scale fracture zones for groundwater supply purposes in Southern Africa (SRK (CE) Inc.)
- **291** Regional investigation into groundwater quality deterioration in the Olifants River catchment above the Loskop Dam, with specialised investigations in the Witbank Dam subcatchment (University of the OFS – Institute for Groundwater Studies)
- **311** Development and evaluation of geohydrological and isotope hydrological methodologies for the identification of areas potentially suitable for waste disposal (University of the Witwatersrand – Schonland Research Centre, and Atomic Energy Corporation of South Africa Ltd)
- **378** Development of techniques for risk analysis and groundwater management of Southern African aquifers (University of the OFS – Institute for Groundwater Studies and CSIR – Division of Earth, Marine and Atmospheric Science and Technology)
- **481** Geochemistry and isotopes for resource evaluation in the fractured rock aquifers of the Table Mountain Group (CSIR – Division of Water Technology)
- **484** Integrated multidisciplinary geodynamic/geophysical approach to groundwater exploration around the South African coastline (Atomic Energy Corporation of South Africa Ltd)
- **487** Analysis and interpretation of aquifer tests in secondary aquifers (University of the OFS – Institute for Groundwater Studies)
- **516** Application of seismic tomography and ground-penetrating radar for the detection of fractures and the determination of hydraulic properties of fractured rock aquifers (CSIR – Division of Earth, Marine and Atmospheric Science and Technology)
- **565** Hydrogeological, isotopic and hydrochemical assessment of the response of a fractured multi-layered aquifer to long-term abstraction (University of the Witwatersrand – Schonland Research Centre)
- **572** Investigation of the contaminant attenuation capacity of the soil/aquifer system with special emphasis on the vadose zone (CSIR – Division of Water Technology and the University of Stellenbosch – Department of Soil and Agricultural Water Science)
- **640** Extension and refinement of the AQUAMOD computer software package (University of the OFS – Institute for Groundwater Studies)
- **641** Assessment of the impact of agricultural practices on the quality of groundwater resources in South Africa (CSIR – Division of Water Technology)
- **653** Regional characterisation and mapping of Karoo fractured aquifer systems – An integrated approach using a geographical information system and digital image processing (DWAF – Directorate of Geohydrology, and the Council for Geoscience)

New

- **676** Preparation of a monograph on South Africa's groundwater resources (JR Vegter Esq.)
- **701** Relationship between the geotechnical and hydrogeological properties of residual soils and rocks in the vadose zone (University of Pretoria – Department of Geology)
- **702** Development of a Windows-based interpretation system for hydrogeologists (University of the OFS – Institute for Groundwater Studies and the DWAF)
- **720** Geohydrological modelling of the Richards Bay area (University of Zululand – Department of Hydrology)
- **721** Groundwater supply assessment and strategy for the Western Karoo, Namaqualand and Bushmanland (University of the Western Cape – Department of Earth Sciences)

CONTACT PERSONS

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7

Agricultural water utilisation

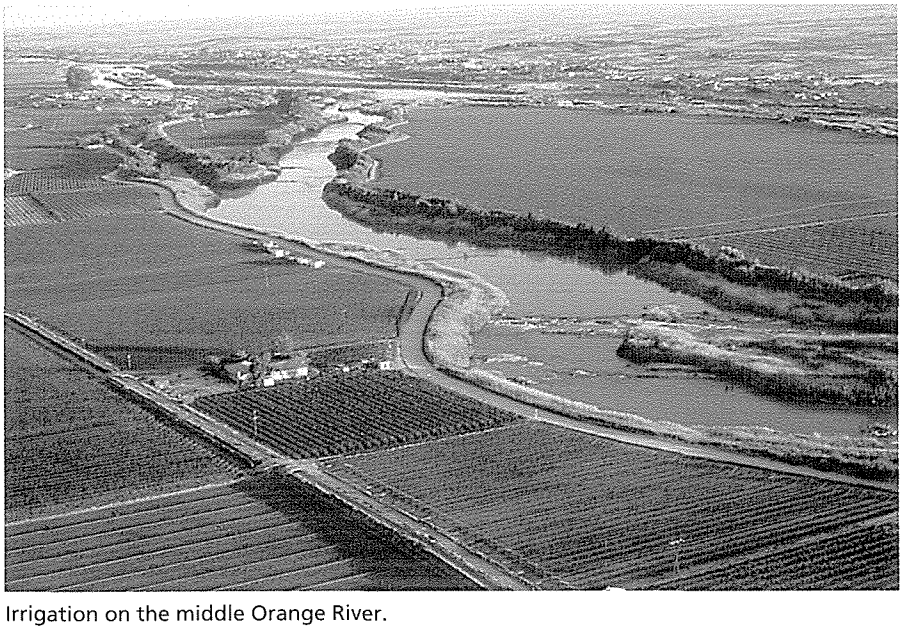
Irrigation and agricultural water management

Water is essential for crop cultivation, animal husbandry and human existence. Economic progress and increasing demand for water because of population growth, urbanisation and industrialisation put pressure on supply. Complicating factors include climatic variability, skewed regional distribution and deteriorating water quality. Due to high costs of exploiting new sources, emphasis must be placed on allocation of existing water resources. Since agriculture constitutes the single largest consumptive use of water, it is often considered to be a source to meet growing demand through water savings.

In the context of water- and agricultural policy reform, the additional requirement for sustainable irrigation development is establishment of productive smallholders, without disrupting profitable commercial enterprises, in a competitive economic environment.

Competition for available water resources obviously leads to pervasive conflict. The major concern of water management is the resolution of conflict between interdependent water uses and users. Economic and social objectives which must be achieved simultaneously are efficient utilisation and equitable allocation of rights to water resources. For this purpose rules or institutions and a combination of market, administrative and judicial procedures must be designed. In so doing, the correct incentives will be provided through secure water rights and pricing according to negotiated transactions. This is based on an evaluation of benefits and costs which leads to water conservation and mutually beneficial exchange from lower valued to higher valued users and uses. Agricultural production can then be maintained at lower levels of water utilisation, i.e. increased efficiency, while rights to water are reallocated to alternative applications, i.e. improved equity. Even under circumstances of relatively fixed water supplies, higher demand can be satisfied or accommodated and balanced economic growth can therefore continue.

An important advantage of the market approach to allocation of water rights is flexibility and timely adaptation. Over-utilisation and misallocation can, however, still occur because of, amongst others, incomplete knowledge and information. The challenge remains for applied research, extension and technology transfer to provide appropriate decision-support. Consequently the master plan for irrigation research is currently being reviewed. A holistic approach is followed and the intention is to continue to provide solutions to problems experienced by different categories of farmers in irrigated agriculture. Furthermore, a range of biological, technical and economic issues continue to receive attention on a catchment and farming systems level. An indication of the variety of research which is undertaken is given by the new and completed projects for 1995.



Irrigation on the middle Orange River.

Completed projects

Drought-tolerant and water-efficient fodder shrubs (DTFS): Their role as a "drought insurance" in the agricultural development of arid and semi-arid zones in Southern Africa

(No KV65/94) Dr HN le Houérou, Consultant

In completion of the above investigation, Dr Le Houérou furnished the WRC with the report entitled *Drought-tolerant and Water-efficient Shrubs: Their Role as a "Drought Insurance" in Agricultural Development of Arid and Semi-arid Zones of Southern Africa.*

Drought-tolerant fodder shrubs (DTFSs) are currently cultivated on approximately 10 m. ha of the world's arid and semi-arid areas as an agricultural development aid, of which approximately 800 000 ha are planted in South Africa. The species which are most frequently planted locally are saltbush (*Atriplex nummularia*) green cactus (*Opuntia ficus-indica*), blue cactus (*O. robusta*) and agave (*Agave americana*). These DTFSs thrive on a relatively wide range of soils and their salt tolerances range from 5 mS/cm in the case of cactus and agave, to 50 mS/cm in the case of saltbush. The latter therefore has the attractive potential of being cultivated under irrigation with water of a high salt content. The potential benefits of this practice are twofold, viz.:

- Advantageous use of water, the quality of which renders it unsuitable for other purposes
- Stabilisation of animal production in areas where the availability of natural vegetation is not always reliable.

The report on the investigation provides a comprehensive view of DTFS cultivation as well as all factors with a role to play in their cultivation and production. As an

authority in this field, Dr Le Houérou gives his views on desert encroachment in South Africa and identifies research needs and priorities with regard to DTFS cultivation in South Africa. The report also evaluates the cultivation of saltbush, agave and cactus with regard to soil, climatic and water requirements, as well as their water utilisation efficiency, danger of becoming invader plants, establishment and management as feed crops, as well as the economic aspects of DTFS cultivation. As far as the proposed research is concerned, it is clear that the results generated thereby will make a substantial contribution to the development of DTFSs as an integral part of animal production in arid or semi-arid areas.

Cost: R7 000
Term: 1993

Storage and utilisation of rain water in soil for the stabilisation of plant production in semi-arid regions

(No 227) Department of Soil Science, University of the OFS

In the past very little information was available on the impact of various soil cultivation and land-use practices on rain-water storage in the soil, and the subsequent use thereof. Few quantitative details on the potential decrease in runoff and on surface water sources recharge as a result of the said practices, were therefore available. Also unknown was the extent to which the stabilisation of plant production in semi-arid regions coupled with the maximum storage and utilisation of rain water in soil, could assist in alleviating the pressure on utilisation of surface water sources for the production of food and fibre. It was therefore necessary to conduct an investigation to determine the most efficient land-use methods and soil-water management practices to ensure that stored rain water in semi-arid areas would be utilised most effectively.

In motivating the project, a distinction was drawn between the water balance during the rain storage period (i.e. between harvesting the previous crop to planting the new crop), and the water balance during the growing season.

Using the data collected, the rain production conversion efficiency was calculated on the basis of mass and monetary value. The water-use efficiency (WUE), which is an index of the production per hectare per mm of evapotranspiration, was calculated in terms of above-ground biomass (kg/ha·mm), gross income (R/ha·mm) and nett income (R/ha·mm). With the aid of the results the costs of water losses due to runoff, evaporation or deep percolation can now be quantified. The rain-use efficiency (RUE), which is an index of the production per hectare per mm of rain plus the change in profile water content, was quantified in the same manner as the WUE. The research indicated that rotational cropping, with conventional tillage, is the most sustainable and economic system. Conservation tillage cannot be recommended due to the high cost of chemical weed control and lower yield. When pastures are established in place of veld the RUE doubles, and when veld is converted into and cultivated for crop production, there is a three- to fourfold increase in the RUE.

Cost: R1 261 000
Term: 1988-1993

Research in this project has shown that conventional tillage results in better water conservation and therefore in better crops.

Factors affecting the water-use efficiency of irrigated crops with special reference to the physiological responses of these crops

(No 228) Department of Agronomy and Horticulture, University of the OFS

Recent progress with pedological and meteorological approaches to irrigation scheduling led to scheduling criteria being developed mainly in terms of soil moisture supply and atmospheric demand parameters, and being applied in practice. Crop yield is, however, largely determined by the physiological behaviour of the plant with regard to water, nutrition and environmental conditions during different growth stages, some of which are more sensitive to water stress than others. A better understanding of plant physiological reactions is therefore needed for the optimal application of irrigation criteria. Other research projects had emphasised the need for further investigations into climate- and water supply-induced plant water status and crop yield relationships and these aspects, therefore, constituted the primary objective of this project.

The research team concerned could not fully attain this objective. During the execution of the project, especially during the early part, above-average rainfall occurred resulting in a shallow water table. A drainage system was installed, but could not solve the problem fully, and throughout the experiment the test results were unfavourably influenced by the relatively shallow water table.

Regarding the other objectives, viz. the comparison of the various scheduling methods, the project did indeed indicate that the methods investigated, particularly those based on the use of the BEWAB and PUTU models, function well and can be recommended for practical application.

An important recommendation is that when plant physiological aspects constitute an important component of the research, it should preferably not be executed under field conditions. Meaningful results can be attained only if it is possible to exercise strict control over all the variables.

Cost: R1 513 000
Term: 1988-1994

Soil-plant-water relations in the upper reaches of plant-available soil water

(No 261) Department of Plant Production and Soil Science, University of Pretoria

When using micro-irrigation systems, relatively high soil-water potentials are maintained continuously (i.e. the soil is kept wet continuously) by means of high frequency applications. Under these conditions there is a danger of keeping the soil too wet, leading to oxygen deficiencies in the root zone which result in degeneration of the plants and in aggravation of root diseases. A thorough understanding of soil-water-air-plant relationships in the upper range of plant-available water is therefore very important when using high frequency micro-irrigation. Consequently the objectives of the project were to identify appropriate upper limits of plant-available water for different soil bulk density/soil water potential combinations, and to identify the effects of soil compaction on plant performance in the upper range of plant available water. These investigations were aimed at improving irrigation management under high frequency micro-irrigation.

In view of the problems experienced by citrus growers, two citrus rootstocks (Rough lemon (RL) and Troyer citrange (TC)) were selected for the experiments in this project.

The two plant parameters most affected by high bulk density soil under high soil water potentials, were the size of the root system and root hydraulic conductivity. Lower soil-water potentials in non-compacted soil resulted in poor hydraulic conductivity and thus poorly developed seedlings. The nutrient status of seedlings was affected by rhizospherical stress conditions and non-aeration of the nutrient solution. Anaerobic rhizospherical conditions in the water culture experiments affected both the top growth and the root system. Furthermore, the pH of aerated and non-aerated nutrient solutions influenced the growth and development of both rootstocks.

The project was concluded with an irrigation scheduling trial at an established citrus estate. Implementation of recommendations by the research team resulted in significant savings in irrigation water and pumping costs, an increase in yield and an improvement in the quality of the yield.

Cost: R553 000
Term: 1989-1993

Moisture sensors to facilitate water management

(No 262) Institute for Polymer Science, University of Stellenbosch

Thin-film polymer techniques can be employed in the manufacture of humidity sensors. The objective of this project was to refine these sensors to a point where such instruments will meet cost, accuracy and reliability criteria of water researchers in agriculture. A further objective was to employ thin-film techniques in the manufacture of soil moisture measuring instruments.

The project concentrated on two developments:

- A soil-water probe to monitor the total water content of a soil. The end result was a device which can be inserted to any depth with a procedure similar to that of standard tensiometers. Readings of changes in the soil-water content were done by means of a small electronic digital readout. The probe had the potential of relatively inexpensive mass production subject to appropriate development of the associated electronic circuitry. In addition it had the potential of being used as the basis of a more sophisticated measuring device capable of monitoring additional variables, e.g. soil-water potential and soil salinity.
  Tests indicated that the basic electronic circuitry required further refinement; that probe installation procedures are critical to the meaningful interpretation of data; and that close contact between the probe tip and the surrounding soil matrix is of vital importance.

- A relative humidity sensor, in the form of a condensor which consists of an electrode deposited on an insulating substrate over which a layer of a moisture-sensitive polymeric coating is formed and an upper electrode permeable to water vapour, deposited over the moisture-sensitive coating.
  The attempt to develop a relative humidity sensor which is capable of a fast response to values approaching saturation has not been successful. Extensive experiments led to the conclusion that a significant improvement in either response times or performance levels close to saturation would require an innovatively different approach.

Cost: R429 000
Term: 1989-1992

Influence of different water-nitrogen regimes on crop canopy development, water flow resistance and crop yield, with a view to improvement of irrigation models

(No 307) Institute for Soil, Climate and Water, Agricultural Research Council

Crop growth and irrigation scheduling models are powerful aids for irrigation planning and management. This project was undertaken to provide the means of improving useful models by identifying and addressing weaknesses which currently limit their applicability.

Comprehensive data sets which will have enduring value for model refinement and validation were acquired. These comprise growth and physiological measurements relating to wheat crop growth and development for a wide range of water- and nitrogen-supply conditions over a period of four seasons. Inabilities of various models to correctly simulate certain aspects of growth and development, e.g. biomass accumulation and duration of the growth period, when water becomes limiting, were identified and underlying reasons suggested.

Other research products were guidelines and precautions relating to the field use of photosynthesis-measuring equipment, as well as useful techniques such as the heat-pulse technique for measuring sap flow in wheat stems and the mini-rhizotron technique for *in situ* root measurements.

Cost: R458 500
Term: 1990-1994

New projects

Irrigation water requirements of small-plot vegetable farmers

(No 689) Institute for Soil, Climate and Water, Agricultural Research Council.

Sustainable small-plot farming is hampered by a lack of information regarding irrigation requirements of vegetable crops under water-limiting conditions. Evaluation of traditional methods of irrigation and implementation of scheduling techniques to enable better on-farm water management require attention. The objectives of this project are to determine water requirements, to evaluate water use of selected vegetable crops and to establish demonstration trials in both rural and urban areas. In addition the constraints facing female farmers in particular as well as the training needs of extension officers or community workers will be considered. The field experiments will involve monitoring of soil-water balance, crop growth and production. Measurements will include effective rooting depth and water extraction patterns. The on-farm trials will run simultaneously and will be a means of testing the results under typical small vegetable plot circumstances. This part of the project will be conducted in conjunction with farmer support programmes of other development agencies. The final phase will be the compilation of results into a user-friendly manual on irrigation scheduling under sub-optimal conditions.

Estimated cost: R603 900
Expected term: 1995-1997

Establishing effects of saline irrigation water and managerial options on soil properties and plant performance

(No 695) Department of Soil and Agricultural Water Science, University of Stellenbosch

As the competition for freshwater intensifies, it is expected that agriculture will have to effect substantial water savings and, furthermore, have to cope with a poorer quality than at present. After three years of irrigating with six irrigation waters of increasing salt content, as part of a forerunner experiment (Project No 303) to assess crop salt tolerance criteria, the most saline treatment had a devastating effect on the vines that were irrigated. However, the effect of more moderate salinity treatments was not yet sufficiently consistent to permit salinity tolerance criteria to be firmly established. This follow-up project will establish irrigation-water quality guidelines based on the effect of saline water on the vegetative and reproductive growth of grapevines, wine quality and soil properties.

Estimated cost: R847 000
Expected term: 1995-1998

Investigation into food-plot production on irrigation schemes in the central region of the Eastern Cape Province

(No 719) Agricultural and Rural Development Research Institute, University of Fort Hare

According to provisional evidence it appears that food plots are one of the more successful models of irrigation development. To date there has not been a comprehensive analysis of factors which contribute to the success of food-plot production. The main objective of this project is to determine the physical, infrastructural, institutional, economic and social factors influencing food-plot production. This research is being undertaken in support of land-reform efforts to provide rural households with access to agricultural land. Irrigation schemes are seen as potentially suitable to enable a large number of households to improve food security and as viable growth points to earn an economically sustainable livelihood. Within the above-mentioned study area, conditions of reliable and adequate supply of irrigation water favour small-scale irrigation enterprises. Of a total area of 11 800 ha, 6 800 ha are developed, 2 500 ha are unused land on existing schemes and a further 2 500 ha need to be developed from the start. On six medium-sized schemes which form a part of this area, 91% of 2 306 households are involved in food-plot production. The area for expansion on unused and new land exceeds the existing area of 2 768 ha presently being irrigated by 651 ha. **Opportunities are therefore available to alleviate the major problem of rural poverty by better utilising existing investment in infrastructure.** At the current standard size of 0,2 ha per household, an additional 17 095 households could potentially benefit. However, the extent of production, financial and tenure problems which affect attitudes of food-plot crop producers, differs between irrigation schemes. Provision of access to irrigated land requires attention to many facets and must be planned appropriately, to ensure economic and social viability. This will be addressed by collection of primary data following rapid rural appraisal techniques, and a desk study of secondary data which will be complemented by field observations. It is expected that the results of this project will lead to formulation of policy guidelines for irrigated food-plot development. This will also enhance the ability of organisations involved with implementation of land reform to undertake successful development by limiting expensive mistakes.

Estimated cost: R196 900
Expected term: 1995-1996

Quantitative evaluation of the hydraulic properties of stony soils by means of laboratory simulations

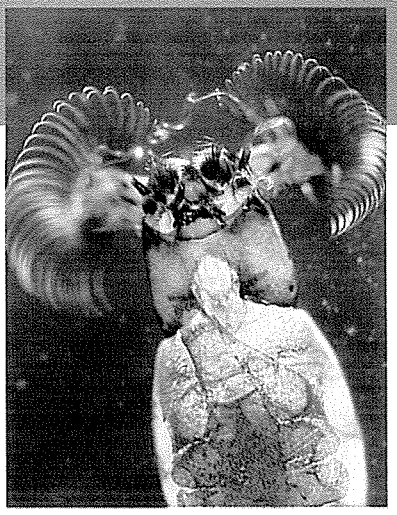
(No 725) Department of Plant and Soil Sciences, Potchefstroom University for CHE

Incomplete and inadequate information exists on the groundwater management of stony soils. Reporting on this aspect in the literature is also often contradictory.

Good management practices are, however, difficult or impossible to achieve due to problems experienced when installing aids such as tensiometers. This gives rise to water wastage and misappropriation of capital and operating expenditure. The purpose of this research is therefore to characterise the hydraulic properties of stony soils and to develop management guidelines using these results. The relevance of this is emphasised by the increasing tendency to irrigate low-potential soils. This is particularly true in the case of dolomitic soils with a predominantly large stone content where groundwater is utilised for irrigation. Mechanised systems such as centre-pivots have been erected in regions of the Northwest and Northern

Cape Provinces, but are not being managed optimally. The project mainly comprises laboratory tests with some field verifications. Variables to be evaluated are clay mineralogy, texture, stone shape, stone size, volume percentage of stone in soil, water content and degree of compaction. The results will be used to devise adapted guidelines for the irrigation of stony soils. Hydraulic conductivity, infiltration ability, surface runoff, hysteresis and soil-water retention curves are of fundamental concern. This information will be useful to irrigators, producers and to technical advisers.

Estimated cost: *R85 700*
Expected term: *1995-1997*



Blackfly control in the middle and lower Orange River.
Right: Blackfly larvae under a microscope.

A good example of flood irrigation near Brits, Northwest Province.

Left and below: *Cladophera glomerata* in the Roodeplaat Dam canal.

CONTACT PERSONS

- **Mr DS van der Merwe**
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- **Dr GC Green**
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- **Dr GR Backeberg**
  (Agricultural Water Management)

☎ **(012) 330-0340**

Research projects

Completed

- **KV65/94** Drought-tolerant and water-efficient fodder shrubs (DTFS): their role as a "drought insurance" in the agricultural development of arid and semi-arid zones in Southern Africa
  (Dr HN le Houérou, Consultant)
- **227** Storage and utilisation of rain water in the soil for the stabilisation of plant production in semi-arid areas (University of the OFS – Department of Soil Science)
- **228** Factors affecting the water-use efficiency of irrigated crops with special reference to the physiological responses of these crops (University of the OFS – Department of Agronomy and Horticulture)
- **261** Soil/plant/water relations in the upper reaches of plant-available soil water (University of Pretoria – Department of Soil Science)
- **262** Moisture sensors to facilitate water management (University of Stellenbosch – Institute of Polymer Science)
- **307** Influence of different water-nitrogen regimes on crop canopy development, water flow resistance and crop yield, with a view to improvement of irrigation models (Agricultural Research Council – Institute for Soil, Climate and Water)

Current

- **290** Flood and furrow irrigation: A critical evaluation of design procedures and the computerisation of the most suitable approaches (University of Pretoria – Department of Agricultural Engineering)
- **303** Use of saline water for irrigation purposes and an assessment of salt tolerance criteria of crops (University of Stellenbosch – Department of Soil and Agricultural Water Science)
- **347** Global farm approach to enhancing the economic efficiency of water and energy use for irrigation in the central RSA (University of the OFS – Department of Agricultural Economics)
- **348** Root development and water usage of commercial timber species (University of Natal – Department of Agronomy)
- **372** Assessing the impacts of varying rainfall conditions on vegetation dynamics, production and certain hydrological properties of natural grassland, using a system modelling approach (Potchefstroom University for CHE – Department of Plant and Soil Sciences)
- **389** Scheduling irrigation of tuber crops with specific reference to potatoes (Agricultural Research Council – Vegetable and Ornamental Plant Institute)
- **417** Optimal water utilisation by turf (Potchefstroom University for CHE – Department of Plant and Soil Sciences)
- **423** Effect of pre-programmed deficit irrigation on crop reaction (University of the OFS – Department Soil Science)
- **440** Identification of irrigated land in an intensively cultivated agricultural area in the South-Western Cape by means of satellite remote sensing (University of Stellenbosch – Institute for Cartographic Analysis)
- **441** Determination of the relationship between transpiration rate and declining available soil water for *Eucalyptus grandis* (CSIR – Division of Forest Science and Technology)
- **476** Transfer of research results on the irrigation of vegetable crops into practice (University of Pretoria – Department of Plant Production)
- **479** Molecular approach to drought tolerance (Agricultural Research Council – Institute for Plant Biotechnology)
- **499** Effect of exchangeable sodium percentage and clay mineralogy on the infiltration capacity of soil already sealed due to cyclic irrigation (Potchefstroom University for CHE – Department of Plant and Soil Sciences)
- **507** Improved estimation of plant and soil evaporation from cropped lands (University of the OFS – Department of Agrometeorology)
- **508** Modelling the water balance on benchmark ecotopes (Agricultural Research Council – Institute for Soil, Climate and Water)
- **513** The development of a computerised management system for irrigation projects (Rand Afrikaans University – Department of Civil Engineering)
- **573** Water-use efficiency of cultivated subtropical forage and pasture crops (University of Pretoria – Department of Plant and Soil Sciences)
- **578** Evaluation of irrigation techniques used by subsistence and emergent farmers (MBB (CE) Inc.)
- **581** Computerised weather-based i rrigation water management system (University of the OFS – Department of Agrometeorology)
- **600** Problem blooms of macro-algae: Investigation of causal factors, seasonality of recruitment and growth, and efficiency of control methods (University of Cape Town – Department of Botany)
- **624** Personal computer-based procedure for the estimation of irrigation requirements of crops in Southern Africa (MBB (CE) Inc.)
- **625** Use of computer models for agricultural water management at farm level (University of the OFS – Department of Soil Science)
- **644** Quality of water for livestock *production with emphasis on subterranean water and the development of a water quality guideline index system (University of Pretoria – Department of Animal and Wildlife Science)
- **645** Optimal management of uncertain water availability at farm and regional level with due allowance for risk and the environment (University of the OFS – Department Agricultural Economics)
- **646** Maximisation of economic water-use efficiency of processing tomatoes (University of Pretoria – Department of Plant Production)
- **650** Integrated control of blackflies along the Orange River (Agricultural Research Council – Onderstepoort Veterinary Institute)

New

- **689** Irrigation water requirements of small-plot vegetable farmers (Agricultural Research Council – Institute for Soil, Climate and Water)
- **695** Establishing effects of saline irrigation water and managerial options on soil properties and plant performance (University of Stellenbosch – Department of Soil and Agricultural Water Science)
- **719** Investigation into food-plot production on irrigation schemes in the central region of the Eastern Cape Province (University of Fort Hare – Agricultural and Rural Development Research Institute)
- **725** Quantitative evaluation of the hydraulic properties of stony soils by means of laboratory simulations (Potchefstroom University for CHE – Department of Plant and Soil Sciences)

8

Industrial water and effluent

Research on industrial water and effluents is oriented towards developing and promoting integrated water conservation and effluent management strategies through the application of sustainable water pollution prevention practices, and cost-effective water pollution abatement technologies. The implementation of these strategies is expected to result in significant savings in freshwater intake, reduced pollution load discharge to the environment per unit of production, minimisation and elimination of toxic chemical discharges, optimisation of energy use and the utilisation of "green" or environmentally friendly technologies for, not only the purification of effluents and the implementation of closed loop systems, but also for the production of high value by-products.

During the past decade attention has been focused specifically on the following industries, i.e. textiles, tanning and fellmongering industries, fish processing, fruit and vegetables processing, mining effluents, pulp and paper industries, electrical power generation, petroleum processing and large and medium-sized meat processing industries. To date, research undertaken in these industries is yielding benefits in terms of increased awareness for the need and importance for total water quantity and quality management, and has resulted in the adaptation and development of several new and cost-effective biological processes to South African conditions, including amongst others, such patented processes as the production of the algae *Dunaliella* from which fine chemicals such as ß-carotene are extracted and the production of *Spirulina* algal biomass as a by-product of tannery waste-water treatment in advanced integrated algal pond systems, protein recovery and water reuse from the meat processing industry, decolorisation of textile effluents in municipal anaerobic digesters and a variety of applications of membrane separation technologies.

Laboratory experiments on the treatment of tannery wastes using the AHROP process.

Completed projects

Establishment of a basis for self-monitoring of water and effluent management in the fruit and vegetable industry

(No KV48/94) SRK (CE) Inc.

In 1987, the WRC published *A Guide to Water and Waste-water Management in the Fruit and Vegetable Processing Industry* to assist these industries in managing their water intake and effluent disposal. Subsequent to this development it was recommended that a computer software package be developed which would enable this industry to review its water and waste-water management quantitatively on a regular basis.

Against this background the objective of this consultancy was to establish a set of data, procedures and tools by means of which the fruit and vegetable processing industry could, in the future, carry out self-monitoring of water use and effluent generation within this industry.

The following results were achieved:

- A questionnaire was designed and used to carry out an initial postal survey of the industry to collect water and effluent data over the production period 1989/90.
- Using a database approach, a software package was developed into which the production, water and effluent data, collected from postal surveys using the questionnaire, could be entered. The software package was designed to capture the data on a standardised "by factory" and "by commodity" basis, to calculate meaningful relationships (e.g. specific water intake values) and then to produce a series of relevant reports.
- A *Users' Manual* was written and presented at a workshop held at Langeberg to instruct representatives of the industry in the use of the software package.

Cost: *R73 120*
Term: *1992*

Water and effluent management self-auditing document

(No KV50/94) CRM Risk Control Consultants (Pty) Ltd

A document has been produced to assist industrial premises in auditing their own water and effluent management situation, both in terms of legal compliance and good management practice. The format of the document is such that it leads the user through several sections of questions and allows him/her to attach a score to each section in order to quantify the level of good water and effluent management practised.

The main sections of the document deal with the reasons for auditing; water effluent and stormwater management; compliance with legislation; the role of management in auditing; and water conservation and effluent discharge targets.

The document is aimed at industry and is intended to be a practical, hands-on tool to assist in improving water and effluent management practices in South African industry.

Cost: R28 500
Term: 1993

Study on a mine-water reclamation test plant

(No 322) Division of Mining Technology, CSIR (formerly Chamber of Mines Research Organisation, COMRO)

The cost of treating spent mine service water for reuse underground is dependent, *inter alia*, on the water's corrosivity which governs the choice of construction material for pipes, pumps, tanks, etc.

The project aimed to assess the influence of individual water-treatment processes (neutralisation, flocculation, filtration, disinfection and desalination) on the corrosion of various metals. ERPM's raw water and a modified ERPM raw water to simulate Klerksdorp's mine water were used in the study.

Unfortunately, the consistency of the water chemistry could not be adequately controlled and the corrosion impact of the individual treatment processes remained obscure. The following conclusions could, however, be drawn:

- Although it was not possible to establish the effect of individual anions on corrosion, the indications are that the corrosion rate of mild steel increases as the total dissolved solids increase.
- The most prevalent corrosion damage to copper and cupro-nickel was due to localised corrosion.
- Negligible corrosion occurred on the stainless steels. However, crevice and pitting corrosion may occur in the long run and this result should be treated with caution.
- Suspended solids cause erosion and fouling and the latter can lead to under-deposit corrosion.

Cost: R650 000
Term: 1990-1992

Use of algae to bioassay for toxic substances in water

(No 393) Department of Botany and Genetics, University of the OFS

Bioassaying is a cost-effective method for monitoring environmental toxicity. Most existing tests determine the toxicity by measuring respiration in the test organism. Plants have a second metabolic pathway, photosynthesis, which may also be measured, and this project investigated the potential use of photosynthesis as a measure of toxicity. Using the microalga *Selenastrum capricornutum*, the tests used gave readings very rapidly, with the quickest being the *in vivo* fluorescence which showed a response within seconds. The conclusion was that these tests would make a useful addition to the suite of rapid tests currently available.

Cost: R59 500
Term: 1991-1993

Technology transfer of aquatic chemical speciation modelling

(No 530) Pollution Research Group, University of Natal

A quantitative appreciation of the chemical composition of an aqueous system and its interaction with the surrounding environment is essential for understanding such diverse phenomena as groundwater quality, water treatment and chemical dosing, effluent treatment, desalination, bioavailability and nutrient cycling, biotoxicity, scaling and corrosion.

In the USA the Environmental Protection Agency (EPA) developed a geochemical speciation program, called MINTEQA2, which is able to calculate the equilibrium composition of chemical solutions or natural aquatic systems. This program was used as a basis by the Pollution Research Group to disseminate information on the scope and capabilities of MINTEQA2 to a wide spectrum of potential users in industry by way of 14 country-wide workshops and seminars between January 1993 and December 1994. They also provided back-up support for MINTEQA2 users, acted as a link between the US EPA and local users and supported several other WRC projects which require a knowledge of chemical speciation.

Cost: R360 000
Term: 1993-1994

Extractive purification of industrial effluents

(No 533) Department of Chemical Engineering, Potchefstroom University for CHE

Many industrial effluents contain a variety of dissolved solids which may be toxic or hazardous and can cause serious ecological problems. The demineralisation of such effluents with an extractive technique, using a supported liquid membrane (SLM), was shown to be technically feasible.

The performance of the SLM extraction technique was evaluated in an exploratory investigation on nickel and its associated chemicals in an electroless electroplating effluent. Several contactors were designed and the most promising one was optimised for the extraction protocol. Extractants, diluents and aqueous conditions were evaluated specifically for the extraction of nickel from an electroless plating effluent. Degradation products from the process were also successfully extracted. Specific proposals were made regarding the reconditioning of extracted species (pollutants) for recycling with a view to achieving an eventual zero discharge in the industry.

Cost: R90 000
Term: 1993

Application of the anaerobic digestion/ultrafiltration (ADUF) process for the treatment of metal-cutting-fluid waste water

(No 593) Membratek (Pty) Ltd

This 6-month project aimed to determine the capability of the ADUF process to treat metal-cutting-fluid waste water emanating from the steel industry. The process study was carried out in a 150 *l* stainless steel reactor, fitted with a 0,44 m^2 MEMTUF ultrafiltration unit, operated at 37 to 39°C and at a pH of 6,8 to 7,5.

The biodegradability of the effluent by anaerobic digestion was established and it was found that no chemical cleaning is required to maintain a stable membrane flux. However, the economic viability of the process is questionable as the low sludge load rates achieved (< 1,05 gCOD/gVSS·d) necessitate excessive anaerobic digester volumes and hence high capital cost.

The experimental results obtained should be seen as an initial phase in the evaluation of the ADUF process for this particular application.

Cost: R60 000
Term: 1994

New projects

Course development for the education and training of industrial waste-water treatment plant operators and managers

(No 657) Department of Biochemistry and Microbiology, Rhodes University

A significant problem identified in maintaining the quality of the public water system in South Africa is the low standard of training of waste-water treatment plant operators.

The WRC is financing the construction of an industrial waste-water treatment research plant which is linked to Rhodes University and closely associated with the Leather Industry Research Institute (LIRI). It presents an outstanding opportunity to provide for the education and practical hands-on training of personnel involved in the treatment of industrial waste water. An investment in this area will have a direct impact on the quality of the public water system.

The University has recently restructured the education and training of leather scientists and technologists through N certificate, university, diploma and postgraduate levels. This process has been approved by the Department of National Education. The courses are structured as modular career path components and are delivered through the medium of distance learning with intensive practical training components on-site at LIRI. Course mentors are appointed to oversee study at the place of employment and the delivery of course assignments. This development provides a functional educational structure for accommodating the development of 2 courses envisaged for:

- Operators of industrial waste-water treatment plants (Module 1). The course will focus on practical hands-on aspects of plant operation. Limited theoretical aspects will be covered. The existing affirmative action programme will be available for upgrading skills in adult literacy, numeracy and general science.
- Managers of industrial waste-water treatment plants (Module 2). This will be an advanced course for which the entrance requirement will be matriculation with mathematics and science. It will include training in both theoretical and practical aspects at an advanced level and result in the award of a National Certificate qualification.

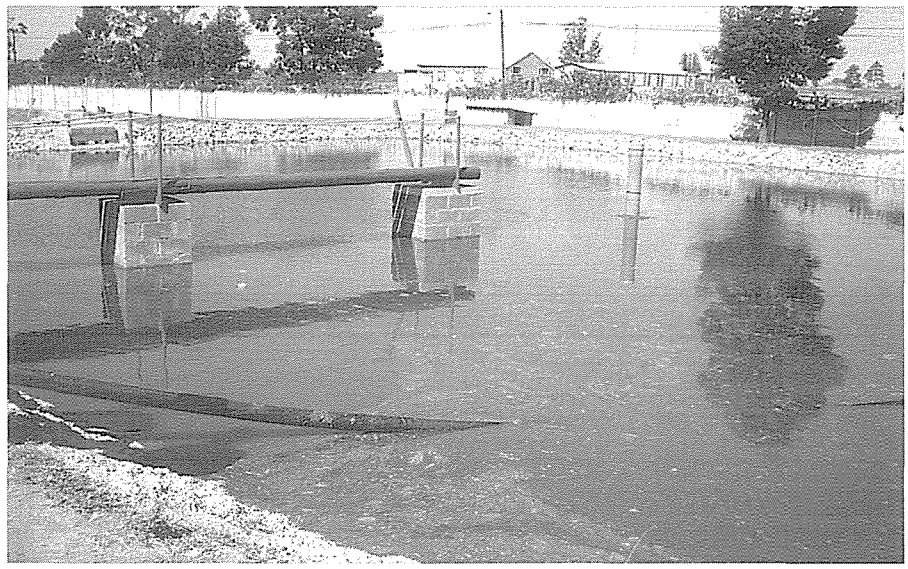
Estimated cost: R140 000
Expected term: 1995-1996

Algal high-rate oxidation ponding for the treatment of abattoir effluents

(No 658) Department of Biochemistry and Microbiology, Rhodes University

Abattoir effluents present significant problems given their high levels of chemical oxygen demand, protein, nitrogen and phosphate. Recent developments in the South African meat industry have seen an increasing shift of stock slaughter numbers to country abattoirs. Consequently the problems associated with abattoir effluents are no longer limited to large abattoirs only, but are also experienced by smaller abattoirs.

An urgent need therefore exists to develop low-cost, robust and low-maintenance treatment systems to meet the needs of country abattoirs. In view of the possibilities of algal high-rate oxidation ponding (AHROP) as an appropriate low-cost system for treating various types of



The AHROP system at Cato Ridge Abattoir showing the primary pond just freshly filled with waste water.

effluent, the WRC launched a research project on the AHROP process with the following objectives:

- A laboratory study to evaluate the function of the AHROP process applied to the treatment of abattoir effluents (previously demonstrated in treating high-protein tannery effluents and sewage).
- Scale-up evaluation of rate functions for the process in a 5 m^2 outdoor pilot-plant facility under semi-laboratory conditions. Both total combined effluent and the polishing of partly treated effluents will be evaluated.
- Construction of a 500 m^2-scale demonstration facility on-site at Cato Ridge.

Estimated cost: R571 300
Expected term: 1995-1996

Purification of high organic effluent by means of a tent-type anaerobic digester

(No 659) Multilog Division, Abakor Ltd

The disposal of high organic animal wastes such as those derived from abattoirs, feedlots and pig farms, create environmental problems especially for medium- to small-scale operations.

In Taiwan, with its thousands of pig farmers, the government through its Taiwan Livestock Research Institute funded research to develop a low-cost, low-maintenance process to deal with this problem. After a decade of research they developed a horizontal anaerobic bag type digester followed by an aerobic treatment step.

The low construction cost of such an anaerobic digester is due to the use of a plastic called Red Mud Plastic, specifically developed for this purpose. The construction details of such a digester have been made available to the WRC.

The aim of this project is to determine whether the technology developed in Taiwan can successfully be applied in South Africa. Abakor is funding the capital involved for the construction of such a unit, whilst the WRC is providing funds for the other facets of the project.

Estimated cost: R490 000
Expected term: 1995-1996

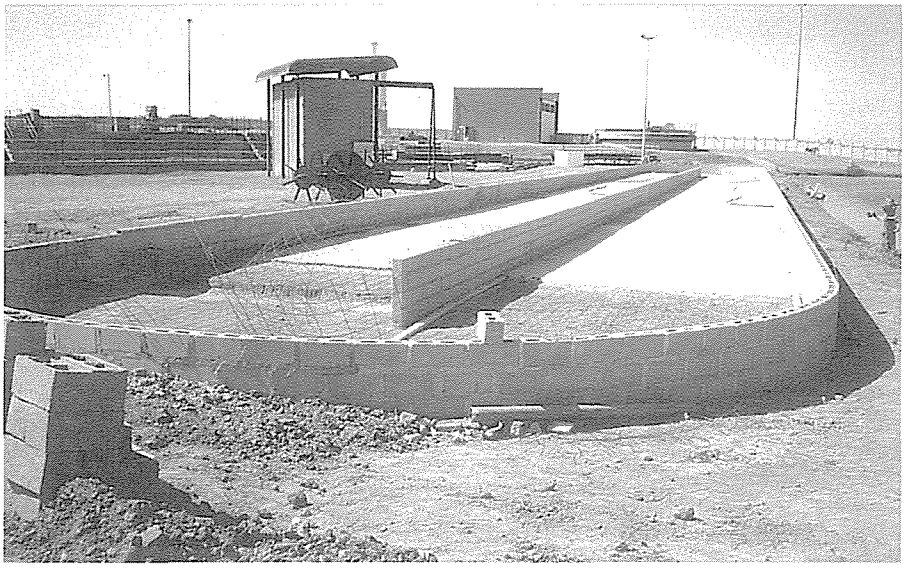
Development and implementation of biological cleaning techniques for ultrafiltration and reverse osmosis membranes for industrial effluents with a high organic content

(No 660) Department of Biochemistry, University of Stellenbosch

Pressure-driven membrane separation processes, such as reverse osmosis (RO) and ultrafiltration (UF) are being used to an increasing extent in the purification of a wide range of industrial effluents. However, when effluents with a high organic content, such as those emanating from abattoirs or paper industries, are treated with UF, serious fouling of the membranes occurs.

The main aims of this project are to identify enzyme/detergent mixtures which are efficient removers of foulants from membrane surfaces, the development of economic large-scale production techniques and the transfer of the cleaning regimes from laboratory to pilot-plant application.

Estimated cost: R176 000
Expected term: 1995-1997



The AHROP system at Cato Ridge Abattoir showing the high-rate oxidation pond.

Role played by *Shewanella* and sulphide-producing bacteria in metallic corrosion in industrial water systems

(No 661) Department of Microbiology, University of the Western Cape

In general, industrial waters contain higher concentrations of dissolved solids and salts than does drinking water. Such higher nutrient levels are conducive to microbial growth in water reticulation and storage systems. Sulphate-reducing bacteria (SRB) are recognised as the main cause of microbially influenced corrosion (MIC) in industrial water systems.

The dominant bacterium, *Shewanella putrefaciens*, is an anaerobic variety whose role in microbial corrosion is as yet unclear. The main aim of this project is to investigate the ecology of SRB and *Shewanella* within biofilms in industrial water systems and their influence in MIC.

Estimated cost: R108 700
Expected term: 1995-1996

Enhanced granulation in upflow anaerobic sludge-bed digesters (UASB) by process induction and microbial stimulation

(No 667) Department of Food Science, University of Stellenbosch

Upflow anaerobic sludge bed (UASB) digesters have a long start-up period and so the usual policy is to purchase pelletised sludge from existing UASB

digesters in order to get the digester operating as quickly as possible.

Preliminary work in this project indicated that, under particular stress conditions, certain bacteria within the consortium present excreted quantities of extracellular polymers which, under specific conditions, would form protogranules. This project will investigate methods whereby the process of granule (pellet) formation may be enhanced.

Estimated cost: R148 700
Expected term: 1995-1996

Complete treatment of dairy factory effluents by means of primary anaerobic digestion and secondary algal protein production

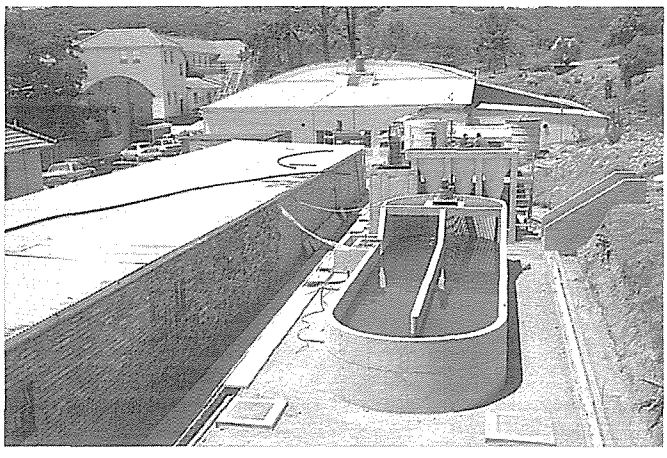
(No 673) Animal Nutrition and Animal Production Institute, Agricultural Research Council

In 1992 the WRC entered into an agreement with the then Department of Agricultural Development through its Animal and Dairy Science Research Institute for an investigation into dairy waste-water treatment processes. The research resulted in the isolation of an aerobic organism that transforms 95% of the chemical oxygen demand (COD) into biogas. The COD of the remaining biomass is, however, still not acceptable for discharge into the environment. Since more and more dairy farmers prefer to process their milk into cheese or yoghurt the discharge of their effluent could result in environmental problems.

By utilising the effluent from the anaerobic process to grow the microalgae *Spirulina* the effluent is not only purified further but a high-valued pro-

A demonstration and training tannery waste biological treatment system at LIRI, Rhodes University encompassing the following:

A common physical pretreatment plant.



A common chemical pretreatment system in the background and the oxidation ditch system in the foreground.

A trickling filter system as either polishing or alternative treatment route.

duct especially in terms of its protein content is produced.

The proposed project therefore aims at combining these 2 processes into an environmentally friendly system, suitable for application by both large organisations and small farmers.

Estimated cost: R120 000
Expected term: 1995-1996

On-site evaluation of an anion-free flocculant for industrial cooling systems

(No 674) Pollution Research Group, University of Natal and Eskom

At present ferric chloride is added to power-station cooling water to effect removal of organic and inorganic contaminants. The resultant build-up of chloride ions in the cooling-water circuit results in corrosion of the condenser tubules, which are expensive to replace. Bleed-off from the cooling-water circuit, to control corrosion, constitutes the largest source, both in volume and salt mass, of liquid effluent from a wet-cooled power station.

An alternative approach is to use an anion-free flocculant, such as iron hydroxide, which is produced electrolytically. This would not only decrease corrosion but would also significantly reduce the effluent produced at a power station and hence the impact on the receiving water environment.

The objectives of the project are thus to:

- Use the information gained from a preceding laboratory study to design and erect a pilot plant for the electrochemical production of iron hydroxide at a power station
- Effect on-site evaluation of its effectiveness to treat the different water circuits in a power station, and to establish how this is affected by variations in water quality.

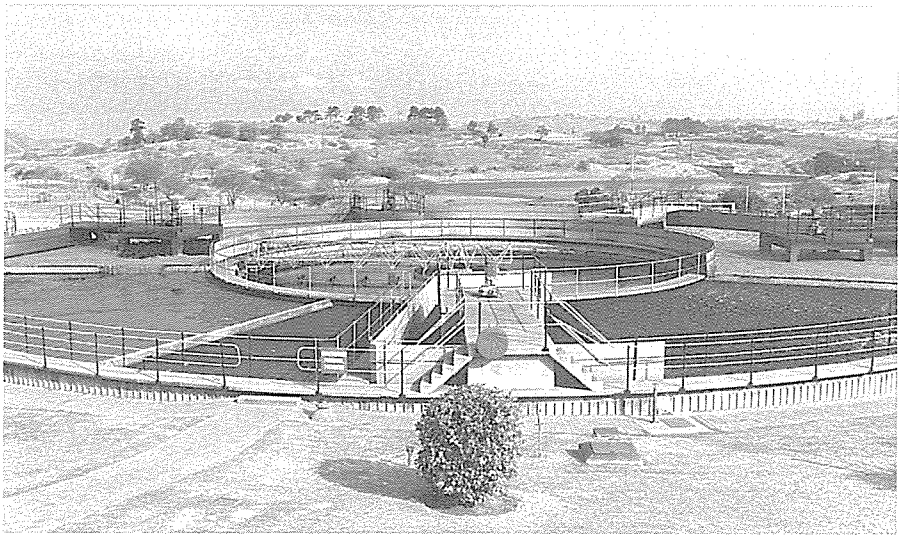
Estimated cost: R130 000
Expected term: 1995-1996

Membrane-based biotechnological systems for treatment of organic pollutants

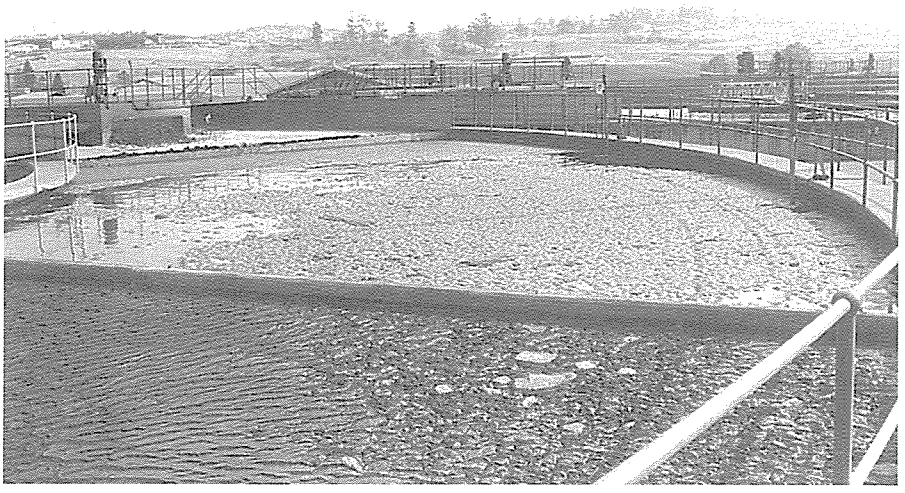
(No 687) Department of Microbiology, Rhodes University

Pollutants such as phenols, pesticides, polycyclic aromatics and polychlorinated biphenyls remain chemically stable under normal chemical or biological treatments. Accumulation of these intractable contaminants leads to toxic hazards at many ecological levels. The main aim of the project is to develop biotechnological processes whereby white-rot fungal enzymes can be used to remove such organic pollutants from industrial effluents. In a preliminary study the viability of using polyphenol oxidase to remove phenols from polluted effluents and to immobilise this enzyme on flat-sheet membranes was demonstrated. The new study proposes to use novel hollow-fibre membrane bioreactors to develop a continuous process for the removal of organic pollutants from contaminated industrial waste water.

Estimated cost: R292 500
Expected term: 1995-1997



One of the 5-stage Bardenpho reactors at the Hammarsdale Wastewater Treatment Works.



The anaerobic and primary anoxic zones of the Bardenpho reactor.

Research projects

Completed

- **KV48/94** Establishment of a basis for self-monitoring of water and effluent management in the fruit and vegetable industry (SRK (CE) Inc.)
- **KV50/94** Water and effluent management self-auditing document (CRM Risk Control Consultants (Pty) Ltd)
- **322** Study of a mine-water reclamation test plant (CSIR – Division of Mining Technology)
- **393** Use of algae to bioassay for toxic substances in water (University of the OFS – Department of Botany and Genetics)
- **530** Technology transfer of aquatic chemical speciation modelling (University of Natal – Department of Chemical Engineering, Pollution Research Group)
- **533** Extractive purification of industrial effluent (Potchefstroom University for CHE – Department of Chemical Engineering)
- **593** Application of the anaerobic digestion/ultrafiltration (ADUF) process for the treatment of metal-cutting-fluid waste water (Membratek (Pty) Ltd)

Current

- **239** Transfer of waste-water management technology to the meat processing industry (SRK (CE) Inc. and Abakor Ltd.)
- **241** Dewatering of compressible filter cakes (University of Natal – Department of Chemical Engineering)
- **263** Biological treatment of industrial water with the simultaneous production of single-cell protein (University of Pretoria – Department of Chemical Engineering)
- **308** Recovery of water and chemicals from ion-exchange regeneration effluents (University of Natal – Department of Chemical Engineering)
- **315** Utilisation of the fungus *Geotrichum* in waste water (University of Pretoria – Department of Chemical Engineering)
- **331** Improved oxygen transfer for high biosludge concentrations (University of Pretoria – Department of Chemical Engineering)
- **333** Removal of suspended solids from pulp and paper effluents by employing a combined sedimentation, flotation and sand filtration process (CSIR – Division of Water Technology)
- **342** Improvement in water usage control and waste-water treatment in the sorghum beer industry (University of Pretoria – Department of Chemical Engineering)
- **365** Evaluation and improvement of the anaerobic digestion/ultrafiltration (ADUF) effluent treatment process (CSIR – Division of Water Technology)
- **388** Evaluation of various methods for the forming of free radicals for the oxidation of molecules in industrial effluents and potable water (University of Natal – Department of Chemical Engineering, Pollution Research Group)
- **408** Fats and oils in effluents (University of Pretoria – Department of Chemical Engineering, Division of Water Utilisation Engineering)
- **409** Phenols in the steel industry waste water: Origin, prevention and removal (University of Pretoria – Department of Chemical Engineering, Division of Water Utilisation Engineering)
- **410** Biological approach to the removal of organics from saline effluents (Rhodes University – Department of Biochemistry and Microbiology)
- **453** Development of procedures to assess whole effluent toxicity (CSIR – Division of Water Technology)
- **455** Anaerobic digestion of dairy factory effluents (Irene Animal Production Institute, Agricultural Research Council)
- **456** Regional treatment of textile and industrial effluents (University of Natal – Department of Chemical Engineering)
- **457** Monitoring and optimisation study of high-rate biofiltration, aerobic biological treatment processes for tannery and fellmongery waste water (LIRI Technologies)
- **458** Development of an expert systems approach to water management in the fruit and vegetable processing industry (SRK (CE) Inc.)
- **478** Saving of water with air-cooled heat exchangers (University of Stellenbosch – Department of Mechanical Engineering and Eskom)
- **495** Biotechnological approach to the removal of organics from saline effluents (Rhodes University – Department of Biochemistry and Microbiology)
- **535** Use of filamentous micro-organisms for the purification of industrial effluents (University of Pretoria – Department of Chemical Engineering, Division of Water Utilisation Engineering)
- **546** Development and demonstration of effluent treatment systems appropriate to the needs of the red meat abattoir industry (SRK (CE) Inc.)
- **551** Evaluation of the potential quantity of methane gas from 85 anaerobic household digesters (BE La Trobe)
- **552** Evaluation of immobilised semiconductor particles for the photocatalytic oxidation of organic pollutants in industrial and municipal waste water (University of Stellenbosch – Department of Chemistry)
- **553** Application of capillary membranes in the biotechnological treatment of industrial effluents (University of Stellenbosch – Institute of Polymer Science)
- **589** Development of management strategies and recovery systems for heavy metal wastes (SRK (CE) Inc.)
- **590** Membrane technology for the treatment of industrial effluents (CSIR – Division for Water Technology)
- **592** Investigation into the use of biodispersants available for biofouling control in industrial water systems (University of Pretoria – Department of Microbiology and Plant Pathology)
- **612** Reduction of scaling in industrial water-cooling circuits by means of magnetic and electrostatic treatment (Rand Afrikaans University – Energy Laboratory and Department of Chemistry)
- **616** Use of algal and yeast biomass to accumulate toxic and valuable heavy metals from waste water (Rhodes University – Department of Biochemistry and Microbiology)
- **617** Extractive purification of industrial effluents (Potchefstroom University for CHE – Department of Chemical Engineering)
- **652** Purification of abattoir effluents by means of the protein reclamation process (Abakor Ltd)

New

- **657** Course development for the education and training of industrial waste-water treatment plant operators and managers (Rhodes University – Department of Biochemistry and Microbiology)
- **658** Algal high rate oxidation ponding for the treatment of abattoir effluents (Rhodes University – Department of Biochemistry and Microbiology)
- **659** Purification of high organic effluent by means of a tent-type anaerobic digester (Abakor Ltd – Multilog Division)
- **660** Development and implementation of biological cleaning techniques for ultrafiltration and reverse osmosis membranes for industrial effluents with a high organic content (University of Stellenbosch – Department of Biochemistry)
- **661** Role played by *Shewanella* and sulphide-producing bacteria in metallic corrosion in industrial water systems (University of the Western Cape – Department of Microbiology)
- **667** Enhanced granulation in upflow anaerobic sludge-bed digesters (UASB) by process induction and microbial stimulation (University of Stellenbosch – Department of Food Science)
- **673** Complete treatment of dairy factory effluents by means of primary anaerobic digestion and secondary algal protein production (Agricultural Research Council – Animal Nutrition and Animal Production Institute)
- **674** On-site evaluation of an anion-free flocculant for industrial cooling systems (University of Natal – Department of Chemical Engineering (Pollution Research Group) and Eskom)
- **687** Membrane-based biotechnological systems for treatment of organic pollutants (Rhodes University – Department of Microbiology)

CONTACT PERSONS

- **Mr Z Ngcakani** (Industrial Water and Effluent Management)
- **Dr TC Erasmus** (Cross-flow Microfiltration and Power Stations)
- **Dr SA Mitchell** (Bioassaying)
- **Dr HM Saayman** (Membrane Applications)

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9

Membrane technology

On 8 May 1995 the WRC accepted the Strategic Plan for Water-related Membrane Research in South Africa, which had been developed over the previous 2 years. The most important goal to emerge from the plan was **Research for Sustainable Development**, which concentrates on the supply of potable water to disadvantaged communities; the abatement of environmental pollution, such as eutrophication and removal of colour or turbidity; and the industrial reuse of process water, including the reclamation of water and valuable products and the removal of toxic materials. These goals were selected with due regard to the government's RDP and the *White Paper on Water Supply and Sanitation*. Two other research needs were identified, namely innovative and technology-driven membrane research and the development of human resources and infrastructure in this regard.

Regarding the development of human resources, the WRC has initiated a programme whereby students at historically disadvantaged universities are being given bridging education in membrane development through involvement in membrane-related research projects funded by the WRC at the University of Stellenbosch. In this way both students and staff benefit from this transfer of technology.

The strategic plan mentioned above formed the background against which new research proposals received during 1995 for funding from 1996 onwards, were evaluated.

Completed projects

Establishment of a membrane file transfer protocol site on the CCWR computer (EMILY)

(No KV70/95) Pollution Research Group, University of Natal

An information repository or Electronic Membrane Information Library (EMILY) was established on the Internet by the Pollution Research Group. Initially it was conceived to disseminate information regarding a model for tubular reverse osmosis systems which had been developed in an earlier WRC sponsored project. The aim was to make model data globally available on the Internet.

From such modest beginnings, EMILY has grown rapidly to become an international clearing-house for an extensive range of membrane-related information covering details of membrane conferences, publication lists, manufacturers' data and newsletters. During the first 7 months of its existence, EMILY has recorded more than 5 000 log-ins from all over the world, representing more than 2 000 different users. The administration of EMILY was continued during 1995 with additional WRC funding. It has been used as the basis for the training of water researchers in the use of the Internet and has also spawned a closely related information repository dealing with water supply and sanitation, called WENDY.

Cost: R45 000
Term: 1994-1995

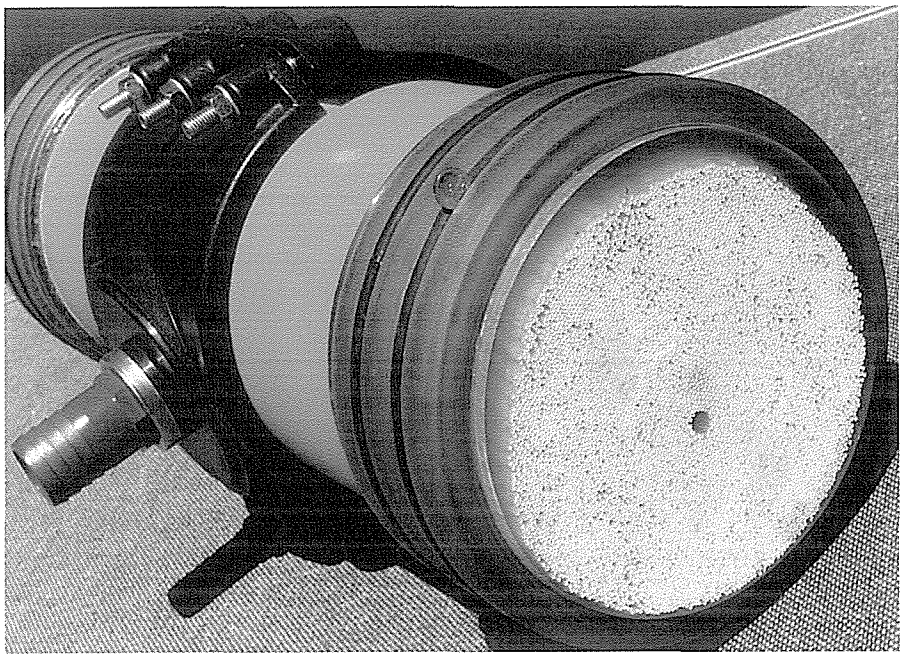
Industrial application of membranes

(No 362) Institute for Polymer Science, University of Stellenbosch

Effluents produced by industries such as SASOL, SAPPI, AECI and the mining industry created diverse opportunities for the development of new membrane processes to treat factory waste waters. The objective of the research project was to evaluate various reverse osmosis (RO) and ultrafiltration (UF) membranes on real or simulated effluents, first on a laboratory scale, and later at selected industrial sites.

Ultra-thin RO membranes were successfully developed for on-site treatment of brackish water for mining concerns in Botswana; UF and RO membranes were used to treat cooling water blow-down at SASOL II; pretreatment with UF, followed by RO were used to fractionate wine lees in order to recover water, yeast cells and cream of tartar; cleaning regimes were developed for tubular UF membranes used in the treatment of abattoir effluents at Cato Ridge abattoir; UF membranes were also used to pretreat sea water before desalination with RO; and finally various supplemental polymer coatings were developed and evaluated to improve the salt-retention properties of various existing membranes.

Cost: R418 800
Term: 1991-1993



Electrically driven membrane separation processes for the treatment of industrial effluents

(No 532) Division of Water Technology, CSIR

Electrodialysis (ED) and its variants – electrodialysis reversal (EDR), electro-electrodialysis (EED) and bipolar electrodialysis (BED) – were the selected technologies used to investigate the reclamation of water and chemicals from nickel and chromium electroplating processes.

ED and EED were found to be cost-effective technologies for the recovery of nickel, chromium and water from electroplating drag-out baths. BED, on the other hand, was successfully used for the regeneration of waste ion-exchange regenerants.

BED was also cost-effective in recovering acids from spent pickling baths and for acid or caustic soda reclamation from effluents containing sodium nitrate, sodium sulphate and sodium acetate.

The positive results obtained in this extensive investigation showed that electrodialysis and its different variants could be used cost-effectively in the recovery of valuable plating metals in the electroplating industry. Recovered water could also be recycled to the different plating processes. Very short pay-back periods were calculated for certain of these treatment processes.

Cost: R98 000
Term: 1993

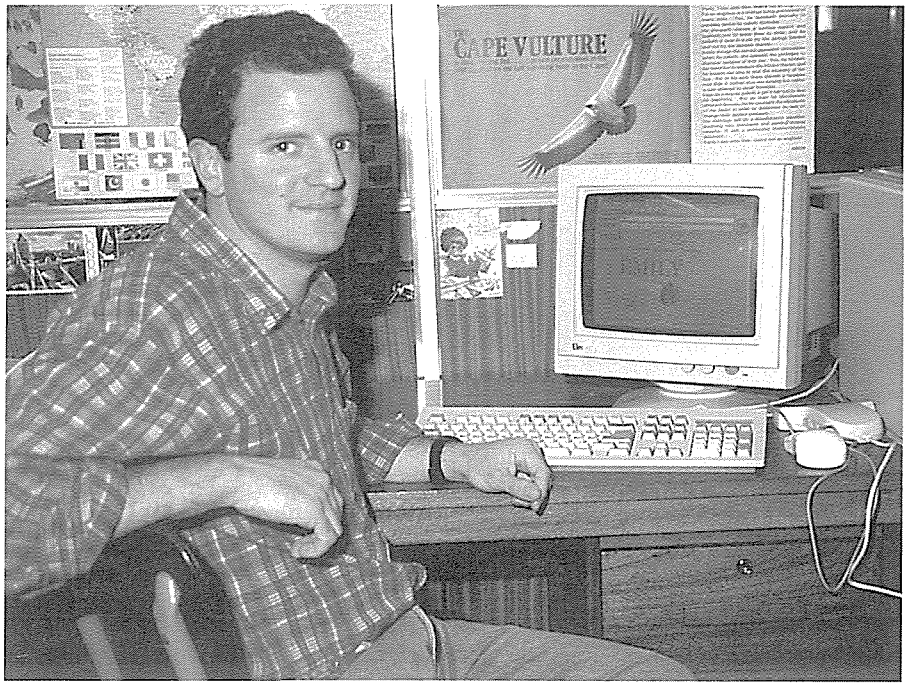
Modelling flow through porous media

(No 585) Department of Applied Mathematics, University of Stellenbosch

The basis for this project was developed in a preceding study. The prime objective of this project was to further improve the modelling framework of the deterministic mathematical analysis of flow phenomena in porous media and to demonstrate the enhancement of the practical predictive capabilities in this field. Aspects such as contaminant transport and dispersion, macroscopic boundary effects, anisotropy of the porous structure and membrane morphology and pore dia. distribution were taken into account during the refinement of the model and the subsequent development of numerical simulation techniques.

Viewed globally, the project produced a sound theoretical basis for the analytical and computational quantification of flow phenomena relating to seepage through foams and granular materials over the entire porosity and velocity spectra. The fact that theoretical predictions, for vastly different physical phenomena, correlate extremely well with experimentally generated results, provides confidence in the theoretical approach adopted and in the models developed.

Cost: R86 000
Term: 1993-1994



Mr Quentin Hurt in front of the EMILY bulletin board.

New project

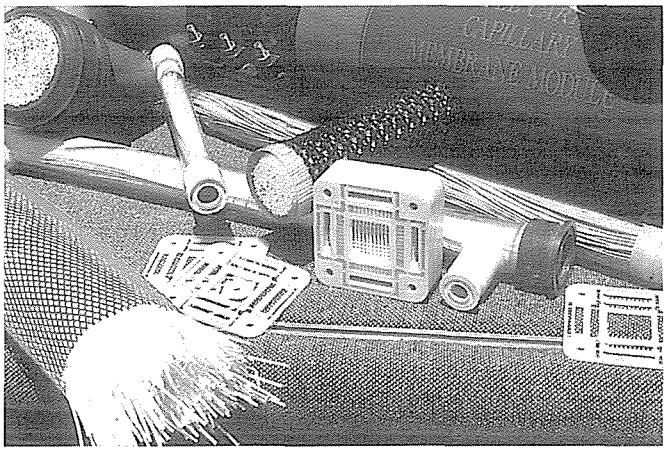
Designed functionalised polymers by anionic macromolecular engineering for membrane development

(No 723) Department of Chemistry, Vista University (Port Elizabeth Campus)

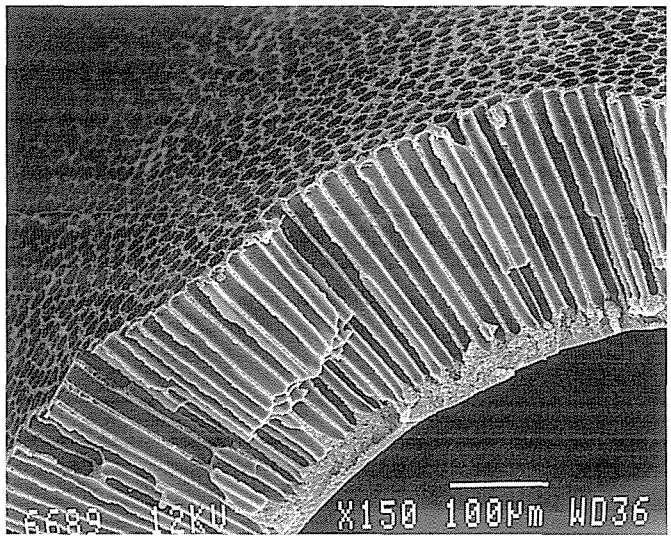
Rapid industrialisation and urbanisation over the past decade have caused severe water pollution and hence the protection of valuable water resources has become a matter of national importance. An effective method of desalinating water for potable or industrial use is by the application of synthetic membrane separation processes.

Although most types of membrane are commercially available, they are still subject to certain disadvantages such as rapid hydrolysis, fouling and excessive cost. The main aim of this project is to develop polymers for membrane production which will overcome most of these problems. Such cost-effective membranes will be used with selected sterilisation techniques to produce potable water for rural and peri-urban communities from locally available sources. At the same time students and staff from a historically disadvantaged university will be given training in membrane production and application at an existing centre with extensive experience in this regard.

Estimated cost: R452 000
Estimated term: 1995-1997



Capillary membranes and modules.



Outer skinless ultrafiltration membrane.

Research projects

Completed

- **KV70/95** Establishment of a membrane file transfer protocol site on the CCWR computer (EMILY) (University of Natal – Pollution Research Group)
- **362** Industrial application of membranes (University of Stellenbosch – Institute for Polymer Science)
- **532** Electrically driven membrane separation processes for the treatment of industrial effluents (CSIR – Division of Water Technology)
- **585** Modelling flow through porous media (University of Stellenbosch – Department of Applied Mathematics)

Current

- **201** Treatment of inorganic brines and concentrates (University of Natal – Pollution Research Group)
- **238** Design criteria for crossflow microfiltration (University of Natal – Pollution Research Group)
- **529** Membrane characterisation by electrochemical measurements and membrane optimisation with computational fluid mechanics (Potchefstroom University for CHE – Department of Chemical Engineering)
- **531** Development of characterising and cleaning techniques to classify foulants and to remove them from ultra- and microfiltration membranes by biochemical means (University of Stellenbosch – Department of Biochemistry)
- **547** Synthesis of organic precursors for the development of novel tubular membranes for the treatment of industrial effluents (University of Stellenbosch – Department of Chemistry)
- **548** Investigation into the upgrading of Orange River water and secondary sewage effluent by means of ultra- and nanofiltration (University of Stellenbosch – Institute for Polymer Science)
- **618** Development of specialised cross- and transverse-flow capillary membrane modules (University of Stellenbosch – Institute for Polymer Science)
- **619** Tolerant membranes (University of Stellenbosch – Institute for Polymer Science)
- **632** Capillary membrane production development (University of Stellenbosch – Institute for Polymer Science)

New

- **723** Designed functionalised polymers by anionic macromolecular engineering for membrane development (Vista University – Department of Chemistry (Port Elizabeth Campus))

CONTACT PERSONS

- **Dr HM Saayman** (Development and Application of Membranes)
- **Dr TC Erasmus** (Engineering Aspects of Membranes)

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10
Hydrometeorology

South Africa's national water resources are both limited and highly variable in time and space. Consequently, the catchment-scale and national assessment of water resources in relation to the water needs of the country and its communities are of vital concern for effective planning and management. Because both surface water and groundwater are closely linked to rainfall, particularly highly variable summer convective rainfall, hydrometeorological studies provide the cornerstone of water resources assessment.

South Africa's raingauge network has, over the years, provided much valuable data for water resources assessment. Information derived from raingauge data include long-term, average spatial distribution of rainfall and also the long-term behaviour, in terms of averages and probabilities, of localised (point) rainfall for periods of varying length, from one day through to several years. While such information makes a useful contribution to water resources assessment, much other rainfall-related information, not as easily obtained, is required by managers and practitioners who are confronted with water resources problems on a daily basis. Particular needs are for:

- Statistics on simultaneous space-time characteristics of storm rainfall over South Africa
- The real-time, continuous monitoring of rainfields with respect to spatial distribution of rainfall amounts and intensities
- Precipitation forecasting and prediction with lead times varying from hours (nowcasting) through to several months (seasonal forecasting) and even decades (in the case of global climate change).

Research projects in hydrometeorology are currently focused mainly on satisfying such needs.

Workshops on hydrometeorology topics

Two successful workshops, each attended by approximately 24 participants, were held in September 1995.

The first, on characterising spatially distributed rainfall, achieved the following :

- Needs for spatial rainfall characterisation were established
- The state of the art with regard to measuring systems, interpolation methods and stochastic modelling was assessed
- Recommendations were made regarding future activities and research.

The second, a joint initiative with the Weather Bureau, was on the potential hydrological uses of weather radar. The hydrological community, which was strongly represented at the workshop, was provided with information on the network of weather radars currently being developed by the Weather Bureau. The needs of hydrologists and water resources engineers for radar data products, to be used both for research and for operational purposes, were assessed and finally, initiatives for satisfying such needs were identified.

Through the workshops, the extent of ground common to meteorologists and hydrologists was revealed and the complementary needs and skills of the two groups, with respect to the solution of water resources problems, recognised. A sound basis for future co-operation was established.

Elizabeth Mahlangu

Completed projects

Development of a rainfall estimation algorithm from Meteosat imagery

(KV 69/95) Department of Geography and Environmental Studies, Potchefstroom University for CHE

The aim of this study was to investigate the relationship between satellite-derived cloud top temperature and observed rainfall in order to develop a satellite-based rainfall estimation scheme. Hopefully, such a scheme would be able to contribute information on the areal distribution of rainfall, a need which cannot be met satisfactorily by using raingauge data alone. Investigations revealed a distinct but weak relationship between cloud top temperature and half-hourly rainfall, with coldest clouds having the highest rainfall probability. Contributing to the weakness of this relationship were the occurrence of cirrus clouds and the significant percentage of cold clouds which did not rain. While the study did not succeed in producing a usable relationship, a sound foundation was laid for further study and more rapid progress towards the goal.

Cost: R20 000
Term: 1992-1994

Techniques for seasonal and long-term rainfall forecasting in South Africa

(No 306) Department of Civil Engineering (Chair of Meteorology), University of Pretoria

Water resources management would benefit significantly from reliable seasonal rainfall predictions. This project aimed to investigate techniques which could be applied to predict rainfall anomalies over South Africa for periods ranging from two weeks to several months in advance. For seasonal prediction, techniques based on the phase of the ENSO (El Niño – Southern Oscillation) still continued to enjoy the most success. However, statistical and neural net models appeared to have potential for improving the spatial and temporal accuracy of seasonal rainfall predictions. Modelling was successful in illustrating the effect of large sea surface temperature (SST) anomalies over the tropical Indian and Pacific Oceans on circulation pattern changes over South Africa. Such circulation changes constitute a non-linear atmospheric response to convective forcing due to SST anomalies. Together with associated rainfall anomalies, they would therefore be difficult to predict using an alternative approach. The modelling route is thus recommended as the best future means of investigating and developing seasonal rainfall prediction schemes.

Cost: R493 000
Term: 1990-1995

Development of a real-time, non-conventional rainfall mapping system

(No 438) Department of Civil Engineering (Chair of Meteorology), University of Pretoria

Information on the spatial distribution of rainfall in near-real time is required by many water resources and agrohydrological applications. The aim of this project was to develop a system for the real-time mapping of daily rainfall using Meteosat data, calibrated on the basis of data obtained with radar and from raingauge networks. Building on results of research done at Potchefstroom University (see above report on KV 69/95), a procedure was successfully developed whereby rainfall rates could be assigned to clouds depicted in Meteosat imagery.

The main features of this procedure are to:

- Classify pixel groups recognised as raining clouds into different types of rain-producing cloud types
- Calculate cloud depths in terms of temperature differences between cloud bases and cloud tops
- Use a predetermined relationship for each cloud type to calculate appropriate rainfall rates from corresponding cloud depths.

Maps depicting satellite-derived daily rainfall compared well with maps based on measured rainfall for non-coastal regions; further research is, however, needed to establish correct procedures for coastal regions.

Cost: R302 800
Term: 1992-1995

New projects

Development of an objective system to forecast summer rainfall over Southern Africa

(No 672) Department of Oceanography, University of Cape Town

Recent research advances have demonstrated that long-range forecasts over the plateau of Southern Africa are possible. Currently forecasts are, often very subjectively, based on a variety of atmospheric and oceanic precursor indices. Uncertainties are high and forecasts are not sufficiently area-specific. The aim of this research project is to develop a statistical forecast system which objectively accounts for the interaction of global and regional predictive indices and climatic forcing patterns.

Estimated cost: R600 000
Expected term: 1995-1998

Weather radar measurement of rainfall as well as hydrological applications of weather radar

(No 693) Department of Civil Engineering (Chair of Meteorology), University of Pretoria

Limitations of available measurement systems have for long prevented adequate characterisation of the joint spatial and temporal properties of convective rainfall over South Africa. With the recent acquisition of a dual wavelength (S- and X-bands) research radar and the deployment of a national network of C-band radars, these limitations can be addressed, provided appropriate techniques are developed. This project aims to develop and apply S- and X-band radar techniques for measuring storm rainfall accurately at scales varying from cloud to catchment scale. Intercomparisons with rainfall observations by means of C-band radar, satellite and raingauges will also be made and analysed.

Estimated cost: R760 000
Expected term: 1995-1998

Research projects

Completed

- **KV69/95** Development of a rainfall estimation algorithm from Meteosat imagery (Potchefstroom University for CHE – Department of Geography and Environmental Studies)
- **306** Techniques for seasonal and long-term rainfall forecasting in South Africa (University of Pretoria – Department of Civil Engineering (Chair of Meteorology))
- **438** Development of a real-time, non-conventional rainfall mapping system (University of Pretoria – Department of Civil Engineering (Chair of Meteorology))

Current

- **349** Evaporation measurements above vegetated surfaces using micro-meteorological techniques (University of Natal – Department of Agronomy)
- **374** Southern Agulhas Current and its influence on the weather and climate of Southern Africa (University of Cape Town – Department of Oceanography)
- **436** Mechanisms of short-term rainfall variability (University of Cape Town – Department of Oceanography)
- **437** Assessment of the potential for using stable carbon isotope ratios of wood charcoal as a climate indicator (South African Museum – Cape Town)
- **550** Development of models to stochastically generate spatially distributed daily rainfields (University of Natal – Department of Civil Engineering)
- **594** Regional climate change scenarios for precipitation and temperature from general circulation models (University of Cape Town – Department of Environmental and Geographical Science)
- **595** Modelling rainfall-producing systems over Southern Africa (University of the Witwatersrand – Climatology Research Group)
- **596** Development of a real-time non-conventional rainfall mapping system for coastal zone cloud systems (University of Pretoria – Department of Civil Engineering)

New

- **672** Development of an objective system to forecast summer rainfall over Southern Africa (University of Cape Town – Department of Oceanography)
- **693** Weather radar measurement of rainfall as well as hydrological applications of weather radar (University of Pretoria – Department of Civil Engineering)

CONTACT PERSON

- **Dr GC Green**

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11

Rainfall stimulation

Water resources augmentation has become a necessity in various parts of South Africa. Rainfall stimulation through cloud seeding is an augmentation option which has been researched locally for many years under the auspices of the WRC and the Weather Bureau. Prior to 1995, however, no operational cloud seeding for rainfall stimulation had yet been attempted.

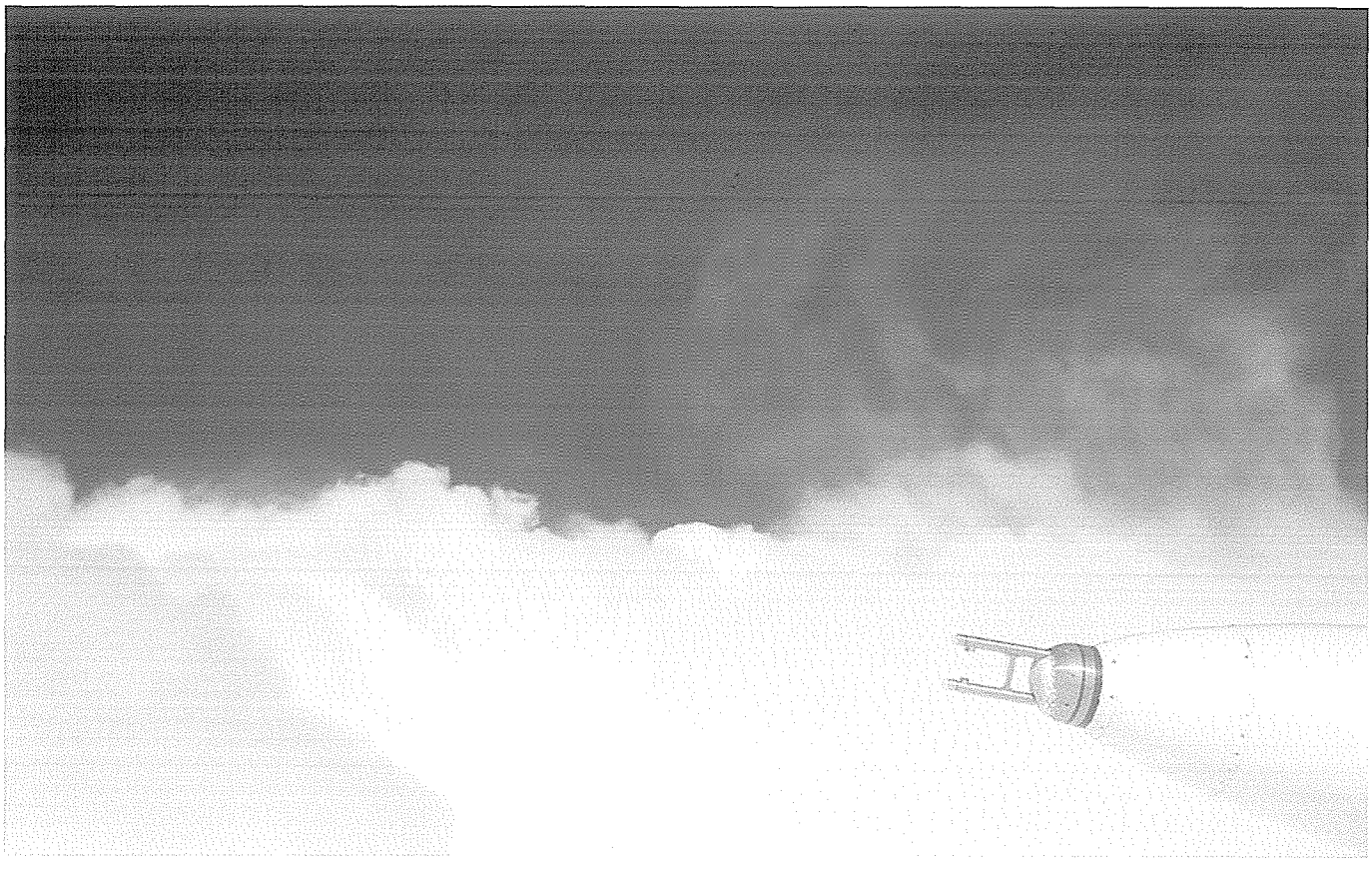
During recent years of research, it has been demonstrated fairly conclusively that convective clouds respond to a seeding procedure whereby hygroscopic particles are released into the clouds' updraft regions by means of aircraft-borne flares especially developed for this purpose. The response becomes evident about 20 min after seeding commences. On average, a sample of randomly chosen treated clouds was found to produce 30% more rain, measured with radar, than a corresponding sample of non-treated clouds.

The experiments which yielded the above-mentioned results were carefully planned by statisticians and carried out in the vicinity of Carolina in Mpumalanga Province and Bethlehem in the Free State. The research team comprised scientists and technicians employed by the Weather Bureau and the firm CloudQuest (Pty) Ltd, assisted by UNISA's Centre for Applied Statistics. Statistical experimentation was supported by microphysical measurements made in clouds using suitably instrumented aircraft, and also by numerical studies undertaken largely with collaborators in the United States.

Early in 1995 the serious drought in the Northern Province resulted in a request to the WRC and the Weather Bureau, through the DWAF, to launch an emergency rainfall stimulation programme in an effort to contribute to much needed drought relief. The public in the province were widely consulted. By 9 February 1995 the parties involved had reached consensus and preparations to launch the programme commenced in earnest. Whereas research in the Carolina area was affected by these activities, research in the Bethlehem area was able to continue unhindered. The Carolina research had ultimately to be terminated because of the need to relocate radar equipment and aircraft to Tzaneen in the Northern Province.

The Northern Province emergency programme was able to commence on 3 March 1995. Although run on an operational basis for the first time in South Africa (i.e. the choice of clouds to seed was no longer constrained by statistical randomisation procedures), aircraft operations and data collection were nevertheless planned with the intention of developing and testing methods of evaluating the success of operational cloud-seeding activities.

By the end of March 1995, 9 opera-



tional days, for which adequate data sets were available, had been logged for further analysis. On these days, selection of storms to be seeded was done very early in the lifetime of each storm, well before it had become clear how long the storm would last and how much rain it would produce. Notwithstanding this, on 8 out of the 9 days, the storms which were seeded produced more rainfall than any other storm within the range of the radar on that day.

The Weather Bureau maintains a district rainfall database containing monthly rainfall over a 75-year period for the 93 districts into which South Africa is divided. Rainfall measurements made by all the rainfall stations within each district contribute to this database, which serves as a basis for rainfall comparisons between districts. Recorded tracks of storms seeded on the 9 operational days in March showed that seeded storms were mostly confined to District 64. Neighbouring districts which could serve as control areas for purposes of comparison were Districts 76 and 48. When district rainfall comparisons were made for March 1995, it transpired that District 64 rainfall was considerably higher than rainfall which one would have expected from linear relationships between March rainfall of District 64 and that of District 76 and District 48.

Although these results cannot, at this early stage, be regarded as conclusive, they do suggest that elevated rainfall was experienced by District 64 during March 1995, possibly as a result of cloud-seeding activities.

Over the next three seasons it is hoped to round off what will then be approximately 15 years of research into the feasibility of rainfall enhancement through cloud seeding. The emphasis will shift towards experimentation aimed at conclusively demonstrating hydrological benefits of operational seeding over a specific target area and towards the development of procedures for the scientific evaluation of operational cloud-seeding programmes in general.

Research project

Current

- 133 National precipitation research programme with a view to rainfall enhancement (Company for Research on Atmospheric Water Supply (CRAWS) and Department of Environment Affairs (Weather Bureau), subcontracting CloudQuest (Pty) Ltd and UNISA)

CONTACT PERSON

- **Dr GC Green**

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12

Management of water resources

The well-known phrase: "So much water and not a drop to drink" illustrates the epitome of what happens if our water resources are not managed in an integrated way. Appropriate public participation in this process is of cardinal importance.

It is extremely heartening to see that the environment is no longer seen as an ordinary water user in competition with other user groups but as the resource base to be protected along with the protection of the environment. This resource base is not only the river but the entire catchment and the ecosystems it harbours. The wise utilisation of this resource base in the face of growing human demands will need all the skills and wisdom we as a nation can muster.

The unequal access to resources needs to be redressed promptly, while maintaining a balance between the resource base and hasty and politically expedient decisions.

The pioneering research which started in 1989 on the quantitative structuring of national water-planning objectives has taught us many things, not the least of which that a society has to grow into accepting new management cultures. This is a slow process.

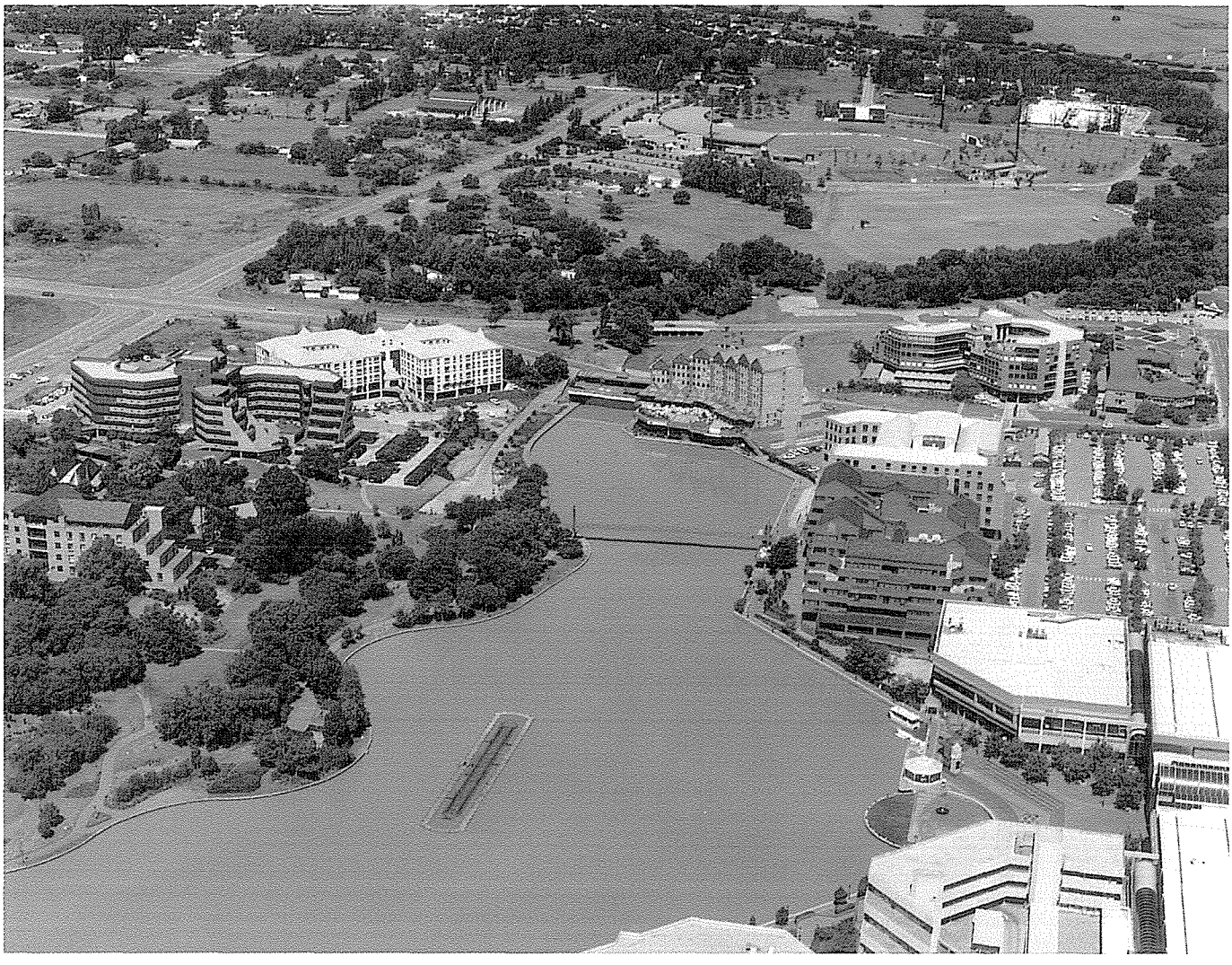
The role of science in this process will have to become more people-orientated because only incentives and policies that can persuade people to change their behaviour can assure equitable access to water and a safe future for our resource base.

Completed projects

Development of flood-damage functions and a computer program to determine the advantages of flood and flood damage control measures

(No 490) Department of Agricultural Economics, University of the OFS

On average once every 2 years South Africa experiences floods which cause significant damage and flood-damage control measures are therefore necessary to reduce the damage. In order to determine the optimal combination of these control measures to be incorporated in a flood management plan, planning aids are needed. An example of such an aid is



The health of an urban lake depends on integrated management of its catchment.

a computer program by means of which the damage caused by various floods can be estimated. As such computer programs were not available in South Africa, the purpose of this project was to rectify this situation.

The programs are aimed at integrating the hydrological information on floods with the topographical properties of the flood-plain, as well as with the land uses within the flood-plain and the flood-damage functions of the various land uses. A flood-damage function refers to relationships which indicate the damage done to a specific land use, for example for various flood-water depths.

Studies were conducted separately in urban and in irrigation areas in order to develop flood damage functions, the relevant computer database and computer program for the optimisation of various flood-control and flood-damage control measures. For the urban areas the municipal area of Vereeniging adjacent to the Vaal River was selected, as well as the Upington municipal area adjacent to the Orange River. The other part of the investigation comprised the irrigation area upstream and downstream of Upington (i.e. from the Gifkloof Barrage up to the Manie Conradie Bridge at Kanoneiland).

The results of the study can be summarised as follows:

- Flood-damage functions were determined for the various land uses in the irrigation and urban areas.
- Computer databases which store the above-mentioned functions, were developed for both areas.
- Computer models were developed to determine various combinations of flood-damage control measures.
- The application of the computer programs was illustrated for both of the areas investigated. It was, for example, shown that the models could be used to estimate the average annual damage; and that they could be applied to determine the benefits of flood-damage control measures in irrigation and urban areas.
- All the research objectives were met for both of the areas investigated. More research is, however, required to further develop the models up to a point where they can be applied more widely than just the Vereeniging and Upington areas, as well as to facilitate their application. A follow-up project will deal with these aspects.

Cost: R443 700
Term: 1992-1994

Case study of stormwater pollution control in a representative valley

(No 518) Wates, Meiring and Barnard Inc.

The area selected for the study was the Hennops River catchment upstream of and including the Centurion Lake. This catchment contains a typical South African assortment of diffuse pollution sources such as the Olifantsfontein sewage treatment plant, a quarry, Tembisa and Ivory Park townships, informal and low-cost housing as well as various agricultural and industrial activities. At the onset of the research it was envisaged that 80% of the pollution could probably be removed at 20% of the cost if some priority ranking of worst cases could be achieved. Results of the study showed that the major source of pollution is solid waste and faecal contaminants which are the result of deliberate pipe blockages, high population densities, ineffective on-site sanitation and general lack of environmental awareness. The contributions of the Olifantsfontein treatment plant were a source of dilution for upstream pollution. The Hennops River water, however, was unfit for use in all the selected water user categories: domestic, irrigation, industry, contact recreation, livestock and aquatic life. The study also highlighted the lack of institutional arrangements to combat pollution on a catchment basis and that integrated catchment management is the answer to restoring the health of urban lakes, as chlorination methods cannot safeguard it.

Cost: *R266 600*
Term: *1993-1995*

New projects

Holistic, catchment-scale, comparison of water-use efficiency of crops, focusing on the comparison between forest plantations and key irrigated agricultural crops

(No 666) Division of Forest Technology, CSIR

The conflict between forestry and irrigated agriculture regarding water use is well known. Typically, forestry is located in higher rainfall upper parts and agriculture in drier lower parts of catchments. If forestry establishment temporally follows agricultural activities, it has been argued that water-thirsty trees reduce runoff and deprive agricultural crops of surface water applied for irrigation purposes. One aspect of this problem is insufficient information on the value of production in relation to water use of various crop types. The objectives of the research are therefore to calculate the water-use efficiency by comparing annual monetary return with water use by forestry species and ranking selected irrigated crops accordingly. These ratios will be a valuable input to determine the economic impact of re-allocation of limited water resources. Due recognition will of course also have to be given to legal, social and ecological considerations. The existing real competition between afforestation and a range of irrigated agricultural crops including tropical fruit, sugar cane and tobacco will be analysed on a case-study basis within the Crocodile River catchment. The aim is to consolidate and refine all available information on water use, yield and revenue. As the ratio of water-use efficiency is sensitive to changes in at least two quantities, it will be necessary to estimate a likely range for each crop. This will allow a realistic comparison under current and expected hydrological and economic conditions. The functionality of the catchment resource allocation model (CRAM) as a tool designed to facilitate comparisons between competing resource users will be tested. These results will assist stakeholders in forestry and agriculture as well as policy-makers on a provincial and

national level to resolve issues regarding the efficient and equitable re-allocation of water.

Estimated cost: R204 700
Expected term: 1995-1996

Capacity of catchments to satisfy the water requirements of rural areas

(No 680) Department of Landscape Architecture, University of Pretoria

The water resources of South Africa are being put under extreme pressure as a result of the historic and unnatural development of the population distribution.

The sad dichotomy of the situation is that growing local over-population seriously affects the ecological capacity of the resource base while at the same time demands on the local resources such as wood and water are increasing.

The spatial distribution of our water resources has never been closely studied in the context of population distributions. Present technology enables us to assess both surface and groundwater resources against the latest census data. On this basis it will be possible to make an evaluation of the specific capacity of catchments to satisfy local water demands. Possibly a national picture of required future water transfers can be painted.

Estimated cost: R110 000
Expected term: 1995

Integrated catchment management approaches in South Africa

(No 682) Division of Environmental Services, CSIR

This project is seen as an initial step in developing an approach to integrated catchment management (ICM) for the South African situation. It has been recognised that there is a need for greater transparency in the process of water allocation and management. In a people-orientated society ICM facilitates the participation of the public in these issues while still maintaining the aims of sustainable utilisation of resources.

However, care has to be taken that this ICM process is implemented in South Africa in an appropriate fashion. A critical review of international experience in this regard is necessary.

Processes and tools applicable to the South African situation need to be identified and this information needs to be conveyed to scientists, managers and the public so that common understanding of methods for arriving at agreed management practices, is enhanced.

Estimated cost: R98 580
Expected term: 1995

Continued research on flood damage functions, models and computer programs for irrigation and urban areas in South Africa

(No 690) Department of Agricultural Economics, University of the OFS and the DWAF

In a previous project models were developed by means of which information can be generated in an *ex ante* manner, i.e. prior to a flood. Thereby it has become possible to estimate the likely occurrence of floods within demarcated areas, and to determine the advantages of various flood control measures. This information is useful for optimal flood and of flood-plain management, in terms of the integrated approach to catchment planning. The functions, models and programs are, however, restricted to certain localities. In order to render them applicable to other areas, adjustments have to be made and their correctness and validity tested anew. The purpose of this research is therefore to develop and adjust the various components of flood damage estimates in order to render them more generally applicable to irrigation and urban areas. Provision also has to be made for three levels of decision-making, namely local, regional and national. This would entail a study to find more rapid and cost-effective methods of gathering information on e.g. land-use patterns and types of housing. The expected recommendations regarding the responsibilities of individuals and local communities with regard to flood consequences, in accordance with the revised flood management policy, should also be taken into account. The need for timely information on damage potential is emphasised due to rapid urbanisation and the risk of loss of life due to habitation within the flood-level boundaries of rivers.

The activities that require attention include situation assessment and selection of alternative study areas, identification of critical variables which need to be adjusted, development of standard survey methods and compilation of a data bank of flood damage functions. Mainly planners and policy-makers are the target groups aimed at.

Estimated cost: R247 500
Expected term: 1995-1996

Research projects

Completed

- **490** Development of flood-damage functions and a computer program to determine the advantages of flood and flood-damage control measures (University of the OFS – Department of Agricultural Economics)
- **518** Case study of storm-water pollution control in a representative valley (Wates, Meiring and Barnard Inc.)

Current

- **375** Development of a distributed hydrological modelling system to assist with water quantity and quality management in the Mgeni catchment, Phase II (University of Natal – Department of Agricultural Engineering)
- **512** Development of procedures for decision support in water resources management (University of Cape Town – Department of Statistical Sciences)
- **515** Groundwater abstraction in the Port Elizabeth municipal area (SRK (CE) Inc. and the Municipality of Port Elizabeth)
- **526** Distribution of fluoride-rich groundwater in the eastern and Mogwase regions of Bophuthatswana: Influence of bedrock and soils and constraints on utilisable drinking-water supplies (University of Cape Town – Department of Geology)
- **639** Economics of groundwater usage: The importance of intrinsic value as a basis for sustainable management (Economic Project Evaluation (Pty) Ltd)
- **640** Extension and refinement of the AQUAMOD computer software package (University of the OFS – Institute for Groundwater Studies)
- **642** Development of a water information management database system for data capture and processing at local authority level (University of the OFS – Institute for Groundwater Studies)

New

- **666** Holistic, catchment-scale, comparison of water-use efficiency of crops, focusing on the comparison between forest plantations and key irrigated agricultural crops (CSIR – Division of Forest Technology)
- **680** Capacity of catchments to satisfy the water requirements of rural areas (University of Pretoria – Department of Landscape Architecture)
- **682** Integrated catchment management approaches in South Africa (CSIR – Division of Environmental Services)
- **690** Continued research on flood damage functions, models and computer programs for irrigation and urban areas in South Africa (University of the OFS – Department of Agricultural Economics and the DWAF)

CONTACT PERSONS

- **Mr H Maaren** (Hydrology and Water Management)
- **Mr HC Chapman** (Urban Water Balance)
- **Mr AG Reynders** (Groundwater Aspects)
- **Dr GR Backeberg** (Aspects related to Agriculture)
- **Mr HM du Plessis** (Pollution Aspects)

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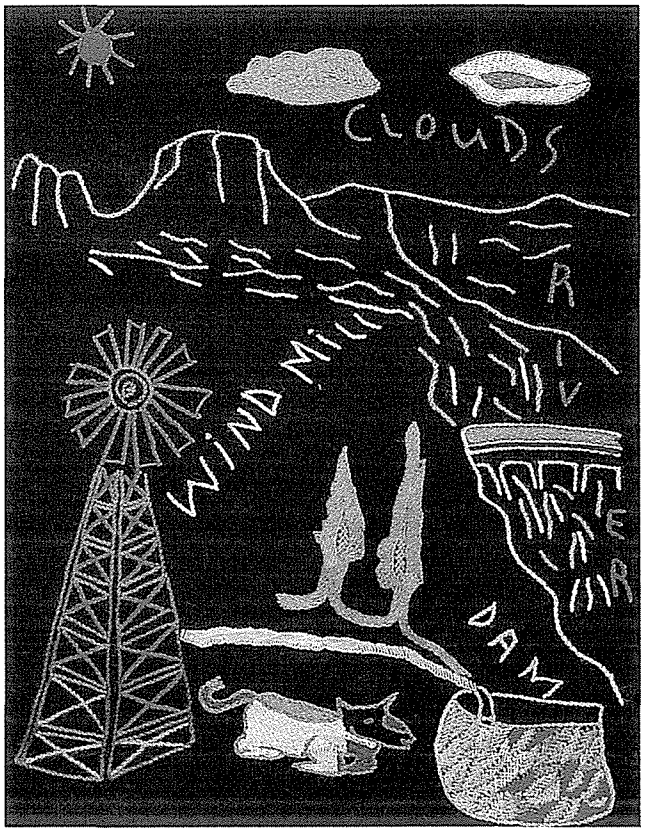
13
Surface hydrology

As the pressure on our water resources increases, the need for better scientific knowledge and understanding of processes increases accordingly. Even at the international level we find that debates on water resources issues are often characterised more by emotional than factual content.

The role of hydrology as an earth science will need clear redefinition; with limited funding, the priorities for research will have to become more society-orientated.

As water shortages are experienced by a growing number of people, there is a considerable risk that a lack of factual information could lead to misdirected ways of alleviating the problem. Some years ago the effect of small dams on our surface runoff regimes started to emerge as an important issue. Presently this problem is well recognised. However, from a hydrological process viewpoint, the large reservoirs we have been building suffer from the same shortcomings. In fact, each reservoir we build creates a new opportunity for accelerated evaporation and disappearance of water into the vastness of the atmosphere, most probably never to make any further contribution to our available water. With each successive assessment, we find that our available water resource is decreasing. Two reasons can be put forward: our droughts are getting worse and/or evaporation losses out of our systems are increasing. If we quantify these losses adequately, we may arrive at solutions to water supply problems that could deviate drastically from traditional approaches.

Knowledge and good information can be expected to play a vital role in the future negotiation process concerning water. However, there is a danger of moving into an area of sectoral hydrology such as forest hydrology, irrigation hydrology and pollution hydrology each supporting specific interests. We must make sure that hydrology continues to be developed as the universal science which forms the basis of integrated water management.



Thandi Sondlo

Completed projects

Adaption and calibration of an urban runoff quality model

(No 299) Division of Water Technology, CSIR

The primary objective of this research was to modify an existing urban runoff model, WITSKM, in order to perform water quality modelling under typical South African urban conditions.

With the model best management practices (BMP), diversion and detention of runoff can be evaluated in terms of water quality. This will allow that, in the management of urban runoff, attention can be given to both quantity and quality of runoff when drainage systems are designed. The developed model, now called WITQUAL, was applied to 7 runoff events for the Shembe catchment near Durban, a catchment dominated by informal and low-cost housing. The pollutant types modelled were suspended solids, total dissolved solids and particulate and dissolved phosphorus. Running the model in a continuous mode, with constant model parameters, for the entire period, showed results that can be considered adequate for examining typical "what-if" management scenarios in urban runoff. However, the biggest unknown factor in applying the model in new situations is the determination of pollutant build-up rates, the nature of the pollutants in the catchment and particle size distributions.

Cost: R656 000
Term: 1990-1994

Revision of the SCS-based design runoff procedures

(No KV 64/94) Department of Agricultural Engineering, University of Natal

The United States Department of Agriculture's Soil Conservation Service (SCS)-based techniques for the estimation of design flood volume and peak discharge from small catchments (i.e. < 30 km^2) were originally adapted for use in Southern Africa by Schulze and Arnold in 1979. Based on extensive research and extended databases, an updated version of the 1979 design manual was produced in 1987 in the form of 3 reports published by the WRC: TT 31/87, TT32/87 and TT 33/87.

In 1991 when more than 1 000 copies of these reports had been distributed, it was realised that a computerised update was needed. This consultancy subsequently produced:

- A user manual of approximately 80 pages
- A user-friendly software package for PC/DOS.

The new South African soil classification was included for easy reference and some other modifications, as suggested by users, were incorporated.

Cost: R19 000
Term: 1994

New projects

Short-duration design rainfall estimates for Southern Africa

(No 681) Department of Agricultural Engineering, University of Natal

Many thousands of engineering and conservation designs, involving millions of rands, are made annually in South Africa requiring the best possible short-duration design rainfall data. Databases used in current depth-duration-frequency procedures only extend to the 1970s and were derived from manually extracted values at 4 time intervals (15, 30, 45 en 60 min). Since 1970 the extended digitised database has become available and this desktop research will use state-of-the-art techniques of extreme value analysis, regionalisation of data, interpolation and extrapolation, while some results will be presented in GIS format.

Estimated cost: R390 000
Expected term: 1995-1998

Evaporation from the Orange River: Quantifying open water resources

(No 683) Division of Forest Science and Technology, CSIR

Evaporation from open-water surfaces constitutes the biggest single loss of water from our river and reservoir systems. A recent study (Report No KV 53/94) on evaporation from the Orange River below Vanderkloof Dam indicated poor relationships between evaporation from pans and Bowen ratio estimates.

Indications are that future estimates of evaporation may be enhanced by using land-based meteorological data rather than traditional evaporation pans. The above study, however, only measured evaporation over a 30-day period.

The present study will measure evaporation over an extended period and establish the relationship between observed evaporation and commonly used climate variables.

Estimated cost: R241 000
Expected term: 1995-1996

CONTACT PERSONS

- **Mr H Maaren** (Hydrology and Water Management)
- **Mr HC Chapman** (Urban Water Balance)
- **Mr DS van der Merwe** (Flow Measurement and Sediment)

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Research projects

Completed

- **299** Adaption and calibration of an urban runoff quality model (CSIR - Division of Water Technology)
- **KV64/94** Revision of the SCS-based design runoff procedures (University of Natal - Department of Agricultural Engineering)

Current

- **317** Urban catchment monitoring (Welkom City Council and SRK (CE) Inc.)
- **319** Monitoring the effect of catchment development on urban runoff and water balance (University of the Witwatersrand - Department of Civil Engineering, Water Systems Research Group)
- **424** Development of an urban component for the ACRU model (University of Durban-Westville - Department of Geography)
- **442** Development of improved flow gauging structures for South African rivers (Sigma Beta (CE))
- **492** Effect of the agricultural environment on water resources (University of Natal - Department of Agricultural Engineering)
- **493** Development and testing of a water balance model for a grassland catchment in the summer rainfall area of South Africa (CSIR - Division of Forest Science and Technology)
- **494** Classification and hydrological modelling of low flows in Southern Africa (Rhodes University - Institute for Water Research)
- **509** Palaeoflood hydrological analysis for selected South African rivers (Geological Survey)
- **511** Hydrological implications of afforestation in the North-Eastern Cape (CSIR - Division of Forest Science and Technology)
- **580** Control of dam siltation in South Africa (BKS Inc.)
- **635** Flow regimes from international experimental and network data (FRIEND) for Southern Africa (Rhodes University - Institute for Water Research)
- **636** Hydrological systems modelling research programme: ACRU model development and user support (University of Natal - Department of Agricultural Engineering)
- **637** Hydrological systems modelling research programme: Hydrological process research (University of Natal - Department of Agricultural Engineering)
- **638** Studies on river losses: Phase 2 (BKS Inc.)
- **643** Development of rigorous engineering methodology for designing vegetative erosion protection systems: Phase 2 (SRK (CE) Inc.)

New

- **681** Short-duration design rainfall estimates for Southern Africa (University of Natal -Department of Agricultural Engineering)
- **683** Evaporation from the Orange River: Quantifying open water resources (CSIR - Division of Forest Science and Technology)

14

Conservation of water ecosystems

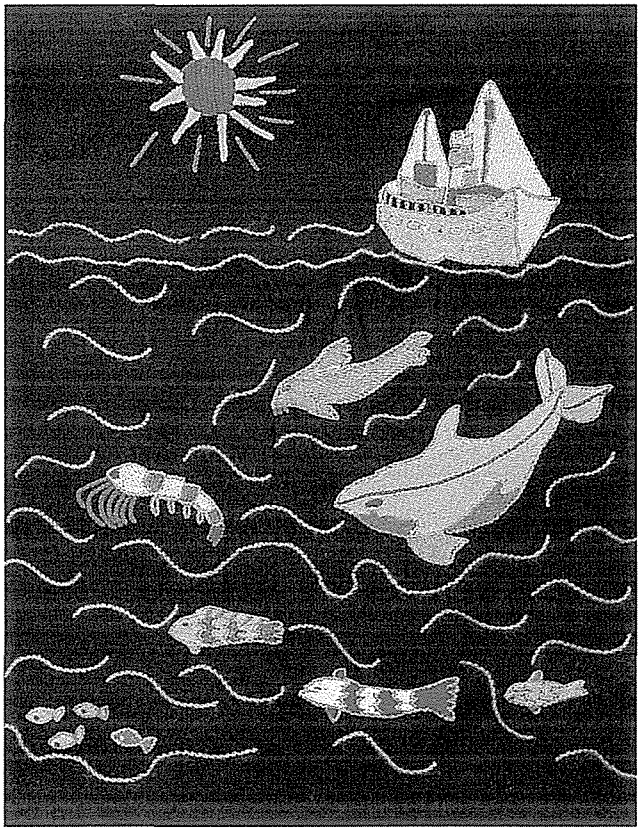
Much of the research being funded in this field is aimed at alleviating the effects of human interference with natural ecosystems. Inter-basin transfers (IBTs) have been widely used in South Africa for some decades, but little is known of the ecological and geomorphological impacts of these on the donor and recipient rivers. With more major IBTs being planned, the WRC has funded 2 projects which started this year to investigate the ecological effects of IBTs.

The development of the South African Scoring System (SASS), a rapid method for the bioassessment of river health using the invertebrate fauna, has reached a point where it gives predictably consistent results, and is now being applied routinely in areas. Techniques for ecotoxicity testing using organisms from the lotic (running water) environment continue to be developed, with the start of a follow-up project by the Institute for Water Research, Rhodes University, on the use of an artificial stream for determining tolerances of organisms to pollutants. Projects from the Kruger National Park Rivers Research Programme are providing information useful not only for the management of these rivers, but also knowledge that may be applied to river management generally. A project on the water quality modelling of estuaries was started during 1995 to further the development of the decision support system being developed for estuarine management by the Consortium for Estuarine Research and Management (CERM).

The Co-ordinating Committee for Water Ecosystems Research met during the year, and it became apparent that the research plan for the field needs substantial revision. This will be done during 1996.

Professor M Newson, a fluvial geomorphologist/hydrologist from the UK, visited South Africa early in the year. During his visit a workshop was held, and one of the products of this was a matrix proposing standardised nomenclature for physical biotopes in lotic habitats by flow type. This was tested by the National Rivers Authority in the UK and it appears that it will form the basis of a useful system.

Dr C Swinnerton of the National Rivers Authority, UK, was sponsored by the WRC and was a keynote speaker at the South African Society for Aquatic Scientists Conference in Grahamstown and visited institutes where river research is being conducted.



Rose Masango

Completed project

Proceedings of the estuaries workshop held at Port Alfred on 3 to 4 November 1992

(No KV60/94) Consortium for Estuarine Research and Management

A workshop was held by the Consortium for Estuarine Research and Management (CERM) with the objective of developing a decision-support approach to determine the research and management needs of estuaries. During the workshop the following issues were identified:

- The need to be able to predict the consequences of altering the natural pattern of freshwater inflow
- The importance of determining the conservation status of estuaries
- The need to make decisions through the IEM (Integrated Environmental Management) framework as used by the DWAF and the Department of Environmental Affairs and Tourism
- The need for an importance rating system for use on estuaries
- The need to develop predictive capabilities for estuarine management
- That CERM will support and enhance decision-making processes for estuarine management.

New projects

System-related scale study to determine the function of the riparian vegetation of the Olifants River, Transvaal

(No 663) Roodeplaat Grassland Institute, Agricultural Research Council

A river system is the natural drainage of a catchment and is regarded as a highly complex ecosystem. These ecosystems are dynamic by nature and reflect the type and condition of the land area which is being drained. Should any part

of the system be disturbed the whole system will be affected.

Incorrect agricultural practices in the past caused unnecessary damage to river systems. Riparian vegetation is an integral part of any river ecosystem and destruction of this vegetation causes destabilisation of river banks which results in greater runoff, an accelerated erosion rate, and more silt deposition in the river system. Poor management practices such as overgrazing of natural vegetation of catchments and river banks or the removal of natural vegetation in favour of the establishment of cash crops, are some of the main causes.

The major part of the research to date comprises the autecology of individual species, more specifically invertebrate and fish species. Knowledge of riparian vegetation of SA river systems is very limited and mostly inadequate.

Against the above background the primary objective of this project is to investigate the functioning of the Olifants River System floristically. In addition it is being envisaged to determine the distribution of riparian plant communities in relation to the physical environment. The third objective is to formulate a management plan for each of these different riparian communities which will result in improved plant cover and species composition, as well as control over soil erosion, improved water infiltration and reduced silt deposits in order to improve water quality.

Estimated cost: R119 000
Expected term: 1995-1997

Investigation into the functioning of the riparian vegetation of the Olifants River.

Water quality modelling of estuaries

(No 664) Division of Earth, Marine and Atmospheric Science and Technology, CSIR

The modelling of water quality in estuaries was identified as a priority task for the management of these estuaries. During this project the objectives of estuarine water quality modelling will be clarified, and the utility of the Mike II model will be assessed by applying it to 3 selected estuaries. Other models available internationally will be examined as well. Recommendations will be made on the development of water quality modelling of South African estuaries.

Estimated cost: R165 500
Expected term: 1995-1997

Assessment of the ecological impacts of inter-basin transfer schemes in dryland environments

(No 665) Department of Zoology, University of Cape Town

Inter-basin transfers (IBTs) are being used increasingly world-wide to redistribute water from regions of relative plenty to regions where it is needed. However, knowledge of the ecological impact of these schemes is minimal. During this project the researchers will collaborate nationally and internationally to collate existing data, and investigate selected IBTs to determine the response of the biota to modification of the flow regime as well as the impact of the IBTs on water quality. Guidelines will be developed for the management of extant schemes which, within the required operation of the scheme, will minimise the impact of the scheme as far as possible.

Estimated cost: R266 000
Expected term: 1995-1998

Survey for potential biological control agents for the troublesome alga *Cladophora glomerata*

(No 669) Plant Protection Research Institute, Agricultural Research Council

Filamentous algae, particularly *Cladophora glomerata*, cause very serious problems in certain irrigation schemes. In the worst cases canal flow is reduced to a fraction of the design flow. Chemical control measures obviously have to be used with caution to avoid adverse effects on crops irrigated. During this project the possibility of harnessing biological control agents specific to the algae will be investigated.

Estimated cost: R115 000
Expected term: 1995-1997

Application of an artificial stream system to investigate macroinvertebrate water quality tolerances

(No 686) Department of Zoology, Rhodes University

Conventional laboratory bioassays usually use ubiquitous organisms, a technique which has certain advantages. However, the results cannot be used directly to predict the effect of certain compounds on endemic aquatic fauna. As South Africa has very little natural standing water, we need information on fauna from running waters.

The artificial stream system was developed and calibrated during the previous project (No 475), and this project follows on with the testing of certain organisms from running water. This system will enable the researchers to quantify the effects of pollutants/toxins on stream fauna.

Estimated cost: R977 500
Expected term: 1995-1998

Status report on the Kruger National Park Rivers Research Programme: A synthesis of results and assessment of progress

(No 711) Institute for Water Research, Rhodes University

At the beginning of 1994 the Kruger National Park Rivers Research Programme moved into its second phase. The goals of the programme are as follows:

- To inform researchers, system managers and stakeholders about the water quality and quantity requirements to sustain the natural environments of rivers which flow through the Kruger National Park
- To develop, test and refine methods for predicting the responses of the natural environments of these rivers to changing water quality and patterns of supply.

With the programme well into the second phase, a need was expressed to measure how far the programme has progressed in meeting its objectives. The intention therefore is to examine and summarise the information collected within the programme up to now, and to relate the resulting synthesis to the objectives of the programme. This would allow stakeholders to judge which objectives have been or are being achieved during this phase, which have not been achieved, and to decide on additional priority objectives that need to be addressed during the remainder of the second phase. Furthermore, it is required to assess how far the information collected can contribute to the setting of interim flow requirements, especially as far as the Sabie River is concerned.

Estimated cost: *R68 000*
Expected term: *1995*

Water quality and aquatic faunal studies in the Umzimvubu catchment, Eastern Cape, with particular emphasis on species as indicators of environmental change

(No 716) Department of Zoology, University of the Transkei

The Umzimvubu is the largest river in South Africa which has not been modified. However, an IBT scheme is being planned which will involve the building of dams on, and abstraction of water from the system. During this project data on water quality and the fauna of the unmodified river and estuary will be collected and changes in both productivity and bio-diversity will be followed as development proceeds.

Estimated cost: *R348 000*
Expected term: *1995-1998*

Tadpoles as bio-indicators of stream quality

(No 718) Department of Biochemistry, University of the Western Cape

Tadpoles are very sensitive to deterioration in environmental quality and there is narrative information describing the decrease in both the total numbers of amphibians as well as amphibian biodiversity in a number of areas of the country. The research conducted during this project will establish the current status of amphibians in selected areas of the country, will identify which are the sensitive species and will begin to determine tolerances to various heavy metals. An identification key will be developed during the project.

Estimated cost: *R162 000*
Expected term: *1995-1997*

Effect of inter-basin transfer on the hydrochemistry, benthic invertebrates and ichthyofauna of the Mhlatuze Estuary and Lake Nseze

(No 722) Department of Zoology, University of Zululand

The IBT scheme taking water from the Mhlatuze River to Lake Nseze was expected to be sufficient to supply water to Richards Bay until the turn of the century. However, the prolonged drought combined with rapid development of the area means that the maximum amount of water is now being transferred. Currently very little water is reaching the Mhlatuze Estuary. The research conducted during this project aims to quantify the effect of the transfer scheme on water quality and biota so that management options may be evaluated and predictions of effects on other schemes may be made.

Estimated cost: *R225 000*
Expected term: *1995-1998*

Collecting insects for biomonitoring studies.

Research projects

Completed

- **KV60/94** Proceedings of the estuaries workshop held at Port Alfred on 3 to 4 November 1992 (Consortium for Estuarine Research and Management)

Current

- **294** Pre-impoundment study of the Sabie-Sand River system, Eastern Transvaal, with special reference to predicted impacts on the Kruger National Park (University of Cape Town – Freshwater Research Unit, and Rhodes University – Institute for Water Research)
- **376** Geomorphological response to changing flow regimes of the Sabie and Letaba River system (University of the Witwatersrand – Department of Botany)
- **406** Structural analysis of the water apportionment mechanisms in the Water Act 54/1956, in view of the requirements of competing user sectors (Advocate M Uys)
- **422** Rapid biological assessment of water quality impacts in streams and rivers (CSIR – Division of Water Technology)
- **428** Overview of the pesticide and heavy metal levels present in populations of the larger indigenous fish species of selected South African rivers (CSIR – Division of Water Technology)
- **463** Diversity and productivity of biotic communities in relation to freshwater inputs in Eastern Cape estuaries (University of Port Elizabeth – Department of Zoology)
- **474** Developing an integrated approach to predicting the water use of riparian vegetation (University of the Witwatersrand – Department of Botany)
- **475** Development of a recirculating experimental stream system (Rhodes University – Institute for Water Research)
- **497** Geomorphological classification system for South African river systems (Rhodes University – Department of Geography)
- **503** Effect of soil utilisation on water quality of the Gamtoos estuary (University of Port Elizabeth – Department of Oceanography)
- **505** Environmental status of the Orange River mouth as reflected by the fish community (University of the OFS – Department of Zoology and Entomology)
- **525** Natural and unnatural factors regulating the structure and functioning of estuarine systems (University of Natal – Institute of Natural Resources)
- **545** Standard laboratory organisms for water quality studies (Rhodes University – Institute for Water Research)
- **576** Effects of different magnitude flows on riverine ecosystems (University of Cape Town – Freshwater Research Unit)
- **577** Decision-support system for the integrated management and conservation of estuaries (University of Natal – Institute of Natural Resources)
- **601** Freshwater requirements of plant communities in different types of estuaries (University of Port Elizabeth – Department of Botany)
- **608** Lethal and sublethal effects of metals on fish physiology in the Republic of South Africa (Rand Afrikaans University – Department of Zoology)
- **626** Water quality requirements for riverine biotas (University of Cape Town – Department of Zoology)
- **627** Integrated modelling system for predicting the impacts of changes in water quantity and quality brought about by upstream development (Sigma Beta (CE))
- **654** Development of a modelling system which will provide a common currency for integration of the results and data emanating from the Kruger National Park Rivers Research Programme (KNPRRP) (University of Pretoria – Department of Landscape Architecture)
- **655** Establishment of an effective information management system for the Kruger National Park Rivers Research Programme (KNPRRP) (National Parks Board in collaboration with the University of Natal – Institute of Natural Resources)

New

- **663** System-related scale study to determine the function of the riparian vegetation of the Olifants River, Transvaal (Roodeplaat Grassland Institute, Agricultural Research Council)
- **664** Water quality modelling of estuaries (CSIR – Earth, Marine and Atmospheric Science and Technology)
- **665** Assessment of the ecological impacts of inter-basin transfer schemes in dryland environments (University of Cape Town – Department of Zoology)
- **669** Survey for potential biological control agents for the troublesome alga *Cladophora glomerata* (Agricultural Research Council – Plant Protection Research Institute)
- **686** Application of an artificial stream system to investigate macro-invertebrate water quality tolerances (Rhodes University – Department of Zoology)
- **711** Status report on the Kruger National Park Rivers Research Programme : A synthesis of results and assessment of progress (Rhodes University – Institute for Water Research)
- **716** Water quality and aquatic faunal studies in the Umzimvubu catchment, Eastern Cape, with particular emphasis on species as indicators of environmental change (University of the Transkei – Department of Zoology)
- **718** Tadpoles as bio-indicators of stream quality (University of the Western Cape – Department of Biochemistry)
- **722** Effect of inter-basin transfer on the hydrochemistry, benthic invertebrates and ichthyofauna of the Mhlatuze Estuary and Lake Nseze (University of Zululand – Department of Zoology)

CONTACT PERSONS

- **Dr SA Mitchell** (Stream Fauna and Flora and Aquatic Ecosystems)
- **Mr HM du Plessis** (Irrigation Return Flow)
- **Mr HC Chapman** (Natural Wetlands)
- **Mr DS van der Merwe** (Facets of the KNP Rivers Research Programme)
- **Dr GR Backeberg** (Resource Economics)

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15

Mine water

Mining remains the single most important industry in South Africa. The mining sector is very diverse and a large number of minerals are being mined. Water usage patterns and impact on water quality vary tremendously throughout the mining sector so that there are bound to be exceptions to any generalisations that can be made about water in mining. None the less, it can be stated in general that although mining uses relatively little water, it is a significant contributor to water pollution.

Mining activities account for less than 3% of the national water demand and its share on a national basis is expected to decrease in future. Although the gold-mining industry uses large volumes of water in its operations it has also done much to save water. More than 80% of its water use is actually being recycled or reused internally. This drastically reduces the intake of freshwater.

Most of the geological formations that are mined in South Africa contain pyrites, which oxidise to form sulphuric acid when exposed to air and humidity. Acid mine drainage is thus almost inseparably linked to mining activities. Acid generated underground in gold and coal mines, and above-ground in the various waste deposits, is the main cause of water pollution originating from mining. Additional pollution originates from the metallurgical refinement and other beneficiation activities on mines. The quality of underground water seeping into mine workings varies geographically. Since these "own" sources are used extensively by mines, its quality largely determines the quality of water they ultimately dispose of.

Mine water discharged from point sources directly to surface waters represents only a small portion of water used by mines. Most mine water is lost inadvertently by seepage to groundwater, is entrained in waste products, or lost to evaporation. As indicated above, much of the pollution from mines is the result of acid mine drainage which is generated over time in waste material above and below ground. Most of the water pollution originating from mining is thus of a diffuse, or non-point, nature. Because it is difficult to measure, control and manage nŏn-point pollution, such pollution received little attention from the regulating authorities. As a result of the increased awareness of the importance of non-point pollution in general, mining pollution is, at present, receiving more attention.

Mines are currently expected to present the authorities with an environmental management programme in which they should indicate, among others, what the background environmental conditions were before the commencement of mining activities and how these activities will influence the environment during and after completion of the activities. It also needs to be shown how the environmental impact will be managed. Our ability to predict these effects quantitatively and to indicate the efficacy of alleviating measures, is still inadequate and requires further research.

Completed project

Catchment water quality deterioration as a result of water-level recovery in abandoned gold mines on the eastern and central Witwatersrand

(No 486) Institute for Groundwater Studies, University of the OFS

Following closure of mines and the cessation of water pumpage, a steady recovery of the water table within a mine can be expected. Upon full recovery the groundwater within the mine will emerge from discharge points such as springs and old mine shafts, and seep into surface water courses. Since the quality of water within gold mines generally deteriorates with time, a very real danger exists that seepage of mine water will cause a deterioration of surface water quality to manifest itself some time after the closure of a mine.

The research project investigated the mechanisms and rate of water level recovery in closed mines, identified discharge points and the volume of water that will discharge, identified factors affecting the quality of the rising water, and predicted the quality of water in the flooded mines. Proposals for managing the potential impacts will be of benefit to both the DWAF and the mining sector.

Cost: R719 000
Term: 1992-1994

New projects

Prediction techniques and preventative measures relating to the post-operational impact of underground mines on the quality and quantity of groundwater resources

(No 699) Institute for Groundwater Studies, University of the OFS, Chamber of Mines of South Africa and the DWAF

The influx of water into an underground mine leads to the progressive flooding of defunct underground workings and an accumulation of inferior quality water. Some non-operational mines are completely flooded and water emerges at the surface, impacting on the ground- and surface water environments. This project will develop a hazard rating for the different types of underground mines and mining environments. It will furthermore evaluate and document the current impact of non-operational underground mines on the quantity and quality of groundwater resources, evaluate credible preventative options to minimise the undesirable impacts and select or design tools for the prediction of water qualities and quantities during the post-operational phase of mining.

Estimated cost: R2 102 000
Expected term: 1995-1998

Pilot-scale development of integrated passive water treatment systems for mine effluent streams

(No 700) Pulles, Howard and De Lange, The Chamber of Mines of South Africa, Eskom and Sasol Coal

Although generally effective, currently available effluent treatment technology for dealing with mine-water quality problems, generally has unacceptably high capital and operational costs and intensive, ongoing, long-term maintenance requirements. There is, therefore, a need to develop low-cost, self-sustaining, low-maintenance passive treatment systems to address the water quality problems that are generally encountered at South African mines. This project will develop preliminary management guidelines to satisfy this need, evaluate them at pilot scale and develop management strategies whereby passive treatment systems can be integrated into the ongoing environmental management programmes of mines.

Estimated cost: R2 190 600
(WRC contribution R1 000 000)
Expected term: 1995-1997

Below: Line source irrigation of crops with neutralised acid mine drainage water. Note the decreasing growth as a result of reduced water application through a line source system.

Research projects

Completed

- **486** Catchment water quality deterioration as a result of water-level recovery in abandoned gold mines on the eastern and central Witwatersrand (Institute for Ground-water Studies, University of the OFS)

Current

- **413** Use of vegetation in the amelioration of the impact of mining on water quality – An assessment of species and water use (CSIR – Division of Forest Science and Technology)
- **454** Occurrence of bacteria causing acid mine drainage in the outer layers of coal waste dumps (University of Stellenbosch – Department of Microbiology)
- **471** Optimisation of mine service water disinfection (University of Pretoria – Department of Chemical and Environmental Engineering, Division of Water Utilisation)
- **477** Guidelines and procedures to assess and ameliorate the impact of gold-mining operations on the water environment (CSIR – Division of Mining Technology)
- **527** Survey of current water management and treatment practices in the South African gold and coal mining industries (Chamber of Mines of South Africa)
- **528** Development of an integrated and generic water quality simulation model for open-cast coal mining water circuits (Wates, Meiring and Barnard (CE) Inc.)
- **559** Prediction of pollution loads from coarse sulphide-containing rock materials (SRK (CE) Inc.)
- **575** Calibration of models for the design of covers for open-cast mine and waste dump rehabilitation (Wates, Meiring and Barnard (CE) Inc.)
- **582** Screening of crop, pasture and wetland species for tolerance of polluted water originating in coal mines (University of Pretoria – Department of Plant and Soil Science)
- **609** Underground neutralisation of mine water with limestone (CSIR – Division for Water Technology)
- **647** Application of isotope chemistry to quantify the contribution of gold and coal mines to salt pollution load in groundwater and rivers (CSIR – Division for Earth, Marine and Atmospheric Science and Technology)

New

- **699** Prediction techniques and preventative measures relating to the post-operational impact of underground mines on the quality and quantity of groundwater resources (Institute for Groundwater Studies, University of the OFS, Chamber of Mines of South Africa and the DWAF)
- **700** Pilot-scale development of integrated passive water treatment systems for mine effluent streams (Pulles, Howard and De Lange, The Chamber of Mines of South Africa, Eskom and Sasol Coal)

CONTACT PERSONS

- **Mr HM du Plessis**
  (Impact Studies and Mitigation of Effects)
- **Dr TC Erasmus**
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- **Mr AG Reynders**
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16
General

As can be seen from the title of this chapter, it was created to make provision for those research projects which cannot readily or logically be accommodated in the other chapters. Previously the nature of the projects reported on in this chapter prominently reflected geological and/or hydraulic aspects. During 1995 two new projects were, however, added to the list – one in which geology does not figure at all, while the other project concentrates exclusively on information technology.

None of the research projects in this chapter was completed during the year under review. The progress and results of one of the current projects (No 502: **Plunge pool scour reproduction in hydraulic models**) were promising to such a degree that the WRC has decided to extend the term of the project up to 31 December 1996 and to make additional funds available for its execution. A wide range of materials has already been tested for use in hydraulic models in order to simulate rock in the plunge pool. The results obtained thus far have indicated that the material best suited to hydraulic models is a cohesive material capable of simulating the steep walls of actual plunge pool scouring. One of the materials (a mixture of lime, cement and coke nuts) yielded such excellent results that it is regarded as the ideal material for hydraulic models, if the disadvantages of the mixture (such as relatively long setting time) can be reduced or overcome. It is precisely with this in mind that the project term has been extended.

Trash racks for the removal of floating and suspended materials.

New projects

Removal of floating and suspended materials from streams

(No 691) Department of Civil Engineering, University of Stellenbosch

Informal urbanisation of river catchments and poor control of littering result in vast amounts of trash entering watercourses. This form of pollution becomes unacceptable from an environmental point of view where these watercourses discharge into open canals, natural rivers, vleis or beaches.

Several local authorities in South Africa have in the recent past attempted to design cost-effective, low maintenance trash-removal devices. For *inter alia* the following reasons these designs have failed to be generally acceptable:

- These devices still require constant attention, especially during periods of high flow.
- Significant level differences are required between the upstream and downstream sides of the trash-collecting structure
- Very often the structure *per se* is large, aesthetically undesirable and expensive.

This project not only addresses the problem of trash removal, but also intends to investigate sediment removal, especially as far as pumping stations and diversion structures are concerned. The intention is to thoroughly analyse the designs for trash and sediment removal currently available, and to investigate the various possibilities to improve the performance of these designs in order to provide local authorities with design criteria to eliminate or at least reduce a problem that has far-reaching environmental and aesthetic impacts.

Estimated cost: R360 000
Expected term: 1995-1997

Pilot study to develop an information system to improve the accessibility and usability of research results and reports, through the application of information technology

(No 703) Division of Information Services, CSIR

Amongst the major products emanating from projects funded by the WRC are reports, technology transfer documents and research papers. The information contained within these documents is not always easily accessible to, or in a format required by, decision-makers and researchers. This is especially the case where informed decisions have to be made at short notice. With the increased emphasis in the RDP on the accessibility of information, the need to make relevant information available to communities in an appropriate form, is crucial.

Developments in the information technology field are providing many opportunities to more easily and efficiently distribute and access information emanating from research projects. This information is the key to technology transfer. In this study it is proposed that information should be available electronically in a hypermedia environment which will allow the linking between articles and reports through the use of keywords, via computer networks.

Estimated cost: R115 000
Expected term: 1995

Research projects

Current

- **433** Engineering properties of important southern African rock types with special reference to the shearing strength of concrete dam wall foundations (Technikon Pretoria – School for Civil Engineering)
- **502** Plunge pool scour reproduction in hydraulic models (CSIR – Division for Earth, Marine and Atmospheric Science and Technology)
- **579** Hydraulic roughness of tunnels bored by machine through various rock-types (University of Natal – Department of Civil Engineering)

New

- **691** *Removal of floating and suspended materials from streams* (University of Stellenbosch – Department of Civil Engineering)
- **703** Pilot study to develop an information system to improve the accessibility and usability of research results and reports, through the application of information technology (CSIR – Division of Information Services)

CONTACT PERSONS

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Research and technology transfer support services

South African Water Information Centre (SAWIC)

The South African Water Information Centre (SAWIC) is now in its 21st year of existence. During this period its main task has been the development of a bibliographic database, WATERLIT, to serve the needs of the South African water community – a task in which SAWIC has managed to achieve great success, gaining international recognition. Changes in South Africa as a whole have also had an effect on the activities of SAWIC. The Centre is now facing the challenge of serving the needs and demands for water information of a much broader community and is pursuing several new and exciting opportunities.

With the growing participation of rural and developing communities in issues that may influence their daily existence, a whole new group of potential users of water-related information has emerged. Although SAWIC has had very little experience in the supply of relevant information to those communities in the past, the organisation now has the opportunity to become involved in a major project where appropriate water-related information has to be made available to community leaders.

The Institute of Water Supply and Sanitation (IWSS) was recently established at the University of the North with the aim of training the community leaders in all aspects of water supply and sanitation, and providing them with suitable material for the training of the people living in their community. SAWIC will assist the IWSS in the development of the course content and to retrieve and evaluate available training materials from all over the world for this course. To be able to identify suitable training materials for the presentation of the IWSS courses, it has become necessary to expand the coverage of the WATERLIT database by adding educational and other training material to the database. A structure to accommodate this type of information has been designed and will now be tested and evaluated.

This past year has seen considerable effort being directed toward the building of 2 new databases, namely a **water-related research projects database** and a **database on water-related information sources**.

SAWIC has experimented with a new concept to market its products and services by way of holding open days in different centres in South Africa. Announcements of the open days appeared in the press and in all 3 cases, great interest was shown and an encouraging number of people attended the sessions. Attendees were introduced to SAWIC's activities and all 3 databases were demonstrated to them.

The past year has seen a tremendous growth in the interest and awareness of the **Internet**. Many people have realised the power of this vast communication tool, and SAWIC has approached the CSIR's Worldnet Africa (WNA) system to have a description of its activities displayed in the ENVIRONMENTAL HUB on WNA. Subscribers to WNA now have the opportunity to conduct their own searches on WATERLIT and the other SAWIC databases through WNA.

The "new" South Africa offers huge challenges to SAWIC to become actively involved in supplying water-related information to a whole new group of users. A great number of information resources which have been previously inaccessible to South Africans have now opened up, and SAWIC will have to exploit those sources to the best of its ability. There is no doubt that information about one of the country's most important strategic resources will become of critical value in the future, and SAWIC is confident that it will be able to meet the needs and demands for such information.

Computing Centre for Water Research (CCWR)

The mission of the CCWR is to support collaboration and the dissemination of knowledge, data and information amongst researchers and practitioners through advanced computing and communication technology in order to enhance water resources management.

The number of users of the CCWR, both in terms of registered users and daily log-ins, is increasing steadily. At the end of September 1995 the total registered number of users stood at 334. This not only represents users from the hydrological community in South Africa but also from outside our country.

The user profile of the CCWR can be illustrated by the following figures, based on user's fields of interest:

	NO OF USERS
Agrohydrology	13
Chemical and salinity	40
Climate change	15
Climatology	32
Crop yield	13
Ecology	23
Economics	5
Forestry	13
Floods	2
GIS	27
Groundwater	15
Hydrology	58
Irrigation	9
Limnology	20
Soil	12
Treatment	15
Urban hydrology	8
Water consumption	5
Wetlands	15

In an era where integrated water resource management is being encouraged, it is somewhat disheartening to find that many of the required sciences are still practised in a fragmented fashion.

Productivity of a research community is difficult to measure but if collaboration between different scientific disciplines and with practitioners can be improved, the efficiency of the total effort will no doubt increase tremendously. Not only will there be improvement in the quality of science being practised but it will most likely become better focused on the real needs of our society.

There is no doubt that at a time when the demand for information and communication is increasing rapidly, the CCWR can build on its experience and provide the service a multi-disciplinary research community needs. This demands that the CCWR maintain a high standard of technology and staff.

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Transfer of information and technology

The promotion of information and technology transfer is one of the most important objectives of the WRC. This is very clearly defined in the Water Research Act, namely to "accumulate, assimilate and disseminate knowledge in regard to the results of such research and the application thereof, and promote development work for the purpose of such application".

For the promotion of its programme of information and technology transfer, the WRC has developed a number of activities. Although some of these activities are directed at the transfer of information, the emphasis falls mainly on technology transfer, i.e. the application of research results, since this will always represent the final dividend of the research investment.

Partnership research

Partnership research is regarded as a very effective method of enhancing technology transfer. The partnership principle is incorporated, as far as possible, in research projects, and means that the end user of the results participates in the planning and execution of the research.

Publications

The WRC's publications cater for three levels, viz. pure scientific, popular scientific and practical scientific.

Water SA

Water SA is the WRC's scientific journal which contains original research articles and review articles on all aspects of water science, technology and engineering. The journal appears quarterly and the first edition was launched in April 1975.

Water SA has a strict refereeing system whereby all articles submitted for publication are first referred to referees, whereafter a decision is taken on publication.

Water SA has an extensive local as well as overseas readership. It also enjoys world-wide coverage in the sense that it is covered by more than 20 international abstracting services who publish and distribute summaries of articles which appear in *Water SA*.

SA Waterbulletin

SA Waterbulletin is a bilingual bi-monthly periodical. Within the broad spectrum of water research it aims to:

- Furnish information on water and water research in a popular scientific manner to the different interest groups in the water field
- Promote the transfer of technology by announcing the availability of reports, manuals, guides etc. which emanate from water research
- Promote communication between the WRC and authorities and individuals, such as researchers, engineers, technicians, government departments, local authorities and the industrial and agricultural sectors
- Convey social news and matters of interest (e.g. about conferences and personalities) to the water research community.

Manuals, guidelines and reports

At the conclusion of a project, and also while research is still under way, results are evaluated in respect of possible use and application and depending on the nature of the results a decision is taken on publication, dissemination and application thereof. More information on these publications appears in the relevant chapters and in the **Annexure**.

List of Commission publications

The **Annexure** to this annual report contains a list of publications (articles, papers and published reports) which appeared during 1995 and which emanated from research supported wholly or in part by the WRC.

Conferences, seminars, workshops and demonstrations

From time to time the WRC, on its own or in co-operation with other organisations, arranges such meetings. These afford ideal opportunities for promoting personal contact between research scientists or between research scientists and the users of research results. In this way the transfer of information and technology is greatly enhanced. More information on meetings held during the year is contained in the individual chapters.

Mass media

In this regard the accent falls on information transfer, and press releases; radio and television are used to this end.

Utilisation of overseas expertise

It is in the national interest that overseas expertise and knowledge be used where these are not available locally, and the WRC has developed various methods to achieve this. Overseas specialists, for example, are engaged as consultants and the WRC from time to time sends personnel and other experts overseas in order to obtain information on a particular problem area. More information in this regard appears in the individual chapters.

Commercialisation

In the future the WRC will focus increasingly on a further aspect of technology transfer, which is in progress already, viz. the commercialisation of research results by e.g. the private sector. The patenting of research results and the sale of publications and computer programs would be classified as such. In this way the WRC earns royalties, locally as well as abroad.

Annexure

Publications emanating from research financed wholly or partially by the WRC.

This **Annexure** contains a list of publications released in 1995, as well as a complementary list of 1994. Requests for publications should be directed, as far as possible, to the authors.

Developing communities

Articles and papers (1995)

- Richards WN (1995) A planning and reporting aid for sanitation development and delivery. Poster presentation at the IAIA'95 Conf., Durban.

Reports (1995)

- Jacobs EP (1995) Mon Villa Rural Watercare Project. WRC Report No. KV 79/95.
- Kent Measurement (Pty) Ltd (1995) Development of a Plastics Bodied Water Meter for Use in South Africa. WRC Report No. KV 78/95.
- Palmer Development Group (1995) Rural Sanitation Review. WRC Report No. KV 71/95.
- Palmer Development Group (1995) Water and Sanitation Handbook for Community Leaders. WRC Report No. TT 68/95.
- Palmer I (1995) Evaluation of Water Supply to Developing Urban Communities. WRC Report No. KV 73/95.

Reports (1994)

- Oellerman RG, Darroch MAG, Klug JR and Kotze DC (1994) Wetlands Preservation Valuation and Management Practices Applied to Wetlands: South African Case Studies. WRC Report No. 501/5/94.
- Palmer Development Group (1994) Water and Sanitation in Urban Areas: Survey of On-site Conditions. WRC Report No. 561/1/94.
- Simes CE, Lings RJ and Tshivhase T (1994) Prepayment Water Metering for South Africa. WRC Report No. KV 56/94.

Drinking water

Articles and papers (1995)

- Botha CJ and Buckley CA (1995) Disinfection of potable water – The role of hydrodynamic cavitation. *The Rev. J. of the Int. Water Supply Assoc.* **13** (2).
- Dickens CWS and Graham PM (1995) The rupture of algae during abstraction from a reservoir and the effects on water quality. *J. Water Supply Res. and Technol. AQUA* **44** (1) 29-37.
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- Offringa G (1995) Dissolved air flotation in Southern Africa. *Water Sci. Technol.* **31** (3-4) 159-172.
- Pieterse AJH (1995) Long-term changes in phytoplankton biomass and environmental variables in the Loch Vaal. Paper presented at Joint Conf., SA Assoc. of Botanists and the Phycol. Soc. of South. Afr., Bloemfontein.
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- Roos JC and Pieterse AJH (1995) Nutrients, dissolved gases and pH in the Vaal River at Balkfontein, South Africa. *Arch. Hydrobiol.* **133** 173-196.
- Roos JC and Pieterse AJH (1995) Salinity and dissolved substances in the Vaal River at Balkfontein, South Africa. *Hydrobiol.* **306** 41-51.
- Steynberg MC, Guglielmi MM and Geldenhuys JC (1995) Pre-oxidation with chlorine and chlorine dioxide as a unit process to assist with algal removal at potable water plants. *Chem. Technol.* **Jan/Feb**.
- Steynberg MC, Pieterse AJH and Geldenhuys JC (1995) Improved coagulation and filtration of algae as a result of morphological and behavioral changes due to pre-oxidation. Paper presented at IAWQ-IWSA Workshop on Separation of Microorganisms from Water and Waste Water, Amsterdam, The Netherlands. 30 October to 1 November.
- Steynberg MC, Pieterse AJH and Geldenhuys JC (1995) The effect of the relationship between pre-oxidation, unit treatment processes and morphological characteristics of algae on potable water production using eutrophic water. Paper presented at 20th Congr. of the Int. Water Supply Assoc., Durban, South Africa. 9 to 15 September.
- Swanepoel A and Pieterse AJH (1995) Growth characteristics and pigment composition of two *Chlamydomonas* species in different growth media. Paper presented at Joint Conf., SA Assoc. of Botanists and the Phycol. Soc. of South. Afr., Bloemfontein.
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Articles and papers (1994)

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- Pieterse AJH (1994) Morphological and taxonomical aspect of phytoplankton populations in the Vaal River I: Species composition and general features. *Proc. 13th Congr. of the Assoc. pour l'Etude Taxonomique de la Flore d'Afrique Tropicale*, Zomba, Malawi. Vol. **2** 825-839.
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- Du Plessis JP (1995) Modelling of Flow Phenomena in Porous Media. WRC Report No. 585/1/95.
- Genthe B and Du Preez M (1995) Evaluation of Rapid Methods for the Detection of Indicator Organisms in Drinking Water. WRC Report No. 610/1/95.
- Genthe B and Kfir R (1995) Studies on Microbiological Drinking Water Quality Guidelines. WRC Report No. 469/1/95.
- Gericke M, Bateman B, Rapholo F, Mashakana J, Maharaj V, Hilner CA and Kfir R (1995) Occurrence of Protozoan Parasites in South African Source and Treated Water. WRC Report No. 451/1/95.
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Reports (1994)

- Dickens CWS (1994) The Rupture of Algae During Abstraction from Reservoirs. WRC Project No. KV 67/94.

Theses

- Bezuidenhout E (1995) Evaluasie van Volskaalse Geaktiveerde Slykverdikking met Opgelostelugflottasie. M.Eng. Verhandeling, Randse Afrikaanse Univ.
- Steynberg MC (1995) Pre-oxidation: A Unit Process to Limit Algal-related Water Quality and Purification Problems. Ph.D. Thesis, Univ. of the Orange Free State.
- Van Beek JC (1994) Optimization of Combined Flotation and Filtration at a Large Water Treatment Plant. M.Eng. Thesis (*Cum laude*), Rand Afrikaans Univ.

Municipal effluents

Articles and papers (1995)

- Brözel VS and Cloete TE (1995) The antibacterial mechanism of action of thiocarbamates. *Int. Biodeterior. and Biodegr.* Section **IV** 108-113.
- Brözel VS, Hall A and De Bruyn R (1995) Effect of microbial flora in low-grade coal on the corrosion of 3CR12 steel. *Int. Biodeterior. and Biodegr.* Section **XIII** 494-499.
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- Cloete TE and De Bruyn EE (1995) The dominant sulphide producing bacteria in SA cooling water systems. *Int. Biodeterior. and Biodegr.* Section **XIII** 507-513.
- De Bruyn EE and Cloete TE (1995) The role of *Shewanella putrefaciens* as a corrosion causing bacteria. *Int. Biodeterior. and Biodegr.* Section **XIII** 535-542.
- Muyima O and Cloete TE (1995) Growth and phosphate uptake of immobilized *Acinetobacter* cells in activated sludge mixed liquor. *Water Res.* **29** (11) 2461-2466.
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- Oellermann RA and Pearce K (1995) Bioaugmentation Technology for Waste-water Treatment in South Africa. WRC Report No. 429/1/95.
- Pearce K, Snyman H, Van Heerden H, Greben H and Oellermann RA (1995) Bioremediaiton Technology for the Treatment of Contaminated Soil in South Africa. WRC Report No. 543/1/95.
- Smollen M and Kafaar A (1995) Development of Electro-osmotic Sludge Dewatering Technology. WRC Report No. 427/1/95.

Reports (1994)

- Ernst EA (1994) Occupational Competencies for the Occupation of Watercare Operator and Watercare Manager. WRC Report No. KV 55/94.

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MISSION STATEMENT

To contribute effectively to the best possible quality of life for the people of South Africa, by promoting water research and the application of research findings.

Therefore, the WRC endeavours dynamically and purposefully to:

- Promote co-ordination, communication and co-operation in the field of water research
- Establish water research needs and priorities
- Fund water research on a priority basis
- Promote effective transfer of information and technology.