1990
ANNUAL REPORT
WATER RESEARCH COMMISSION

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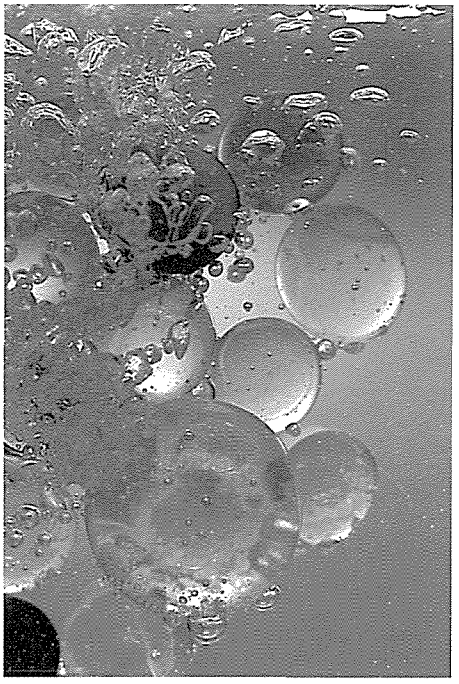

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Water Research Commission
PO Box 824
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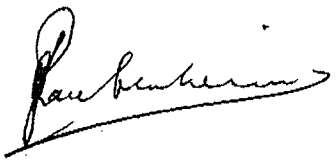
25 March 1991

Dear Mr Kotzé

We take pleasure in submitting to you, herewith, the report of the Water Research Commission for the period 1 January to 31 December 1990.

The balance sheet and statement of revenue and expenditure for the financial year to 31 December 1989, as certified by the Auditor General, as well as a receipts and payments account for the year ended 31 December 1990 and a budget for 1991, are furnished under **Financial Statements** of this report.

Yours respectfully



AJ Raubenheimer
CHAIRMAN

PE Odendaal
EXECUTIVE DIRECTOR

Mr GJ Kotzé, MP
Minister of Water Affairs and Forestry
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Dr MJ Pieterse
(Municipal effluents; industrial water and waste water; drinking water; treatment technology)

Research managers

Dr TC Erasmus
Dr OO Hart
Mr G Offringa
Dr HM Saayman
Dr SA Mitchell

DEPUTY EXECUTIVE DIRECTOR

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Mr HM du Plessis
Dr GC Green
Mr H Maaren
Dr PCM Reid

Deputy research manager

Mr AG Reynders

ADMINISTRATIVE

DIRECTOR: ADMINISTRATION

Mr PM van der Schyff

MEMBERS OF THE WATER RESEARCH COMMISSION AS ON 31 DECEMBER 1990

CHAIRMAN

The Honourable AJ Raubenheimer (DMS)
Former Minister of Water Affairs.

VICE-CHAIRMAN

Mr GCD Claassens
Director-general:
Department of Water Affairs and Forestry.

EXECUTIVE DIRECTOR

Mr PE Odendaal
Executive director:
Water Research Commission.

MEMBERS

Mr EJ Hall
Member: Council for the Environment and former city engineer of Johannesburg.

Dr AJ Heyns
President: Agricultural Research Council and former superintendent-general: Department of Agricultural Development.

Mr DH Marx
Chairman: Magalies Water Board and former city engineer of Pretoria

Mr DW Steyn
Former Minister of Economic Affairs and Technology; chairman: Roadfix Africa Ltd.; and chairman: Prisma Food CC.

Prof PD Tyson
Vice-principal: University of the Witwatersrand.

Dr WL van Wyk
Former deputy director-general: Department of Mineral and Energy Affairs.

CO-OPTED MEMBER

Mr M Erasmus
Deputy director-general: Department of Water Affairs and Forestry.

THE OBJECTIVES OF THE WATER RESEARCH COMMISSION

In terms of section 2(3) of the Water Research Act 1971 (Act No 34 of 1971) the objectives of the Commission are "to co-ordinate, to promote, to encourage or to cause to be undertaken, as determined by the Minister specifically or in broad outline, research in respect of

- the occurrence, preservation, conservation, utilization, control, supply, distribution, purification, pollution or reclamation of water supplies and water;

- the use of water for

  - agricultural purposes;
  - industrial purposes; or
  - urban purposes".

Section 3(1) of the above-mentioned Act describes the functions of the Commission and stipulates *inter alia* that the Commission shall "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".

THE YEAR UNDER REVIEW

During the past year the Water Research Commission (WRC) faced many challenges and achieved success in a number of fields, with various highlights in research activities.

The multidisciplinary approach to water research was extended further during the year with a new field being entered, viz. the water requirements and conservation of ecosystems. Five new projects were launched in this field. The following main research areas are currently financed by the WRC:

- Hydrometeorology
- Rainfall stimulation
- Surface hydrology
- Ground water
- Agricultural water utilisation
- Water pollution
- Municipal effluents
- Industrial water and effluents
- Drinking water
- Treatment technology
- Aquatic ecosystems

The allocation of funds to the various areas is shown in the accompanying bar chart.

The WRC does not do research but contracts other organisations to conduct the research. The research sectors responsible for the research and their degree of involvement are listed in the following table:

Research sector	Number of times involved	%
Universities	92	45
CSIR	48	24
Consulting engineers	16	8
Government departments	9	4
Local authorities	11	5
Private companies	18	9
Other organisations	11	5
TOTAL	205	100

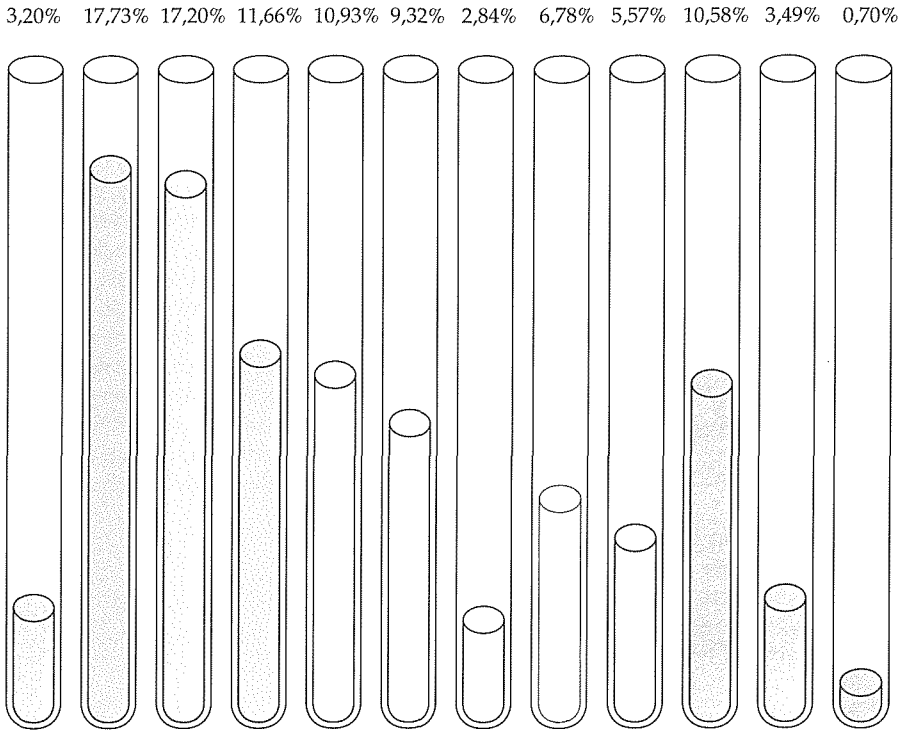
From these figures it can be seen, *inter alia*, that universities are involved in 45% of the total number of contracts. The number of times that organisations are involved, viz. 205, exceeds the number of projects which were supported as more than one organisation is sometimes involved in a project. During 1990 the Commission supported 137 projects financially.

Apart from the direct funding of contractual research projects, the WRC supports three research support services:

- The SA Water Information Centre (SAWIC)
- The Computing Centre for Water Research (CCWR)
- The Hydrological Information System (HIS)

Although the year's activities are reported on in the various chapters, a number of highlights are singled out:

- Hydrometeorology
- Rainfall stimulation
- Surface hydrology
- Ground water
- Agricultural water utilisation
- Water pollution
- Municipal effluents
- Industrial water and effluents
- Drinking water
- Treatment technology
- Aquatic ecosystems
- General



ALLOCATION OF FUNDS (%) TO THE VARIOUS AREAS DURING 1990

WATER SCIENCE IN THE RSA AT HIGH LEVEL

The Scientometric Advisory Centre of the CSIR conducted an analysis of the relative strengths of scientific speciality fields in South Africa over the period 1981-85*. The method used was based on bibliometric and citation analyses. The figures for the speciality field **Water Resources** are significant.

1. In terms of the number of articles published in accredited international water journals, South Africa holds the fifth position in the world after the USA, Canada, the UK and West Germany.

2. The **Activity Index** for South African water resource articles is 12,7. This figure reflects the ratio of the RSA's share in world literature in respect of **Water Resources** to the RSA's share in world literature with regard to **all scientific fields.**

3. The **Attractivity Index** for South African water resource articles is 12,5. This gives the ratio of the RSA's citation share through publications in respect of **Water Resources** to the RSA's citation share through publications in **all scientific fields.**

4. The **Relative Citation Rate** for South African water source publications is 1,43. A citation rate of 1 indicates that a set of publications is cited at the average international rate for a specific field.

South African water resource articles maintain a standard which is considerably higher than the world average

A rate of more than 1 reflects an impact which is higher than average. The rate of 1,43 indicates that South African water resource articles are maintaining a standard which is considerably higher than the world average. It is also the highest relative citation rate for all speciality fields in South Africa.

The indices in 2 and 3 above provide an indication of the strength of water research and water science in South Africa, relative to other speciality fields in the country. The figures in 1 and 4 reflect the high impact of South African water science on the international scene.

MASTER PLAN FOR GEOHYDROLOGICAL RESEARCH

The first WRC master plan for geohydrological research was prepared in 1975. This was followed in 1981 by a revised master plan, formulated in collaboration with the Department of Water Affairs and Forestry, which has been in use up until now. It was decided at the time that the research fields covered, and the priorities assigned to them, would be revised on a regular basis to ensure that research and development programmes were progressively adjusted to meet the immediate and future needs.

During the past nine years a number of ground-water projects have been completed and the priorities assigned to research fields have changed somewhat. Consequently, a decision was taken by the Commission's Co-ordinating Committee for Geohydrological Research (CCGR) that the master plan be revised and for this purpose a workshop took place during the latter part of November 1989.

During the workshop situation assessment statements, followed by SWOT (strength, weakness, opportunity, threat) analyses of the research fields, were presented on 6 primary goals. These documents and the subsequent discussion thereof formed the basis for the prioritisation of geohydrological research goals, the outcome of which was a prioritised goal structure. This was subsequently developed into a strategy which will allow the WRC to address the most pressing geohydrological research needs pro-actively.

A HYDROGEOLOGICAL MAP OF SOUTH AFRICA

The need for a hydrogeological map of South Africa has been expressed for some time by water resource planners, decision makers and the ground-water community. Prior to the Commission's involvement in the development of the National Ground-water Data Base such an exercise would have proved extremely difficult. However, with the Data Base in place and following a strong plea by the ground-water user community at a workshop held at the WRC in June this year, the momentum has been created which will lead to this ideal becoming a reality.

The Commission is actively supporting this hydrogeological mapping programme by directing research into providing a link between the National Ground-water Data Base and the Geographic Information System of the Department of Water Affairs and Forestry. The WRC has also embarked on the production of a ground-water development potential map of South Africa to address some of the more immediate needs expressed by water resource planners.

WATER RECLAMATION ON THE CAPE FLATS

The project on the construction and operation of the prototype Cape Flats water reclamation plant and surveillance of the reclaimed water quality was finalised during the year.

The conclusion of this project represents the end of an era of research on the reclamation of treated sewage for drinking-water purposes. Water reclamation research has been supported by the WRC over several years and has been conducted by the CSIR; the municipalities of Windhoek, Pretoria and Cape Town; the South African Institute for Medical Research; and the Medical Faculty of the University of Cape Town. On the one hand the research focused on treatment technology and on the other hand the chemical, bacteriological and virological quality of the reclaimed water was addressed. The overall conclusion is that the necessary treatment technology for

* Pouris, A (1989) Strengths and weaknesses of South African science. *South African Journal of Science* **85** 623-626.

reclaiming water from treated sewage, which complies with all the drinking-water quality criteria, has been developed.

This project on the prototype water reclamation plant on the Cape Flats, conducted by the Municipality of Cape Town, aimed to determine whether a local authority could operate a reclamation plant with their own personnel. The research clearly showed that this was possible.

Furthermore, it was established that the cost of the reclaimed water (based on 1986 figures) was four times more than the cost of available water sources in the Cape area. The biggest single cost item was that of activated carbon which amounted to almost 33% of the total cost of 88c/m^3. Carbon regeneration facilities should, however, reduce these costs considerably. The importance of optimising the sewage treatment process and the operation thereof was also emphasised.

It was concluded that drinking-water reclamation from treated sewage was feasible, but that it should only be used after the economic aspects of all other methods of drinking-water supply have been thoroughly investigated.

NEW APPROACH TO WATER POLLUTION CONTROL

The Department of Water Affairs and Forestry decided recently to adjust its approach to water pollution control. It was compelled to make this adjustment as water quality could not be maintained at acceptable levels by using the old approach. In contrast with the old approach of having uniform standards for effluent disposal into rivers, the effluent quality in terms of the new approach is determined by the water quality requirements of down-stream users.

Inherent in the new approach to water pollution control is the acceptance that water bodies have a quantifiable and manageable capacity to absorb wastes, without affecting water quality to the extent that the water becomes unsuitable for recognised uses. The cornerstone of this new approach to water pollution control is the determination of these capacities for different pollutants and the distribution thereof by making waste load allocations.

However, the dearth of local expertise in this area currently still hampers the implementation of the new approach. As part of its technology transfer function the Commission, in collaboration with the Department of Water Affairs and Forestry, presented a short course on the technique and methods of waste load allocation. Over and above the contributions made by a number of local experts, the course was mainly presented by Dr Ray Whittemore (Tufts University, USA) who is an expert with wide practical experience in the application of techniques and the underlying principles.

The expectation is that a good deal of future research will be stimulated by the needs of the new approach to water pollution control.

A good deal of future research will be stimulated by the needs of the new approach to water pollution control

DEVELOPMENT OF MANAGEMENT-ORIENTATED MODELS FOR EUTROPHICATION CONTROL

A decision support system (DSS) based on eutrophication control models which have been adapted to South African conditions was recently completed by the CSIR in terms of a contract with the WRC.

Next to salinisation, eutrophication (excessive growth of algae and aquatic plants as a result of the enrichment of water with plant nutrients) is regarded as the most serious water pollution problem in South Africa. Restrictions on the phosphate concentration of effluents in sensitive areas have been in force since 1985, after it had been found that the extent of algal blooms was determined mostly by the availability of phosphates. As the costs associated with phosphate removal are high, the imposition and extension of phosphate restrictions should be treated with circumspection.

The success of this project has been demonstrated *inter alia* by the fact that the Department of Water Affairs and Forestry almost exclusively used the DSS, which had been developed as part of the project, to re-evaluate the effect of the phosphate standard (1 mg/*l* as P) in sensitive areas and to decide on the possible easing and extension of the restrictions.

SALINISATION RESEARCH STRATEGY

The WRC, *inter alia*, makes use of co-ordinating committees in the various research fields to carry out its co-ordinating function, which includes the development of research plans. The Co-ordinating Committee for Salinisation Research decided on a pro-active strategy to address the most urgent research needs in this field. This strategy which was approved by the Commission at its November 1990 meeting, will now be made available to the research community for submitting research proposals in line with the identified priorities.

The salinisation research strategy was preceded by a clear definition of its mission and goals by the Co-ordinating Committee and a two-day workshop in November 1989 in order to prioritise its goals. This prioritisation took place against the background of a situation analysis for each of the goals which had been prepared by experts. In assigning priorities, the highest value was attached to the extent of the problem, followed by the present state of the art and the availability of data and information. Because the Committee realised that it would not be possible to deal with all the needs, that one research facet must often be preceded by other research, and that priorities can change in the light of findings, it was decided not to prepare a comprehensive research plan, but rather to implement a research strategy aimed at attaining specific goals.

DESALINATION OF MINE SERVICE WATER

The South African gold mining industry circulates some 4 000 M*l* of service water daily and consumes about 220 M*l*/d of Rand Water Board water in the execution of its underground activities. A considerable water preservation benefit would thus result if the spent underground service water, usually augmented by saline fissure water, could be economically desalinated for reuse.

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The feasibility study on the WRC-supported (SPARRO) process has been successfully completed. This process comprises reverse osmosis coupled with slurry precipitation and recycle and was developed by the Chamber of Mines Research Organisation to desalinate spent service water with high calcium sulphate content. The 0,85 *l*/s pilot plant at ERPM Gold Mine has operated almost continually from start-up in February 1989 to shut-down in August 1990, during which time several process problems were solved.

The refined SPARRO process has a proven availability exceeding 90%, while both its permeate recovery and salt rejection capability are in excess of 90%. Operating costs, excluding capital charges, are estimated to be in the order of R1,20 to R1,50 per k*l*, of which the main contributing components are membrane replacement, power and maintenance. To round off the project a detailed design and cost estimate for a plant to desalinate 5,68 *l*/s (500 k*l*/d) of spent mine service water is being prepared.

FIRST SOUTH AFRICAN PLANT FOR DESALINATED DRINKING WATER

On 26 October 1990 the Minister of Water Affairs and Forestry, Mr GJ Kotzé, officially opened the first desalination plant for drinking water in the RSA at Bitterfontein. The South Namaqualand Water Supply Scheme purifies the local brackish borehole water which is pumped from six boreholes in the Bitterfontein area and supplies good quality drinking water to communities at Bitterfontein and neighbouring Nuwerus.

The process makes use of tubular reverse osmosis membranes which are manufactured by Membratek (Pty) Ltd. It is based on technology which was developed by the Institute for Polymer Science of the University of Stellenbosch with WRC funding. The plant treats 150 m^3 of brackish water daily.

Since 1971 the WRC has been supporting research and development in the field of water desalination by means of reverse osmosis membranes at the Institute and has also supported several research projects at Membratek (Pty) Ltd.

The present scheme which was implemented by the Department of Water Affairs and Forestry for this region, is the first of its kind to make desalinated drinking water available on a regional basis in the RSA. This desalination plant represents the culmination of a research effort of many years' standing to put into service a large-scale and viable South African desalination plant for drinking water.

The production costs are not yet available at this early stage.

WATER QUALITY MONITORING SYSTEMS

A short course on the design of water quality monitoring systems was held in Pretoria from 13 to 17 August 1990, under the auspices of the WRC. This was a second extremely successful course which followed on the effective presentation of a first course in 1988. Prof Robert C Ward and Prof Thomas G Sanders, both from the Colorado State University, USA, again acted as the main instructors of the course which was attended by 60 people.

The course introduced the systems approach to water quality monitoring. The system components consist of determination of information expectations, the monitoring network, analysis of data accumulated and reporting the information in a format suitable to meet information expectations.

Min Gert Kotzé, Mr GCD Claassens and Min Eli Louw photographed at the official opening ceremony of the South Namaqualand Water Supply Scheme at Bitterfontein.

ELECTROCHEMICAL PHOSPHATE REMOVAL FROM MUNICIPAL EFFLUENTS

Sewage works often experience problems regarding biological phosphate removal processes which do not conform to the phosphate effluent standard. Consequently chemical phosphate treatment by means of metal salt dosing is also practised. In the case of biological filter plants, the application of metal salts is presently the only method employed to remove phosphates. Inevitably the addition of metal salts leads to an increase in the concentration of salts in the effluent, which can result in unacceptable salinisation in cases where water is reused.

An alternative process which uses only cations and coagulants for phosphate removal by means of an electrolytic reaction during which a metal dissolves directly in water, was tested in two recent research projects at the University of Pretoria. Iron electrodes and a bipolar cell configuration, with the cells linked in series, were found to be the most suitable.

This electrolytic cell was tested in an activated sludge pilot plant. Optimal phosphate removal was obtained when iron was added to the effluent after secondary sedimentation.

Although the production of chemical coagulants is somewhat cheaper than the electrochemical method, the latter process holds an advantage in reducing salinisation.

A NATIONAL INDUSTRIAL WATER AND WASTE-WATER SURVEY (NATSURV)

Research in the fields of industrial water management and pollution control has been proceeding for many years in varying degrees of intensity and scope. From examination of data collected during the course of some of these projects it became clear that large variations existed in water and waste-water management practices for factories producing the same commodities. In order to achieve optimal water usage and minimum pollution load by industry it was decided that a planned national research and development programme was necessary. As part of this programme the WRC, in collaboration with the Department of Water Affairs and Forestry, initiated the NATSURV project in January 1984. This project has now been completed.

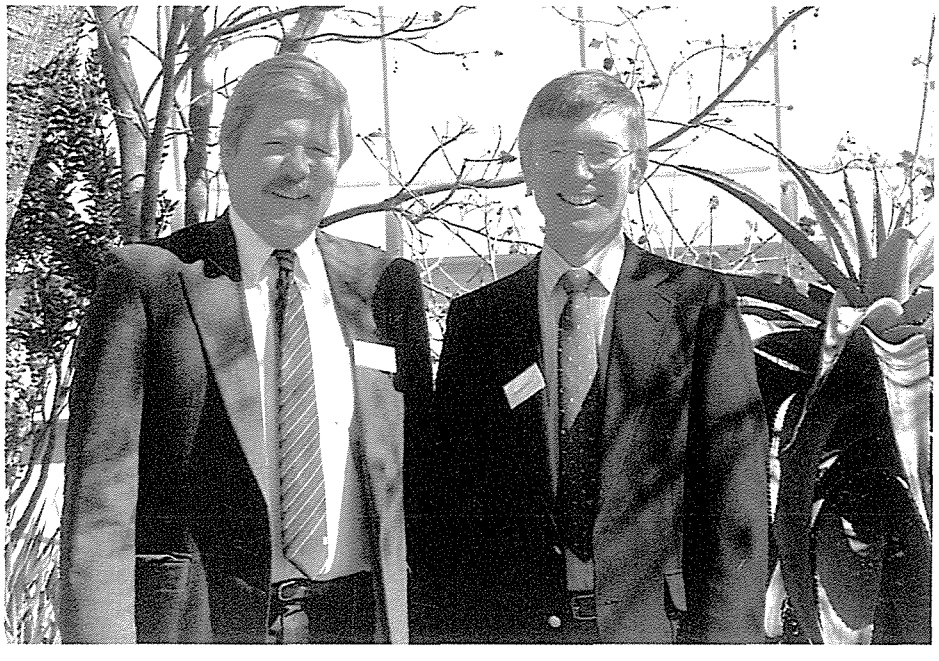
The aims of the survey were:

- To establish a data base (containing information on water intake, raw materials used, products, waste-water quality and quantity and industrial waste) which can be used to determine targets for water intake and pollution loadings reasonably achievable by industry.
- To establish areas where research is needed to assist industry in improving its water and waste-water management at minimum cost or even to its own advantage.

Some 539 industries were surveyed and an extensive data base of industry-related information was compiled

During the course of the project some 539 industries were surveyed and an extensive data base of industry-related information was compiled. Some 34 potential research projects were identified, the details of which have been circulated to research institutions.

A part of the NATSURV survey focused specifically on the Vaal Barrage catchment area and included every industrial premises using more than 50 m^3 of water per day. The Vaal Barrage catchment area is the most heavily industrialised area in the country, and includes the industrial areas of Johannesburg, Germiston, Alberton, Boksburg, Brakpan, Benoni, Springs, Heidelberg, Meyerton, Nigel, Vanderbijlpark, Vereeniging and Sasolburg. The study carried out was aimed at quantifying the total industrial water intake and pollution load for this very important area by summing up the contributions by each industrial premises. This was the first time that such a study had been carried out in South Africa, and the results revealed that previous estimates of water intake by industry in the RSA seem to have been too high. The total industrial water intake and pollution load for the study area was also broken down in terms of contributions by specific industries and areas.



Dr Thomas Sanders and Dr Robert Ward from the Colorado State University, USA, who were the presenters of the water quality monitoring systems design short course.

GUIDES ON INDUSTRIAL WATER AND WASTE-WATER MANAGEMENT

A further benefit flowing from the NATSURV project described above, will be the production of 14 industry-specific guides on water and waste-water management. Three of these guides were already published in 1989, while 8 more appeared in 1990, dealing with the following industries: dairy; sorghum malt and beer; edible oil; red meat; laundry; poultry; tanning and leather finishing; and sugar.

These guides are aimed at the industries themselves, and at other interested parties such as municipalities, administrators, researchers, and consultants in the water and waste-water fields.

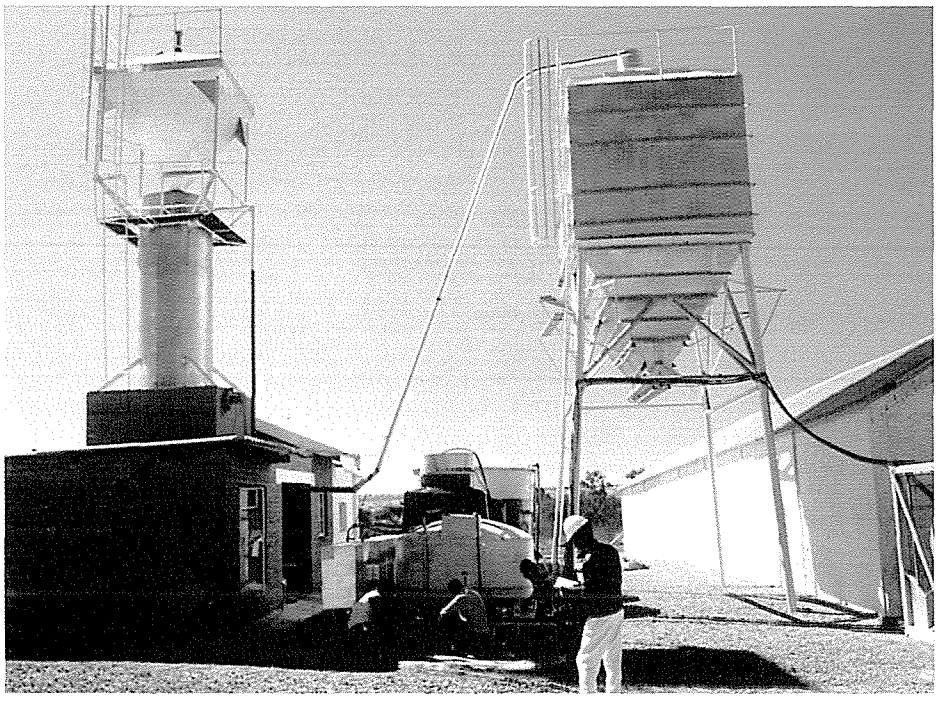
Targets proposed in the guides for water intake and pollution load per unit of product provide a basis both for regulation and for action within industries by providing them with a valid basis for comparison. In each case the target figures proposed have been discussed in detail with representatives of the industry to ensure that the targets are achievable and are likely to have a significant impact in reducing industrial water intake and pollution load.

CROSSFLOW MICROFILTRATION AND BIOLOGICAL REACTORS COMBINED

Research, conducted recently by the Universities of Natal and Cape Town, demonstrated that the use of dynamic membranes and crossflow microfiltration could possibly provide solutions to problems which are traditionally experienced in solids-liquid separation.

For anaerobic digestion in particular, the performance of a reactor could be improved substantially if the concentration of solids in the reactor could be increased, while new reactors could be designed smaller than conventional reactors. The University of Cape Town therefore aimed at removing the suspended solids from biological reactors, by means of a relatively inexpensive membrane technique, viz. crossflow microfiltration. At the same time the concentrate was returned to the reactor, thereby increasing the biomass concentration in the reactor. This study was carried out both on an activated sludge system and on an upflow anaerobic sludge bed reactor.

The results were very promising, as the biomass concentrations in the anaerobic reactor and in the activated sludge reactor were increased to approximately 6 000 mg/*l* and 19 000 mg/*l* respectively. At the same time the effluents were purified to suspended matter levels of lower than 50 mg/*l*, with an average value of 13 mg/*l*. An innovative aspect was the maintenance of a final aerobic section at the top end of the anaerobic reactor. This final aerobic section ensures the increased removal of organic pollutants and a very satisfactory effluent quality. A provisional patent has been taken out for the integrated combination of an anaerobic reactor, coupled to crossflow micro-filtration and an aerobic section at the top end of the anaerobic reactor.



The ASP pilot plant at Klipgat, north of Pretoria.

PASTEURISATION OF SEWAGE SLUDGE FOR AGRICULTURAL USE

As sewage sludges possess soil-conditioning properties and also contain significant quantities of plant nutrients such as nitrogen and phosphate, as well as the elements calcium, magnesium and a variety of trace elements, it can be beneficially applied in agriculture.

Sludges destined for agricultural use should, however, be free of pathogens and not contain excessive quantities of heavy metals which may, in the long term, be toxic to plants. Unfortunately both these problem aspects are associated with the sludges from many South African sewage works. Although correct composting techniques can to a large degree solve the problem of pathogenic organisms, high levels of heavy metals in certain sewage sludges still limit the free use of sewage sludge in agriculture.

The CSIR's Division of Water Technology recently evaluated the new active sludge pasteurisation (ASP) process, developed by a local firm, with regard to the degree of pasteurisation and stabilisation of the sludge which can be obtained with the process. The ASP process is based on the principle that a combination of high temperature and high pH sterilises the sludge. The high temperature results from the fact that the reaction between the chemicals added and the sludge is exothermic. Because the added chemicals have a high nitrogen and phosphate content, the sewage sludge is

in actual fact converted into a liquid fertiliser. The high levels of nitrogen and phosphate in the treated (enriched) sewage sludge result in much lower applications per hectare being needed, compared with for example composted sewage sludge. The added benefit of this lower application is that the problem of excessive concentrations of heavy metals in the soil is dealt with, since the heavy metals are spread over a wider area of soil.

Results obtained by the CSIR from pilot-plant tests indicate that both sterilisation and stabilisation of the sewage sludge are successfully accomplished by the ASP process. Tests conducted by the Department of Soil Science and Plant Nutrition at the University of Pretoria indicate that plant nutrients in the treated sewage sludge are available to the plant for a longer period than the corresponding quantity of plant nutrients in an inorganic fertiliser.

DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEMS (GIS)

In the effective management of our water resources, information on catchment characteristics is becoming increasingly indispensable. However, the sheer volume of data demands the use of modern computer technology.

GIS is now widely recognised as the one technology that may contribute to higher efficiency in this regard. Problems with data capture, data quality and data exchange are still formidable and high demands are made on co-ordination and co-operation. Several new projects launched this year will contribute in this new field by developing new approaches by hydrological modelling and evaluation of development scenarios.

At the same time GIS related tools will be developed to use this information in more informed decision making.

GROWING INTEREST IN ACRU MODEL

The ACRU modelling system was developed by the Department of Agricultural Engineering of the University of Natal for synthetising typical South African hydrology and agrohydrology, and is aimed at practical application in water management and planning.

The ACRU model has been applied widely, locally and overseas

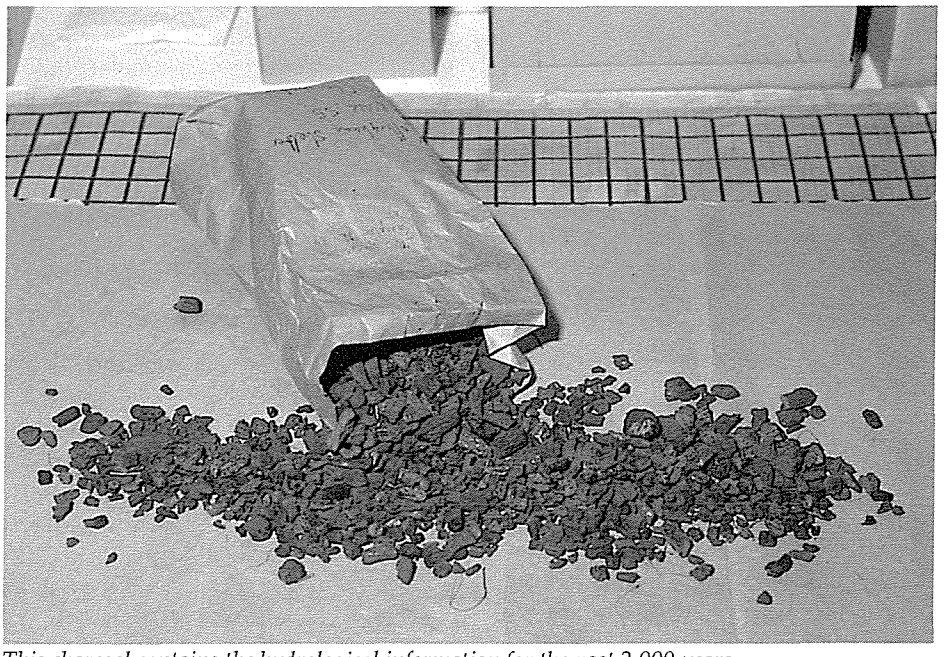
As indicated in the *1989 Annual Report* the model has been finding wide application, locally and overseas. This trend is continuing, and during 1990 some 35 representatives from the academic and consulting fraternity attended a user's course.

International interest in the model has resulted in Professor Schulze, the leader of the research team, being invited to give courses on the model at the Technical University of Braunschweig and a further invitation has been received to present a special training session for the model at the University of Lanquedoc in association with the French Institute for Research Development and Co-operation (ORSTOM). The session will be aimed at researchers and engineers working on the hydrology of agricultural catchment basins.

RECONSTRUCTION OF CLIMATIC HISTORY - THE WOOD ANATOMY APPROACH

Relatively short climatic records (anything less than 100 years but more commonly less than 40 - 50 years) create considerable uncertainty about whether the variability to be seen in such records gives a true reflection of the expectancy of specific, and especially extreme and potentially catastrophic, climatic events and sequences. With WRC support, the South African Museum in Cape Town is making good progress in assessing whether the wood anatomy approach can be used to identify periods during the past 2 000 years when South Africa's summer rainfall climate deviated substantially from its average state.

Wood which has grown at various times during the past 2 000 years is often well-preserved as charcoal, occurring in archaeological deposits throughout the region. By recording and comparing the anatomical characteristics of many thousands of charcoal samples and fresh wood samples from the summer rainfall



This charcoal contains the hydrological information for the past 2 000 years.

regions, the museum has succeeded in identifying the most common species represented in the archaeological deposits as *Buddleia, Protea* and *Combretum* spp. More extensive sampling of living examples of these species along known climatic gradients is now taking place in order to quantify statistically the effects of climate on wood anatomical variables, specifically the dimensions and frequency of xylem vessels. Already a general trend towards larger and fewer vessels with warmer and moister conditions has been confirmed.

Once the relationships between anatomical and climatic variables have been quantified for fresh wood and the effect of the charcoaling process on anatomical characteristics has been precisely established, the anatomical characteristics of the dated archaeological charcoal samples should prove to hold the key to information about certain climates of the past.

It is unreasonable to expect that any single technique, such as this wood anatomy technique, can be used to entirely reconstruct a climatic record. This technique could, however, assist in providing a meaningful approach which can be used in conjunction with other approaches to obtain as complete a climatic record as possible.

CLIMATE CHANGE

Global climate change is highly topical at the present time, with more and more countries, up to government level, paying serious attention to discovering more about possible impacts of so-called greenhouse gases on global and regional climates. While the uncertainties in the climatic change scenarios generated by current world-wide scientific research and modelling efforts are still enormous, the possibility that such changes may occur cannot be ignored. Any systematic warming which takes place is bound to have repercussions in the area of water resources, as in most other areas connected with life on earth.

The WRC has not committed itself formally to participating in the international research effort and specifically in the International Geosphere-Biosphere Project (IGBP). However, research is nevertheless supported which, if successful, will greatly facilitate the assessment of the significance of projected or observed future climatic variations, both in terms of their deviations from normal variability and in terms of their predicted impact on water resources and related matters.

Basically, this research can be grouped into four topics, three of which are concerned with climate itself and more specifically its rainfall components, and the fourth which broadly relates to impacts on water supply and demand.

Firstly, efforts are being made, through the Universities of Pretoria and Cape Town, to identify the role and contributions - at various scales - of those atmospheric and oceanic features which will enable rainfall over Southern Africa to be forecast with better precision over the medium to long term, i.e. from some weeks to a season in advance.

Secondly, continuing attention is being given, through the University of Cape Town, to the development of stochastic daily climate models and the evaluation of associated model parameters for South Africa, based on existing climate records. Such models encapsulate all properties of present climatic regimes and enable accurate inferences to be made about normal and abnormal occurrences of wet, dry, hot and cold spells of any description. Unfortunately, the stability of current climatological and hydrological regimes in South Africa is somewhat uncertain because of the relatively short length of climate records. This provides the motivation for the third topic, viz. the WRC's attempt, through the SA Museum, to contribute to the reconstruction of the climate of the past 2 000 years, specifically in the summer rainfall regions of Southern Africa.

Fourthly will be the development and refinement of appropriate simulation models. In this regard the WRC has already made notable contributions to the development of the successful ACRU hydrological model at the University of Natal and the PUTU wheat growth and irrigation scheduling model at the University of the Orange Free State, and is continuing its support for similar efforts.

PIONEERING WORK ON WATER LOSS CONTROL AND LEAK DETECTION IS PAYING OFF

The WRC pioneered the establishment of water loss control and leak detection on municipal water distribution mains in South Africa

The WRC pioneered the establishment of water loss control and leak detection on municipal water distribution mains in South Africa with two projects: the first with the then National Building Research Institute of the CSIR, to define a methodology for local conditions; and the second with the firm Castle Brass Holdings (Pty) Ltd and the Johannesburg City Council. In the latter case approximately 14% of the municipal area was used as a field testing site. The lessons learnt from these exercises have been published from time to time and as a consequence of this, other major local authorities have embarked on practical water loss control programmes.

The Durban Corporation has spent a number of years gathering base data and paring the city into control zones and is optimistic of reducing the unaccounted-for water to single figures. The programme started in Johannesburg is continuing through regular tenders. Pretoria has had a programme in operation since 1984 which has contributed considerably to the honing of the methodology developed earlier. Pietermaritzburg, Bloemfontein, Roodepoort, Cape Town and Port Elizabeth all undertake their water loss control efforts in-house while Boksburg, Soweto and Benoni on the Reef and Vryheid in Natal have made use of a consultancy service when required.

The KwaZulu Government is also making concerted efforts to limit wastage and losses from water supply systems and has appointed a number of consulting engineering firms to undertake investigations in their large towns. To promote this, the Commission participated in a one-day workshop organised by the

Development Bank of Southern Africa and held in Richards Bay in March of this year. Here the intricacies of water loss control and leak detection were explained to a group of consulting engineers and local authority personnel.

Five commercial concerns, providing services for water loss control and leak detection, were established following the Commission's initiatives.

IRRIGATION RESEARCH BEARS FRUIT

It has been an eventful year for irrigation research in that various farming communities around South Africa are now picking the fruits of many years of intensive irrigation scheduling research.

A WRC funded research project is on-going on farms in the Winterton region of Natal. The aim of this project is to assess the feasibility and effectiveness of on-farm irrigation scheduling. The early success of this project can best be judged against the fact that some farmers have in fact entrusted their entire irrigation operation to the researcher for scheduling purposes. A further indication of the success of the project can be seen in the fact that a large broiler chicken company, which grows its own feed, has agreed to make available two extra automatic weather stations, at a total cost of R80 000, to the project, in the belief that they will recover this cost in a short while, due to more efficient water use practices.

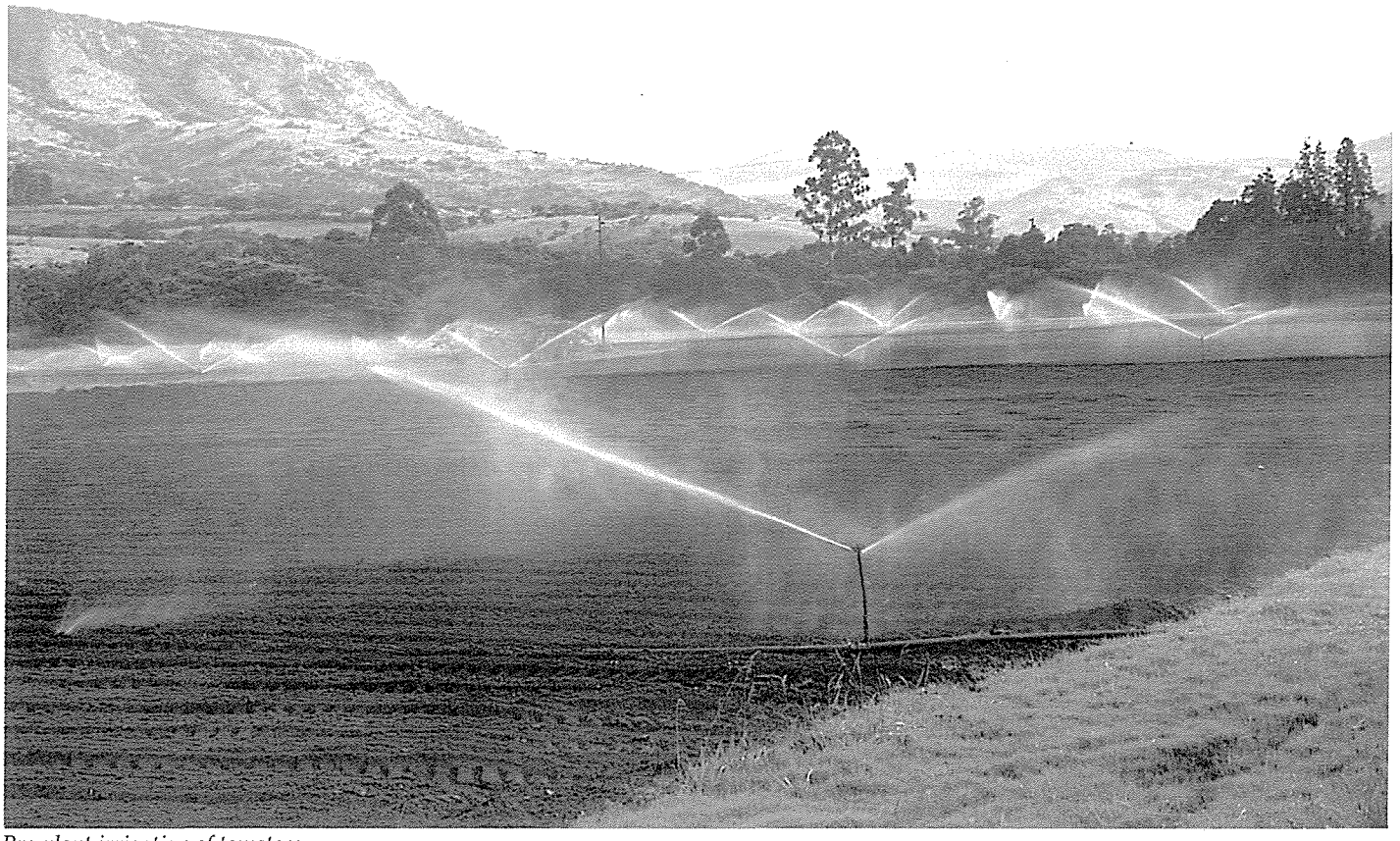
A further indication of the scientific value of the irrigation research can be found in the fact that the Free State Region of the Department of Agricultural Development is utilising two scheduling programmes on farms in the Riet River State Water Scheme, that have been developed using WRC funds. Similar type management practices are to be found in Bophuthatswana at Taung where WRC-financed scheduling programmes are successfully employed.

AQUATIC ENVIRONMENTAL RESEARCH

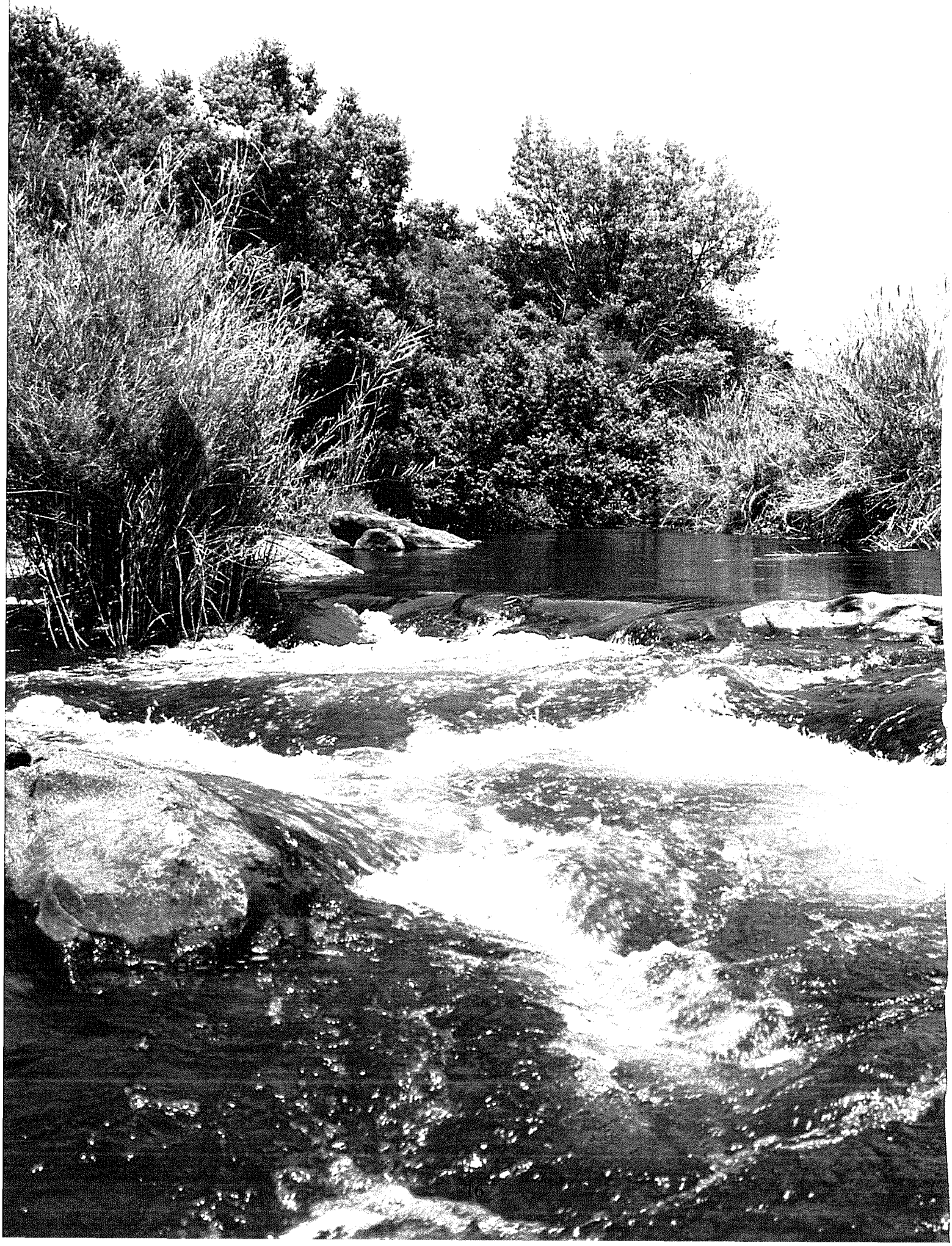
1990 saw the start of aquatic environmental research projects funded by the WRC. In total five projects in this field, being as diverse as the freshwater requirements for estuaries to the water requirements of fauna in the lowveld rivers, were launched.

In order to guide research, debate the opinions of experts and ensure the minimum of unnecessary duplication of research, the WRC has put into place a Co-ordinating Committee for Water Ecosystems Research (CCWER). This Committee will not only be of use to the WRC but its opinions will be widely publicised in the aquatic environmental research community.

The Kruger National Park Rivers Research Programme, of which mention was made in the *1989 WRC Annual Report*, got off to a resounding start in 1990. To date efforts revolved around the purchasing and setting up of infrastructure at Skukuza itself. Such infrastructure consists of accommodation and office space, a cross-country vehicle (kindly made



Pre-plant irrigation of tomatoes.



available by the Nissan motor company), caravan, boat and trailers. A technician and game guard are also employed by the National Parks Board for the Programme. It is pleasing to report that the above infrastructure is in place and functional. On the research side, all of twenty projects are registered under the Programme.

RAINFALL STIMULATION

The amalgamation of formerly separate research projects concerned with assessing the potential for rainfall stimulation in South Africa took place in January 1990.

The resulting research programme has been named the National Precipitation Research Programme (NPRP) and has been placed under the leadership of a senior scientist of the Weather Bureau. Funding is provided in approximately equal proportions by the Weather Bureau and the WRC. Facilities are being maintained at Bethlehem, Carolina and Nelspruit to enable research to take place within an extended corridor in the hydrologically important eastern highveld and escarpment region of South Africa.

South Africa is now in a position to play a leading role in rainfall stimulation research world-wide

Amalgamation was enthusiastically approached by the separate research groups whose skills and facilities immediately proved to be highly complementary. The groups have been welded into a formidable, well-equipped research team of which South Africa can justifiably be proud. In fact, South Africa is now in a position to play a leading role in rainfall stimulation research world-wide. The continuity of research funding over the years, the large data base which has already been built up, availability of one of the best equipped and operated cloud physics research aircraft fleets in the world, coupled with the positive results to date and the ability and experience of the scientists, engineers and technicians involved, give South Africa an advantage over most other countries in this field of research.

Even if research does prove that rainfall stimulation is technologically feasible, the application of the technology will ultimately depend on the net benefits which will be realised in the target area where rainfall stimulation is practised. In the light of possible conflicting requirements of various sectors present in the target area, the assessment of net benefits is no trivial matter. With the help of Ninham Shand Inc. the WRC has completed a planning study which served to identify a range of steps needed for a sound assessment to be made. Steps include the establishment of realistic scenarios of spatially distributed enhanced rainfall which will then be used to separately model effects on runoff, dryland agriculture, natural grassland, forestry and the environment in general. Finally, modelled effects and anticipated social impacts would have to be integrated by way of a comprehensive socio-economic cost-benefit analysis. The approach of the WRC will be to tackle the steps timeously in a logical sequence to ensure that information required for decision-making is available when needed.

WRC CLOSELY INVOLVED WITH IAWPRC

Since its inception in 1971 the WRC has maintained close ties with the International Association on Water Pollution Research and Control (IAWPRC). This is evident from the following facts:

- The first Chief Executive Officer of the WRC, Dr GJ Stander, was the President of the IAWPRC for four consecutive terms, for the period 1968-76.
- The WRC housed the Association's secretariat for the period 1971-75, the current Executive Officer, Mr PE Odendaal, having been its Honorary Secretary/Treasurer.
- Besides Dr Stander, three Commission members have already served on the IAWPRC's Board of Control, namely Mr EJ Hall, Dr MR Henzen and Mr PE Odendaal.
- Dr Stander was President of the 11th Biennial Conference of the IAWPRC in Cape Town, 1982.
- Papers emanating from research financed by the WRC have been presented at each of the IAWPRC's biennial conferences since the inception of the WRC.

Papers emanating from research financed by the WRC have been presented at each of the IAWPRC's biennial conferences since the inception of the WRC

- At the IAWPRC's biennial conference in Kyoto, held in August 1990, South Africa, together with Germany and Australia, had the third most papers accepted. Papers were accepted from 36 countries. Of the 10 South African papers, 6 were based on WRC projects.

NEW COMMISSION MEMBER

Mr DW Steyn was appointed as member of the Commission to replace Dr Louw Alberts who resigned in the course of the year.

Mr Steyn was a Member of Parliament from 1974 to 1989 and since 1980 has occupied various ministerial positions: 1980 - Deputy Minister of Finance and Industry, Trade and Tourism; 1982 - Minister of Education and Training; 1983 - Minister of Mineral and Energy Affairs; and 1986 - Minister of Economic Affairs and Technology up until his retirement in September 1989.

In addition to a B.Sc degree in Electronic Engineering (University of Stellenbosch) Mr Steyn holds an M.Comm. degree in Business and Administration (University of Pretoria). He is a member of the South African Council of Professional Engineers.

HYDROMETEOROLOGY

Hydrometeorology focuses on understanding, predicting and where possible, manipulating the immensely important role played by the atmosphere in the hydrological cycle. This life-giving cycle is driven almost entirely by solar radiation transmitted through the atmosphere. Furthermore, the atmosphere is the only source from which Southern Africa's limited surface and ground-water supplies can be replenished. The WRC supports a wide range of hydrometeorological projects and also, through the Co-ordinating Committee for Research on Hydrometeorology, contributes to identifying and prioritising research needs in this field and to co-ordinating hydrometeorological research on a national basis.

Through its involvement in hydrometeorological research, the WRC hopes to achieve certain goals, viz.:

- to develop an adequate understanding of the spatial and temporal characteristics of rainfall and other forms of precipitation in Southern Africa;
- to characterise, understand, predict and where possible, ameliorate the impact of weather and climate on the demand for and usage of water;
- to develop weather and climate forecasting tools urgently needed for the better management and more effective utilisation of Southern Africa's water resources; and
- to assess the feasibility of, and develop appropriate technology for, augmenting water supplies from atmospheric sources.

During 1990 the Commission financially supported 7 hydrometeorological research projects; of these 2 were new research agreements.

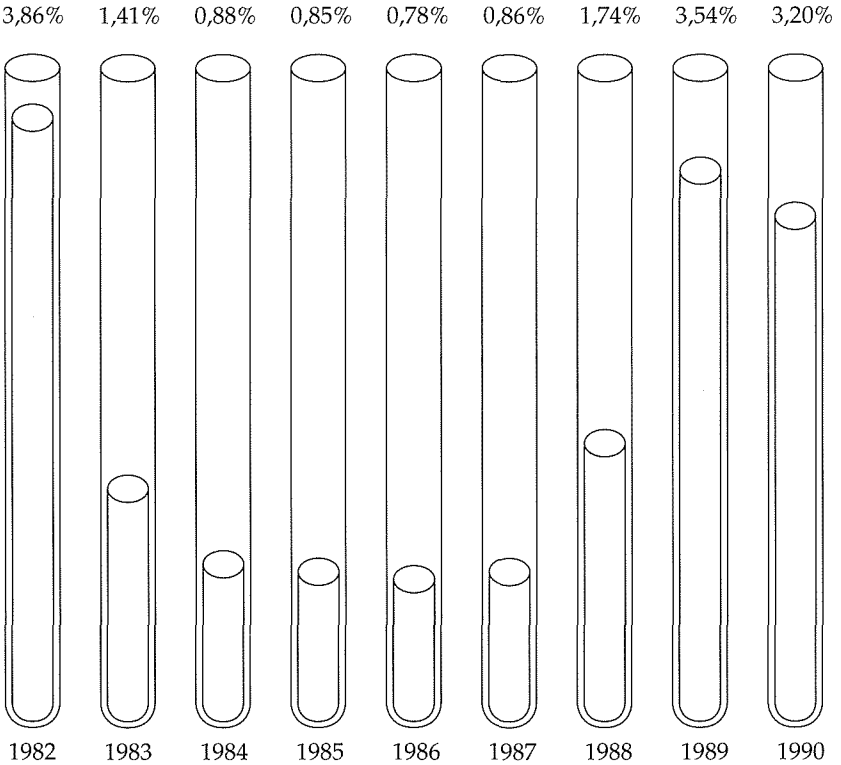
DISCUSSION OF NEW PROJECTS

Interpolation and mapping of daily rainfall model parameters for South Africa

In 1984 the development of a set of stochastic daily rainfall models was completed and model parameters were evaluated for approximately 2 500 locations in South Africa where suitable daily rainfall records existed. The models have been used widely to generate long synthetic daily rainfall time series and have enabled questions concerning, for example, drought frequencies and length and intensity of dry spells to be far more easily and reliably answered than through examination of the frequently imperfect original daily rainfall records. Unfortunately, because of the sparse rain gauge network, parameter values are not available for many hydrologically important parts of South Africa, specifically the mountainous regions.

This new three-year project, which is being undertaken by the Department of Mathematical Statistics of the University of Cape Town, will attempt to establish a reliable means of interpolating model parameters, thus making representative parameter values available for any location in South Africa.

FUNDING OF RESEARCH ON HYDROMETEOROLOGY EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1982 TO 1990



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

The development of better tools for medium and long-term rainfall forecasting would greatly facilitate optimal management of South Africa's water resources. The Department of Civil Engineering's Chair of Meteorology at the University of Pretoria has commenced a five-year project to investigate various techniques which could give rise to better rainfall forecasts. Aspects which will receive attention are the following:

- the use of the Southern Oscillation and associated atmospheric circulation to provide an early indication of trends in seasonal rainfall;
- the degree to which changes in dominant summer circulation patterns can be used to predict midsummer rainfall up to 60 days in advance;
- the tendency towards persistent domination by certain systems of the hemispherical circulation, as reflected in monthly mean circulation and what significance this has for long-term forecasting; and
- the possible use of climate and general circulation models as a means of investigating and testing forecasting techniques.

The development of better tools for rainfall forecasting would greatly facilitate optimal management of South Africa's water resources

LIST OF RESEARCH PROJECTS

Current projects

- The development of a stochastic daily climate model for South African conditions (The University of Cape Town - Department of Mathematical Statistics)
- The reconstruction of the climatic history of the last 2 000 years in the summer rainfall regions of Southern Africa (The South African Museum)
- Precipitation and airflow in cumulus clouds (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))
- Relationships between lightning and precipitation (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))
- The prediction of South African summer rainfall variability from ocean surface temperatures (The University of Cape Town - Department of Oceanography)

New projects

- Interpolation and mapping of daily rainfall model parameters for South Africa (The University of Cape Town - Department of Mathematical Statistics)
- Techniques for seasonal and long-term rainfall forecasting in South Africa (The University of Pretoria - Department of Civil Engineering (Chair of Meteorology))

A typical thunderstorm over the Highveld, Transvaal.

RAINFALL STIMULATION

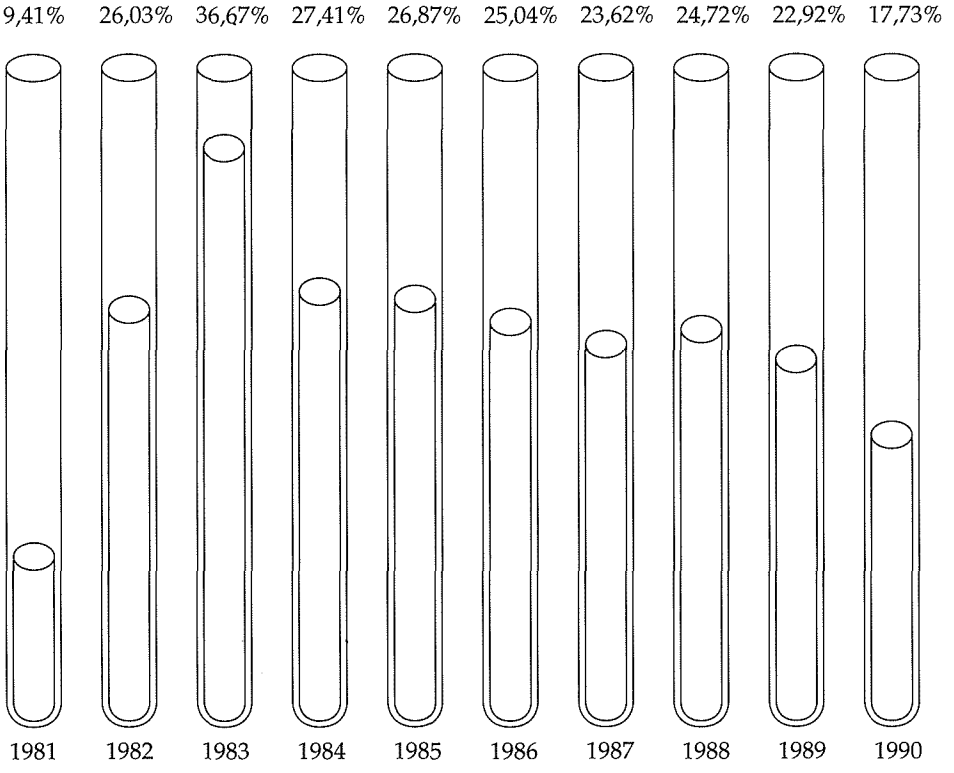
Rainfall stimulation research, which forms part of the broader field of hydrometeorology, has received concentrated support from the WRC for the past eight years. Because South Africa's water resources are seriously limited, no potentially viable option for augmenting these resources should remain unexplored. Rainfall stimulation is such an option, since it appears to offer the means of exploiting, at fairly modest cost, a portion of the vast reserve of atmospheric water which does not naturally become available as rain.

RESTRUCTURING OF RAINFALL STIMULATION RESEARCH

Prior to 1990, rainfall stimulation in South Africa was researched through 2 projects, viz. Programme for Atmospheric Water Supply (PAWS) at Nelspruit and the Bethlehem Precipitation Research Project (BPRP). PAWS was supported by the WRC and was executed under contract by EMATEK (CSIR) and CloudQuest (Pty) Ltd. BPRP was financed and executed by the Weather Bureau, with assistance from the WRC. With the completion of the second phase of the PAWS contract in December 1989, it was decided that PAWS and BPRP should merge into a single research programme, entitled the National Precipitation Research Programme (NPRP) with a view to rainfall enhancement. This was done to make optimal use of the available scientific leadership as well as the considerable expertise and impressive facilities developed over the past eight years. NPRP is in a position to build more strongly on the solid foundation laid by PAWS and BPRP than were the individual projects. These projects had already demonstrated that cloud properties can, through seeding, be modified in a manner which is consistent with increases in rainfall.

All rainfall stimulation research in South Africa now falls under the National Precipitation Research Programme

Despite these positive indications, however, results fell short of providing convincing evidence that controlled and significant increases in rainfall can be achieved through appropriate treatment of clouds. The main difficulty, which still has to be overcome, is to deal successfully with the enormous natural variability of precipitation processes in multicellular



FUNDING OF RESEARCH ON RAINFALL STIMULATION EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990

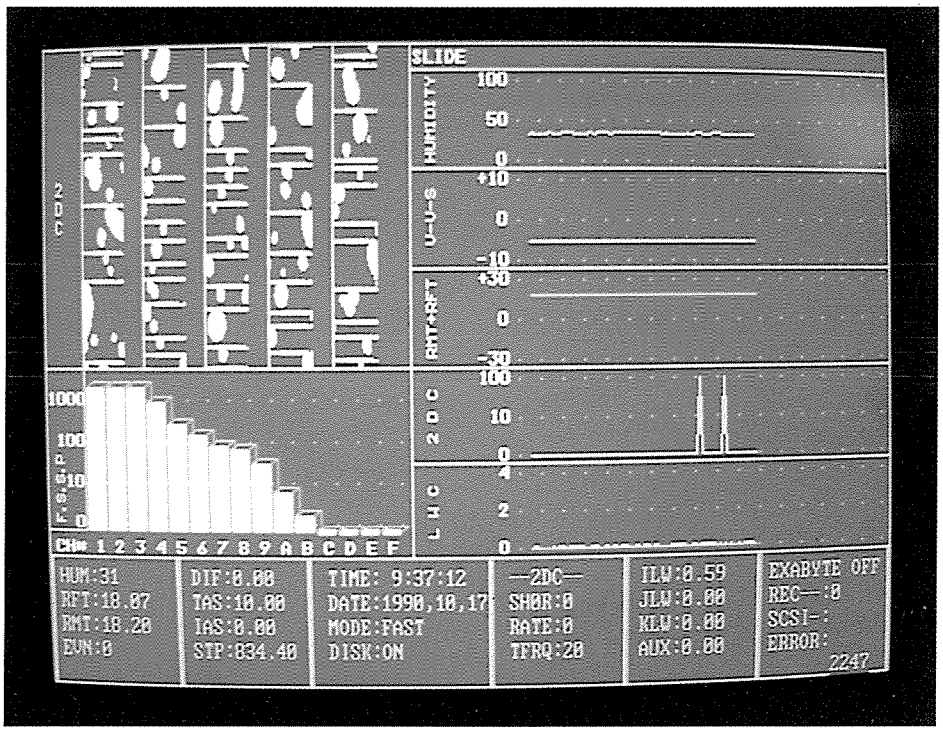
convective clouds, the class of clouds singled out for treatment. The main thrust of NPRP in the near future will thus be to develop a better understanding of the physics of precipitation development in a variety of multicellular convective clouds, both treated and untreated, encountered under different environmental conditions. The aim is to use the knowledge so gained to identify those environmental conditions in which the precipitation efficiency of the natural clouds can be increased through human intervention.

NPRP, currently led by a senior Weather Bureau scientist, will consist of investigations carried out within radar range of research radars situated at Carolina and Bethlehem. Participants in the research are drawn mainly from the Weather Bureau, CloudQuest (Pty) Ltd and UNISA, with minor contributions from other organisations. The research is being financed jointly, with approximately equal contributions by the WRC (through the Company for Research on Atmospheric Water Supply) and the Weather Bureau.

LIST OF RESEARCH PROJECTS

Current project

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



Computer screen in aircraft displaying real-time cloud observations.

SURFACE HYDROLOGY

The modern hydrological model has become an information processing system, more physically based, and more process and management-orientated

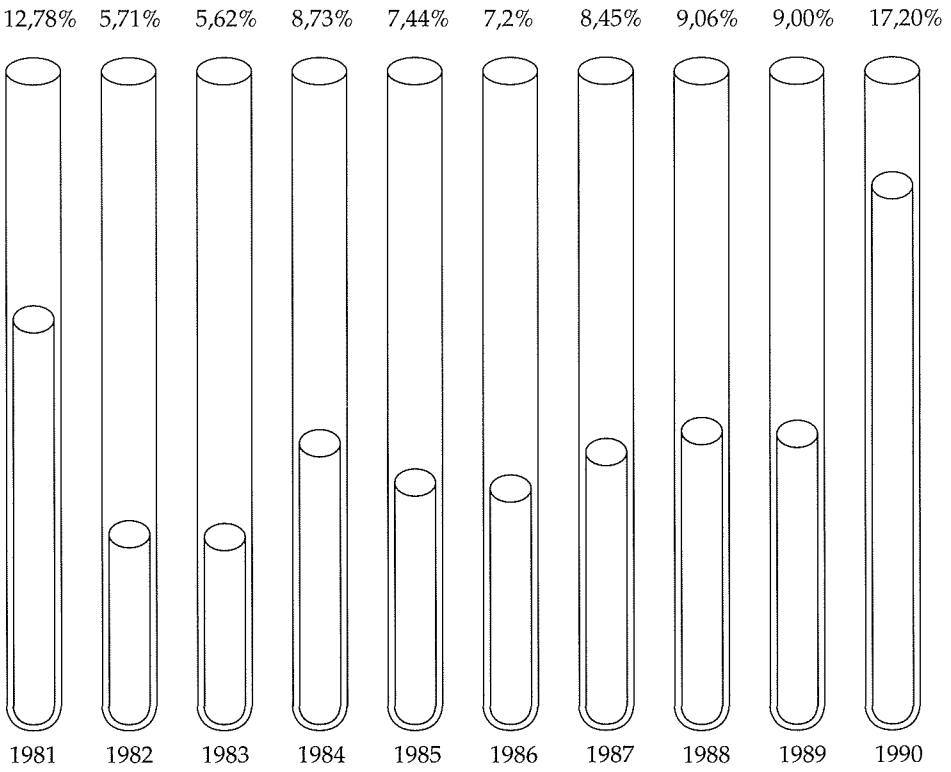
One of the main tools in applied hydrology and water management, namely the hydrological model, is changing its character. The "old" hydrological model was primarily concerned with transforming rainfall into runoff, often via the proverbial "black box". The modern hydrological model has become an information processing system, more physically based, and more process and management-orientated.

Rainfall is only part of the information input. Other input information is about soils, climate, land cover, fertiliser usage and land management factors. The list will increase as the complexity of our water management increases. The soil-plant-atmosphere continuum, traditionally seen as the realm of agricultural science, is now recognised as the heart of hydrology. Urban hydrology and especially the connection between water quantity and water quality is receiving continuous attention.

But water management is only partly concerned with the physical system and probably just as much with people and their value systems. The value of water is not easily measured or determined. Economic considerations are only partly responsible for its value and intangible aspects are in many cases just as important. In a changing society the values of people and the perceptions of problems are highly fluent. Keeping hydrological research on track to serve society requires diversity of scale in space and time. Detail on the survival of fish in a certain stretch of river is as much in the picture as the effect of possible global warming.

The powerful integrating role of the geographic information system (GIS) is increasingly recognised as the fundamental base from which water and catchment management have to proceed. The lead that the Department of Water Affairs and Forestry is taking in this regard is fully supported.

During 1990 a total of 16 hydrological research projects were supported by the Commission of which 9 have been launched during the year.



FUNDING OF RESEARCH ON SURFACE HYDROLOGY EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990

DISCUSSION OF NEW PROJECTS

The quantitative structuring of national water planning objectives for use in decision support systems in South Africa

This project is being carried out by the University of Cape Town's Department of Mathematical Statistics over 3 years.

The objective of the project is to develop management procedures and support systems to assist planners and managers in interpreting and evaluating the consequences of proposed plans or policies in order to identify courses of action which best satisfy the goals of society.

A decision support system handles in a structured way the information overload with which managers are burdened. Conflicting goals have to be satisfied and therefore the operative word is not optimisation but equitable compromise. To demonstrate the practical utility of the methodology being developed, certain demonstration projects are selected to test management procedures. The Sabie catchment in the Eastern Transvaal was found to be suitable for this purpose. It is believed that this project is a forerunner of a new approach to water management.

The preparation of a review document on sediment transport in Southern Africa, including revision of the sediment production map of Southern Africa

It is estimated that the reduction in storage capacity of the Republic's water storage reservoirs caused by sedimentation is in the order of 80 million m^3 per annum, equal to a reservoir twice the size of Roodeplaat Dam. Because water storage is a vital part of water supply systems, this storage must be replaced at an estimated cost of about R100 million per year. In addition sediment in rivers also affects the ecology of aquatic systems.

The sediment delivery map currently in use was produced in 1975. Since that time the data base has increased enormously and this project aims to utilise this information in the best possible way. A novelty in the project is that the map will be made available in GIS compatible format.

This project is being carried out over 2 years by Sigma Beta Consulting Engineers.

The surface water resources of South Africa 1990

This five-year project is carried out by a consortium of consulting engineers.

The evaluation of Southern Africa's available surface water resources needs continuous attention. The severe drought since 1981, when the previous inventory was completed, can now be evaluated. The study will use an updated version of

A study on forest hydrology at Bloemendal (Natal) in co-operation with the University of Natal.

the Pitman model. The survey will cover Southern Africa south of the Limpopo and will include the RSA, Swaziland, Lesotho, the TBVC countries and the National States. The project will not only review new data but will also develop an advanced GIS-based methodology for streamlining such an update at regular time-intervals. The survey will be based on the "official" tertiary and quaternary catchment boundaries of the Department of Water Affairs and Forestry.

The utilisation of geographic information systems (GIS) and integrated environmental management (IEM) in the planning and management of water resources within river catchments

In future water resources and the catchments from which the water originates will be utilised to their full potential. Changing environmental conditions, such as land use and storage reservoirs, will affect the ecology of down-stream aquatic systems. The use of GIS will allow evaluation of alternative development scenarios in a holistic manner, allowing the consequences of certain development action to be taken into account in the selection of the most acceptable solution. To ensure the practicality of the methodology to be developed, the Sabie River catchment has been selected as a test region. Practical problems with the use, computer storage and integration of different data sources and products will also be addressed in this project. One of the by-products will most probably be a guideline for land-use and land-cover classification for Southern African water management.

This three-year project is carried out by the University of Pretoria's Department of Landscape Architecture.

The adaptation and calibration of an urban runoff quality model

The fact that runoff from urban areas can be a threat to water resources is well established from the vast amount of research that has been conducted previously. Studies into this problem have found that the main contributor of pollution to water courses, after agricultural activities, is urban runoff. Heavy metals are the most prevalent of the priority pollutants.

The results are, however, highly variable between studies due to different techniques used to collect the data, and other factors.

With the rapid spread of urbanisation, both formal and informal development within and surrounding the cities, there are ever-increasing sources of diffuse pollution which will continue to degrade the quality of surface waters.

The new project will adapt and calibrate the urban hydrological model called WITSKM to include continuous quality simulation and various options for the treatment of storm-water runoff. The project will be executed over a period of 3 years by the Division of Water Technology of the CSIR.

Urban catchment monitoring

The Welkom City Council has joined forces with the WRC and consulting engineers, Steffen, Robertson and Kirsten Inc. of Johannesburg, to identify and install instrumentation required in an urban catchment to formulate a storm-water master plan and to test the accuracy of assumed parameters of both rainfall and runoff. These data will be used to test and calibrate models developed elsewhere and to quantify the increase in flood peaks and volumes due to continuing urbanisation. The project will run for a period of 2 years with the last 18 months being allocated exclusively to data collection and processing.

Monitoring the effect of catchment development on urban runoff and water balance

In terms of a new agreement, the Water Systems Research Group of the University of the Witwatersrand will continue its research into the effects of urbanisation on hydrology and urban water balance. Waterval, a rural catchment which has been monitored for the past 5 years, is now earmarked for urban development and the University and the developers will work together closely to gain maximum benefit as changes to storm-water runoff, water table fluctuations, water consumption and quality of runoff all take place during development. Such a monitoring programme is unknown to have been performed before.

The bulk of the project is due to be reported on in 5 years, with the likelihood of continued monitoring taking place if development is not completed by that time.

A hydrological investigation of storm-water runoff from the Khayelitsha urban catchment in the False Bay area, South-Western Cape

and

Pollution loads, dispersion and effects of urban runoff from the Motherwell township into the Swartkops River, Eastern Cape

The effects of rapid urbanisation and informal settlement on the quality of storm-water runoff are being investigated in two areas: in Khayelitsha (CSIR); and in Motherwell (University of Port Elizabeth).

In both cases, runoff eventually ends up in the marine environment: in the case of Khayelitsha in False Bay and for Motherwell in the Swartkops estuary. The effects and eventual fate of pollutants will be studied within the marine environment and ameliorative measures will be tested and implemented.

The CSIR project in Khayelitsha will be carried out over 2 years, while the University of Port Elizabeth study into the Swartkops estuary is scheduled to take 3 years.

LIST OF RESEARCH PROJECTS

Current projects

- The effects of urbanisation on catchment water balance (The University of the Witwatersrand - Department of Civil Engineering, Water Systems Research Group)
- Development of methods to assess the impact of agricultural practices on water resources in Southern Africa (The University of Natal - Department of Agricultural Engineering)
- The investigation of the hydrological response to Third World settlements in the peri-urban areas of Natal/ KwaZulu (The University of Zululand - Department of Hydrology)
- The development of a systems model for the Mgeni catchment (The University of Natal - Department of Agricultural Engineering)
- Hydrological modelling studies in the Eastern Cape (Rhodes University - Department of Geography)
- Hydrological systems model development (The University of Natal - Department of Agricultural Engineering)
- Development of a model to simulate flow in alluvial rivers (A firm of consulting engineers: Bruinette, Kruger and Stoffberg Inc.)

New projects

- The quantitative structuring of national water planning objectives for use in decision support systems in South Africa (The University of Cape Town - Department of Mathematical Statistics)
- The preparation of a review document on sediment transport in Southern Africa, including revision of the sediment production map of Southern Africa (Sigma Beta Consulting Engineers)
- The surface water resources of South Africa 1990 (Consortium of consulting engineers)
- The utilisation of geographic information systems (GIS) and integrated environmental management (IEM) in the planning and management of water resources within river catchments (The University of Pretoria - Department of Landscape Architecture)
- The adaptation and calibration of an urban runoff quality model (The CSIR - Division of Water Technology)
- Urban catchment monitoring (Welkom City Council and a firm of consulting engineers: Steffen, Robertson and Kirsten Inc.)
- Monitoring the effect of catchment development on urban runoff and water balance (The University of the Witwatersrand - Department of Civil Engineering, Water Systems Research Group)
- A hydrological investigation of stormwater runoff from the Khayelitsha urban catchment in the False Bay area, South-Western Cape (The CSIR - Division of Water Technology)
- Pollution loads, dispersion and effects of urban runoff from the Motherwell township into the Swartkops River, Eastern Cape (The University of Port Elizabeth - Department of Oceanography)

GROUND WATER

Two events which will contribute significantly toward the direction taken by ground-water research over the next five years, took place during 1990.

- The first was the formulation of a strategy for achieving prioritised geohydrological research goals. The groundwork for this strategy was decided upon at a workshop held in November 1989 where the current situation in the field of ground-water research was presented and the research priorities were identified. Viewed in the light of current research trends world-wide, it is not surprising that the primary goal "Determination of the occurrence, degree and potential for ground-water contamination" received the highest priority. It is envisaged that this strategy will be widely publicised in an attempt to encourage research proposals directed towards addressing the most urgent needs.

The outcome of the workshop was an overwhelming plea for a hydrogeological map of Southern Africa

- The second event took the form of a workshop held in June 1990 where representatives of the ground-water user community were invited to express their requirements in terms of hydrogeological information. The outcome of the workshop was an overwhelming plea for a hydrogeological map of Southern Africa. This has led to the establishment of task groups who will assist in the preparation of a mapping strategy. The WRC is actively involved in directing research towards this objective.

During 1990 the Commission supported 17 projects related to ground water of which 4 commenced during the year, and 3 were completed.

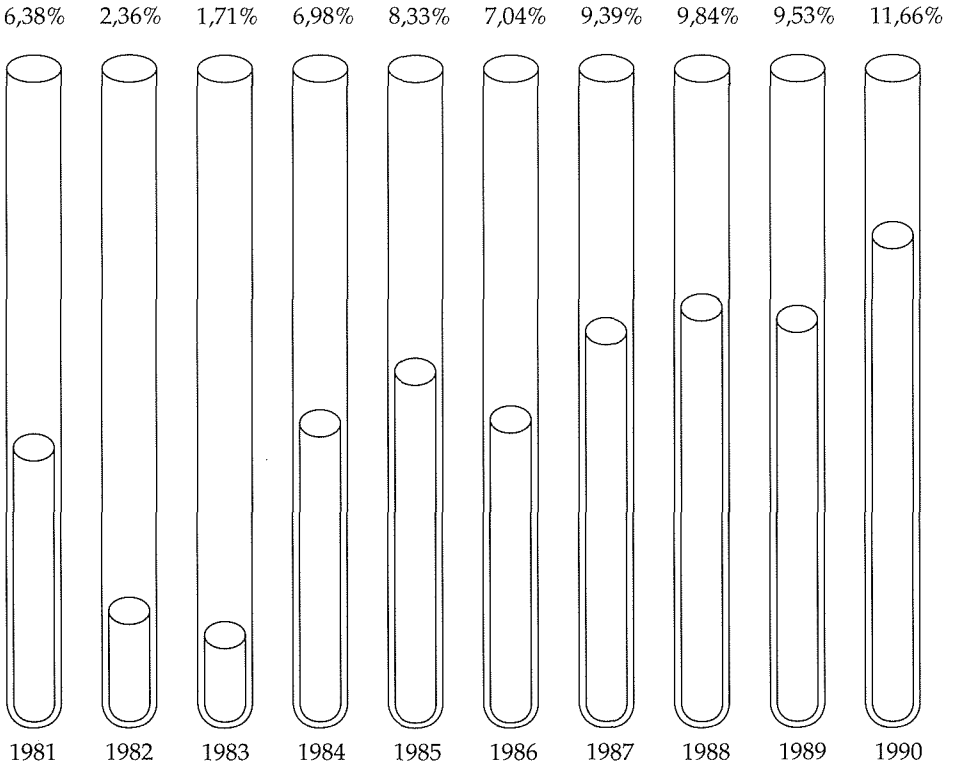
REPORT ON COMPLETED PROJECTS

The exploitation potential of Karoo aquifers

The exploitation potential of an aquifer is the long-term assured yield of water from the aquifer and is dependent upon the amount and variability of recharge from rainfall, the subsurface movement of water in and out of the aquifer and its storage capacity.

The main objective of this project, carried out by the Institute for Ground-water Studies of the University of the OFS, was

FUNDING OF RESEARCH ON GROUND WATER EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



to provide the water resource engineer with a method of obtaining an estimate of the exploitation potential of an aquifer in the semi-arid Karoo regions without having to conduct a full geohydrological investigation of the area.

Apart from obtaining very promising results using the saturated volume fluctuation method for the calculation of ground-water recharge, significant advances were made in our understanding of recharge processes, particularly during extreme rainfall events.

Modelling of the ground-water quality in the Atlantis aquifer

Since ground water is generally invisible, it is difficult to detect any pollution present in it without a suitable monitoring system. However, such a monitoring system yields only passive information. To combat ground-water pollution effectively, scientists tend to supplement the traditional monitoring system with a more indirect method of predicting the rate of dispersion of pollutants in aquifers, namely conceptual models.

The main aim of this study, undertaken by the Institute for Ground-water Studies, was to gain information on the mechanisms which are responsible for the pollution of ground water and to develop computer programs for the conceptual models, which in turn could be used to model contamination in South African aquifers. To achieve this, a number of new computer codes for conceptual models of ground-water flow phenomena were developed.

Investigations of the chemical composition of ground water in the vicinity of the recharge basin at Atlantis, together with virological studies, have contributed significantly to our understanding of the divergent processes which need to be taken into consideration when modelling ground-water contamination. This study included participation by the Division of Water Technology (CSIR) and the Department of Medical Microbiology, University of Cape Town.

Ground-water abstraction in residential areas

The Division of Building Technology, CSIR, undertook a three-year study to assess the annual quantity of water abstracted from private boreholes in Pretoria in relation to the quantity of water supplied by the municipal water supply system. Secondary aims included the variation in ground-water levels and quality for the period of the project and the prediction of future ground-water abstraction trends.

It was found that some 37,5 per cent of properties in Pretoria possess a borehole and that the annual quantity of ground water abstracted for use in private gardens was roughly equal to the quantity of municipal water used per year by all residential properties in Pretoria.

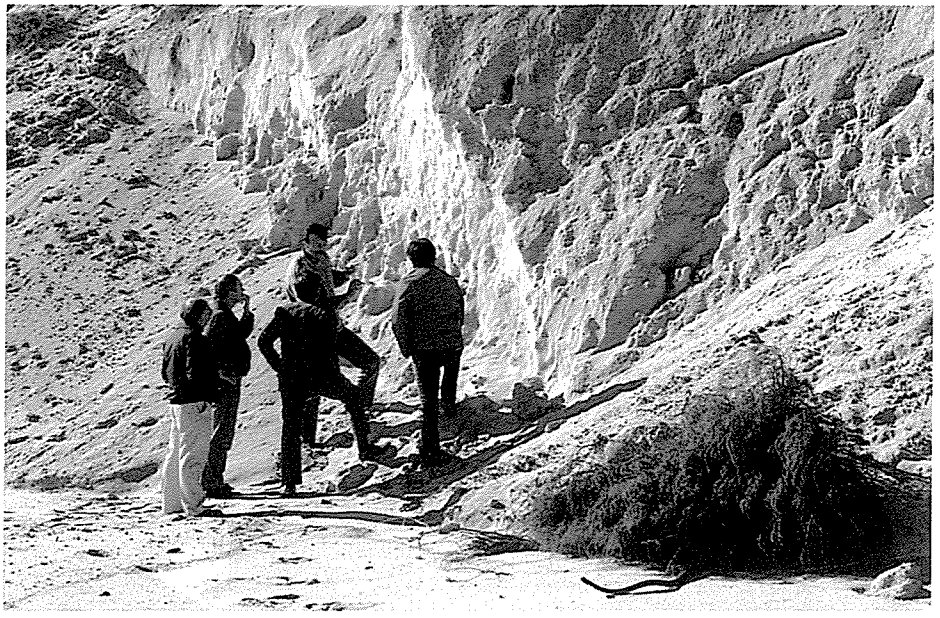
Changes in the elevations of the ground-water tables were found to be influenced by aquifer characteristics, but in general they were seasonal and no long-term trends were observed. The chemical quality of the ground water compared favourably with the municipal water quality but it was found that the microbiological quality of the ground water varied unpredictably.

DISCUSSION OF NEW PROJECTS

The integration of remote sensing, digital image processing and geographical information systems technologies for regional scale ground-water resources assessment in South Africa

To date, in South Africa, most assessments of the ground-water resource potential of a region have relied almost exclusively on a limited range of hydrogeological data collected by conventional ground surveys. Manual-based techniques have been applied to a large extent for processing and interpretation of these data. This approach has proved inadequate for reasons such as limited utilisation of various types of data, high costs for data acquisition, and lack and unreliability of data.

The overall aim of this project is to evaluate the contributions that remote sensing, digital image processing and geographic information systems can make towards the availability, range and quality of information on which ground-water resource assessments and management are based.



Exposure of the upper zone of the Atlantis aquifer along the coastline.

The development and evaluation of geohydrological and isotope hydrological methodologies for the identification of areas potentially suitable for waste disposal

In the rapidly expanding urban areas, waste disposal is becoming a significant problem with attendant pressure on available sites. Unless clear guidelines and useful approaches to impact assessment are in place, major damage could be inflicted on ground-water resources which are being, or may have to be, harnessed for domestic supply.

This project has as its main aim the development of methodologies by which the disposal of waste can be planned so as to minimise the impact on ground water. To this end, geohydrological and isotope hydrological studies are being conducted jointly by the Earth and Environmental Technology Division of the Atomic Energy Corporation of South Africa and the Schonland Research Centre at the University of the Witwatersrand.

The compilation of a comprehensive guide for ground-water sampling in South Africa

In many instances ground-water sampling in South Africa is undertaken in an unscientific manner. To a great extent this is because no published standard methods exist for ground-water quality sampling for South Africa.

The aim of this project, which is being carried out by the Division of Water Technology, CSIR, is to establish a formal and standardised protocol for use country-wide for all ground-water quality monitoring.

The guide will be in two parts - the first will be a simple "how to" manual designed along a "decision-tree" format. The second part will discuss in detail the "why's and wherefore's" of the sampling equipment, the collection method, the method of preservation and related aspects.

A regional investigation into ground-water quality deterioration in the Olifants River catchment above the Loskop Dam, with specialised investigations in the Witbank Dam subcatchment

This four-year project, which is being funded jointly by the WRC, the Chamber of Mines of SA, The Department of Water Affairs and Eskom, is being carried out by the Institute for Ground-water Studies of the University of the Orange Free State.

Elevated sulphate and low pH levels in the surface waters of the Olifants River and specifically in the Witbank Dam subcatchment, clearly indicate that the quality is deteriorating. At this stage the origin of these pollutants is still uncertain. It is known, however, that mining activity and power generation in this area expanded significantly during the past number of years. The impact that this expansion will have on the environment, especially on slow reacting systems like ground water, is expected to become visible only over an extended period of time. This investigation aims to quantify the contribution of various activities to the water quality deterioration in the area, predict future salt loads in ground water, improve management and precautionary measures to minimise ground-water quality deterioration and assist with integrating this information with that from other investigations, in order to derive a catchment management programme, aimed at reducing or reversing the trend towards water quality deterioration.

LIST OF RESEARCH PROJECTS

Completed projects

- Modelling of the ground-water quality in the Atlantis aquifer (The University of the Orange Free State - Institute for Ground-water Studies)
- The exploitation potential of Karoo aquifers (The University of the Orange Free State - Institute for Ground-water Studies)
- Ground-water abstraction in residential areas (The CSIR - Division of Building Technology)

Current projects

- The use of electromagnetic exploration techniques for the development of ground-water resources (The University of Pretoria - Department of Geology)
- The evaluation and development of techniques for the determination of geohydrological parameters by using geoelectrical methods (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))

Burning coal discards contributing to ground-water pollution in the Olifants River.

- The enhancement of the National Ground-water Data Base facilities (The University of the Orange Free State - Institute for Ground-water Studies)
- A geohydrological investigation and evaluation of the Zululand coastal aquifer (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))
- The development of techniques for the evaluation and effective management of surface and ground-water contamination in the Orange Free State goldfields (The University of the Orange Free State - Institute for Ground-water Studies)
- An investigation of the potential use of NOAA satellite remotely sensed data for identification of regional-scale fracture zones for ground-water supply purposes in Southern Africa (A firm of consulting engineers: Steffen, Robertson and Kirsten Inc.)
- A preliminary survey of pesticide levels in ground water from a selected area of intensive agriculture in the Western Cape (The CSIR - Division of Water Technology)
- The evaluation and development of geophysical techniques for characterising the extent and degree of ground-water pollution (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology and Division of Water Technology)
- A comparative study of two- and three-dimensional ground-water models (The University of the Orange Free State - Institute for Ground-water Studies)
- An investigation into the oscillation method for the determination of aquifer transmissivity (The University of the Orange Free State - Institute for Ground-water Studies)

New projects

- The integration of remote sensing, digital image processing and geographical information systems technologies for regional scale ground-water resources assessment in South Africa (A firm of consulting engineers: Steffen, Robertson and Kirsten Inc.)
- The development and evaluation of geohydrological and isotope hydrological methodologies for the identification of areas potentially suitable for waste disposal (The University of the Witwatersrand - Schonland Research Centre, and the Atomic Energy Corporation of South Africa)
- A regional investigation into ground-water quality deterioration in the Olifants River catchment above the Loskop Dam, with specialised investigations in the Witbank Dam subcatchment (The University of the Orange Free State - Institute for Ground-water Studies)
- The compilation of a comprehensive guide for ground-water sampling in South Africa (The CSIR - Division of Water Technology)

The Hex River valley was selected as a study area for pesticide levels in ground water.

AGRICULTURAL WATER UTILISATION

The Commission's funding of research projects in this field of operation during 1990 was characterised by the following events:

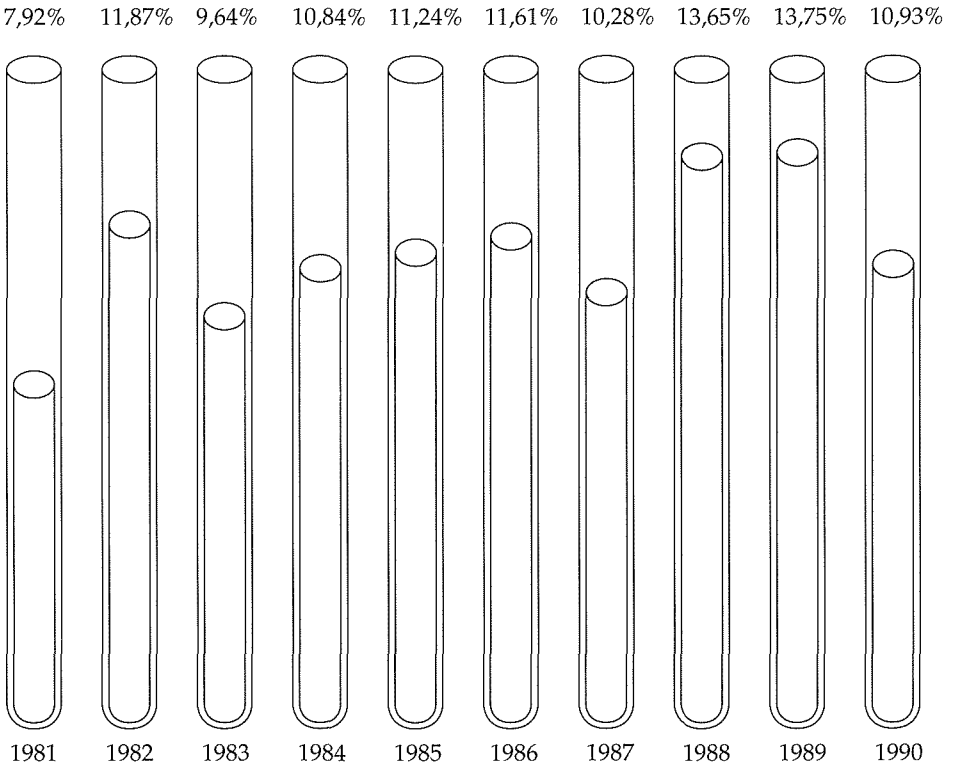
- Whereas the Commission's involvement in the past used to be restricted to crop and other irrigation-related research projects, financing of other agricultural-related research also occurred. Here mention should be made of the new research projects on the blackfly problem along the Orange River, and on the minimum quality of water for animal production. In both cases reduced animal production gave rise to this research.
- It became clear that irrigation farming in the RSA was experiencing extreme pressure. This state of affairs is mainly attributable to the current cost structure of production resources such as equipment and energy. A global farm approach to the economic efficacy of irrigation, taking into account alternative crops and re-allocation of water between different farming branches, is therefore a research need which would require urgent attention if optimal water utilisation in the South African agriculture is to be attained.

A global farm approach to the economic efficacy of irrigation is a research need which requires urgent attention

With the above in mind, development of a master plan for irrigation research and prioritisation of research needs continued in 1990. A draft master plan was formulated during an in-depth discussion session held between experts in irrigation research, and is to be finalised in 1991.

The number of agriculturally related research projects financed by the Commission in 1990 came to 23. Of these 2 were completed, while 4 new research agreements were entered into.

FUNDING OF RESEARCH ON AGRICULTURAL WATER UTILISATION EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



LIAISON WITH THE TRANSVAAL AGRICULTURAL UNION (TAU)

Liaison with the Irrigation and Water Affairs Committee of the South African Agricultural Union (SAAU) which had been initiated in 1989 was extended during the past year to include liaison with the corresponding committee of the TAU as well. This TAU committee met at the WRC by invitation and this meeting was followed by an information session during which the Committee was introduced to the WRC's agriculturally related water research projects. Both parties were thereby presented with the ideal opportunity to present their respective points of view.

REPORT ON COMPLETED PROJECTS

The development of a computer program to simulate water flow in distribution canals

This project was carried out by the Department of Civil Engineering of the Rand Afrikaans University over a period of four and a half years. The results indicate unequivocally that losses in distribution canals are minimised by the use of the computer package and that the operation of canal systems is facilitated as well. The computer package was put to the test at the Loskop State Water Scheme and successful remote control over the operation of the canal system was established. An office data base which carries out administrative functions such as bookkeeping of water utilisation, was also established. This data base has, however, not yet been linked up with the distribution program.

An investigation into water use and productivity of crops under conditions of water stress and the modelling thereof

The final report of this project, carried out between 1984 and 1989 by the Soil and Irrigation Research Institute of the Department of Agricultural Development, is entitled *Investigating and Modelling Crop Water Use and Productivity under Conditions of Water Stress*. The project revealed, *inter alia*, that a simple morphological indicator of water stress, based on leaf movements, can be used in a quantitative sense to schedule the irrigation of soya beans. High frequency irrigation of wheat to minimise water stress was shown not to be beneficial, unless the frequency of nitrogen applications was adjusted accordingly. Leaf water potential proved to be a successful indicator of wheat irrigation requirements and could be adequately modelled under local conditions, obviating the need for tedious measurement. Additional insight into relationships between wheat yield and water use was obtained.

DISCUSSION OF NEW PROJECTS

The development of an effective and environmentally safe larviciding programme for the control of the blackfly, *Simulium chutteri*, along the Orange River

The project is to be carried out by the Research Institute for Veterinary Science of the Department of Agricultural Development over a period of 3 years.

The blood-sucking blackfly, *Simulium chutteri*, is a serious stock infestation occurring along the Orange, Vaal and Fish Rivers. Although it does not play a role in the vection of stock disease, it nevertheless is an extremely serious infestation causing annual sheep production losses of R22 million along the Orange River.

Under normal conditions the rise and fall in the water levels would be sufficient to contain the infestation. Since 1966, however, the blackfly infestation has been on the increase annually, as dam construction has caused the flow in rivers to stabilise. The problem could not be resolved by varying the river water flow through dam sluice manipulation.

With the above in mind the project is aimed at determining the efficacy of a biological larvicidal agent, viz. an extract of *Bacillus thuringiensis* var. *israelensis*, under local conditions. In addition to this the influence of seasons and water temperature on the incidence and development of the blackfly will be investigated. The knowledge thus attained, will be used in establishing a practical and effective programme for the control of the blackfly along the Orange River.

Ear damage in sheep caused by Simulium chutteri.

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

Models which simulate crop responses to soil water availability and uptake are potentially powerful tools for irrigation planning and management. The aims of this new project, which is being undertaken over a period of 4 years by the Soil and Irrigation Research Institute of the Department of Agricultural Development, are to obtain data to strengthen weaker areas in such models and to evaluate and improve their usefulness as irrigation management aids. Areas which have been identified as requiring special attention are the development of the crop canopy and the better characterisation of water transport resistances in the soil-plant-atmosphere continuum, as affected by varying water-nitrogen regimes.

An investigation into the quality of water for animal production

The problem of minimum water quality for animal production was identified by die Directorate of Soil Conservation and Drilling Services of the Department of Agricultural Development, and brought to the attention of the WRC.

The situation is that boreholes are being sunk at great cost and that the quality of the water found is often suspect. The standards to which water intended for the watering of cattle have to conform are, however, based on outdated and haphazard information, to such an extent that the question may well be asked if the standards are realistic. Information available in South Africa in this regard is extremely inadequate, therefore use is being made of either overseas information (which is not really valid locally) or of standards which have not been thoroughly investigated experimentally.

As the situation stands, extensive research on the maximum acceptable salt content of water for the watering of cattle has as yet not been undertaken in the RSA. This is a complex problem which involves not only the local climatic and grazing conditions, but also the kind of stock, gestation and whether it is meat, milk or wool production that is at stake.

The project will be carried out over a period of 4 years by the Department of Animal Science of the University of Pretoria.

The use of saline water for irrigation purposes and an assessment of salt tolerance criteria of crops

This project is to be carried out over a period of 5 years by the Department of Soil and Agricultural Water Science of the University of Stellenbosch.

The research strategy in respect of salinisation is based on a dual approach, viz. on the one hand to conduct research aimed at combating salinisation, and on the other hand to conduct research which will improve the possibility of living with salinisation. This research project focuses on increasing the efficacy of the use of saline water for irrigation. During the past few years criteria were formulated for the salt content of irrigation water at a number of irrigation schemes, based on overseas findings which had not been checked under local conditions. Criteria which are either too strict or too lenient are unacceptable, depending on the point of view from which this is approached. The aim of this project is to check the validity of one of the sets of criteria (for the irrigation of vines in the Breë River valley), as well as the methodology used to establish the criteria.

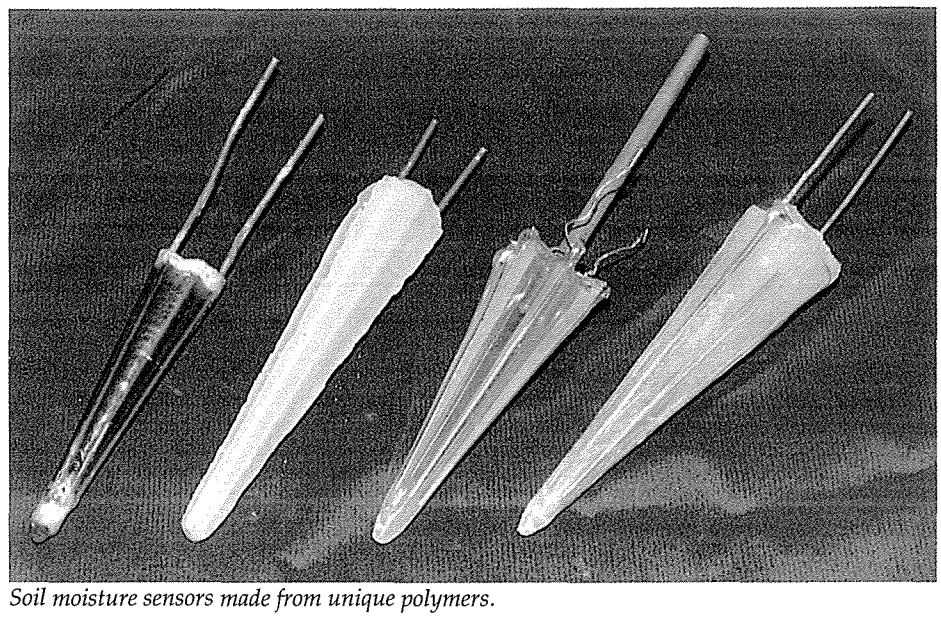
LIST OF RESEARCH PROJECTS

Completed projects

- The development of a computer program to simulate the flow of water in distribution canals (The Rand Afrikaans University - Department of Civil Engineering)
- Investigation into water use and productivity of crops under conditions of water stress and the modelling thereof (The Department of Agricultural Development - Soil and Irrigation Research Institute)

Current projects

- An investigation into methods of developing operational rules for individual irrigation systems (The University of Stellenbosch - Department of Civil Engineering)
- The development of an adjustable low pressure flow-rate control valve for flood irrigation (The University of Pretoria - Department of Agricultural Engineering)



Soil moisture sensors made from unique polymers.

- The quantification and limitation of water losses associated with centre-pivot irrigation systems (The University of the Orange Free State - Department of Agricultural Engineering, in collaboration with the Department of Agronomy)
- Development of a manual to be used with the IDES computer programs for the design of irrigation systems (A firm of consulting engineers: Murray, Biesenbach and Badenhorst Inc.)
- Economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State (The University of the Orange Free State - Department of Agricultural Economics)
- The development of criteria for sprinkler irrigation systems to combat surface sealing of soils (The Potchefstroom University for CHE - Department of Pedology and the University of Pretoria - Department of Agricultural Engineering)
- The practical scheduling of irrigation in the Northern Transvaal (The University of the North - Department of Crop Production)
- Drip irrigation of tomatoes (The University of Pretoria - Department of Plant Production)
- Maximising irrigation project efficiency in different soil/climate/irrigation situations (The University of the Orange Free State - Department of Agrometeorology)
- The storage and utilisation of rain water in the soil for the stabilisation of plant production in semi-arid areas (The University of the Orange Free State - Department of Soil Science)
- The factors affecting the water-use efficiency of irrigated crops with special reference to the physiological responses of these crops (The University of the Orange Free State - Department of Agronomy and Hortology)
- The estimation and evaluation of moisture stress in crops by means of remote control aerial surveillance (The University of the North - Department of Soil Science)
- The water-use efficiency of certain irrigated temperate pasture species (The University of Pretoria - Department of Plant Production)
- Moisture sensors to facilitate water management (The University of Stellenbosch - Institute of Polymer Science)
- The relationship between climate and crop factors (The University of the Orange Free State - Department of Agrometeorology)
- Soil/plant/water relations in the upper reaches of plant available soil water (The University of Pretoria - Department of Soil Science)
- Flood and furrow irrigation: A critical evaluation of design procedures and the computerisation of the most suitable approaches (The University of Pretoria - Department of Agricultural Engineering)

New projects

- The development of an effective and environmentally safe larviciding programme for the control of the blackfly, *Simulium chutteri*, along the Orange River (The Department of Agricultural Development - Veterinary Research Institute)
- The influence of different water-nitrogen regimes on crop canopy development, water flow resistance and crop yield, with a view to improvement of irrigation models (The Department of Agricultural Development - Soil and Irrigation Research Institute)
- An investigation into the quality of water for animal production (The University of Pretoria - Department of Animal Production)
- The use of saline water for irrigation purposes and an assessment of salt tolerance criteria of crops (The University of Stellenbosch - Department of Soil and Agricultural Water Science)

WATER POLLUTION

As South Africa is a country with a relatively low and variable rainfall the emphasis in the past used to fall on the development of water resources. In so doing it was attempted to ensure an adequate water supply for use during the drier periods. In addition to this the reuse of effluents also received attention. In order to counteract the deterioration in the water quality which is associated with the reuse and discharge of effluents, standards to which effluents had to conform before further discharge, were laid down and enforced. It, however, gradually became clear that the quality of water could not be maintained at acceptable levels merely by applying effluent standards.

The Department of Water Affairs and Forestry embarked on a new approach for the control of water pollution

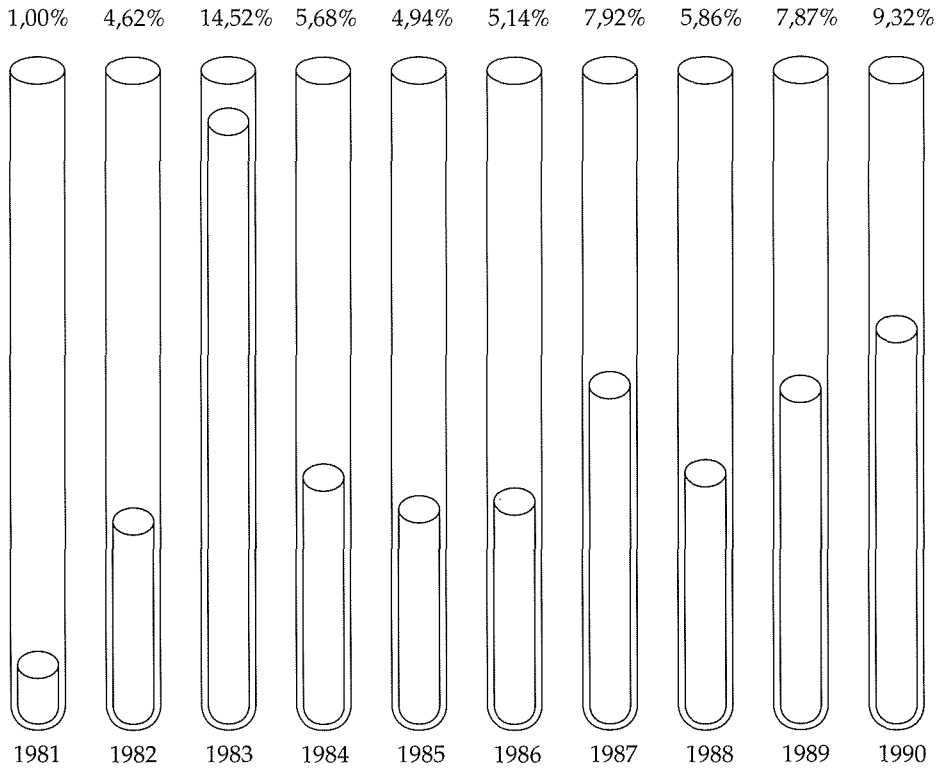
The Department of Water Affairs and Forestry therefore embarked on a new approach for the control of water pollution, in terms of which the water quality requirements of the users downstream would play a decisive role in the nature and quantity of pollutants to be allowed. Ideally non-toxic substances are restricted to levels which are acceptable to the most sensitive of users, while the discharge of toxic substances is prohibited. It is envisaged that this new approach to water pollution control will have a significant impact on the future research requirements with regard to water pollution.

Inherent in the new approach to water pollution control is the acceptance that water bodies have a quantifiable and manageable capacity to absorb waste products without affecting the water quality to such an extent that it becomes unsuitable for acknowledged uses. The determination of these capacities for different waste products and the distribution thereof by means of waste load allocations, form the cornerstone of the new approach to water pollution control.

A lack of local expertise in this area presently still hampers the implementation of the new approach. In partial fulfilment of its technology transfer function, the Commission, in co-operation with the Department of Water Affairs and Forestry, presented a short course on the technique and methodology of waste load allocations. Except for the contributions by a number of local experts, the course was presented mainly by Dr Ray Whittemore (Tufts University, USA), an expert on the application of techniques and their underlying principles.

Salinisation and eutrophication were identified as the two results of water pollution which pose the greatest problems in South Africa. Salinisation incurs additional costs for consumers in that water becomes less suitable for most uses. Eutrophication encourages the excessive growth of algae and aquatic plants which *inter alia* makes the treatment of water for drinking purposes more difficult. Both these phenomena are to a large extent the result of development - salinisation of the degree to which a variety of salts have been added to the water environment through use and reuse, and eutrophication of the degree to which water resources have been contaminated by effluents rich in plant nutrients.

FUNDING OF RESEARCH ON WATER POLLUTION EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



SALINISATION

Subsequent to prioritising the objectives of salinisation research in November 1989, the Co-ordinating Committee for Salinisation Research decided on a pro-active strategy in order to address the most urgent research needs. The strategy was accepted by the WRC at its meeting held in November 1990, and will now be made available to the research community to enable them to formulate research proposals in terms of the priorities identified.

During 1990 the Commission financed 6 salinisation projects of which 1 was initiated and 1 was completed.

REPORT ON A COMPLETED PROJECT

The inhibition of bacterial oxidation of pyrite and the accompanying acid mine water

The natural oxidation of pyrite to form iron sulphates and sulphuric acid is a slow process, but it is largely accelerated by the action of certain bacteria. This is a widespread problem in the coal and gold-mining industry and causes serious salinisation of water sources. The research was aimed at drenching certain materials with bactericidal chemicals. These materials can be placed in residue dumps where the inhibiting chemicals can be released slowly in the course of time.

The first phase of the research comprised the successful production of pellets or membrane sachets made of natural or synthetic rubber in which the inhibiting substances were impregnated in order that controlled release thereof could be obtained. The elastomeric membrane sachet has been found to be the most economic release mechanism. In further studies various chemicals were tested as inhibitors of the bacteria *Thiobacillus ferro-oxidans* in gold-mine dumps. Sodium lauryl sulphate was the best inhibitor, but the use of the inhibitors deep inside gold-mine dumps, where pyrite oxidation also occurs, is a big problem. The last phase of the research focused on coal residue dumps and several inhibitors and combinations thereof were tested. The advantages of using sodium bensoate and sorbic acid were apparent, but a major problem regarding the adsorption of the chemicals on the coal and the variance in the coal particle size was experienced. Apart from the practical problems the use of the inhibitors, as tested, is also not an economical proposition.

Measurement of soil salinity using the four-electrode electrical conductivity technique.

DISCUSSION OF A NEW PROJECT

An investigation into the contribution of ground water to the salt load of the Breë River using natural isotopes and chemical tracers

This project will be carried out by the University of the Orange Free State over a period of 1 year. Salinisation of rivers is a commonly observed result of irrigation along rivers. In spite of the considerable effort which has been made to improve the knowledge of this subject, the understanding of the interaction between ground water and irrigation return flow and the ability to quantify their relative contributions to the salt load in a river system, are still insufficient. Results obtained during a previous feasibility study indicated that the natural tracer concentrations in surface and ground waters differ to such an extent that it is theoretically possible to proportion their relative contributions to the quantity of water (and therefore also salt) flowing in the river. The aim of this project is to establish whether such a proportioning would be practicable, on the basis of water and salt balances.

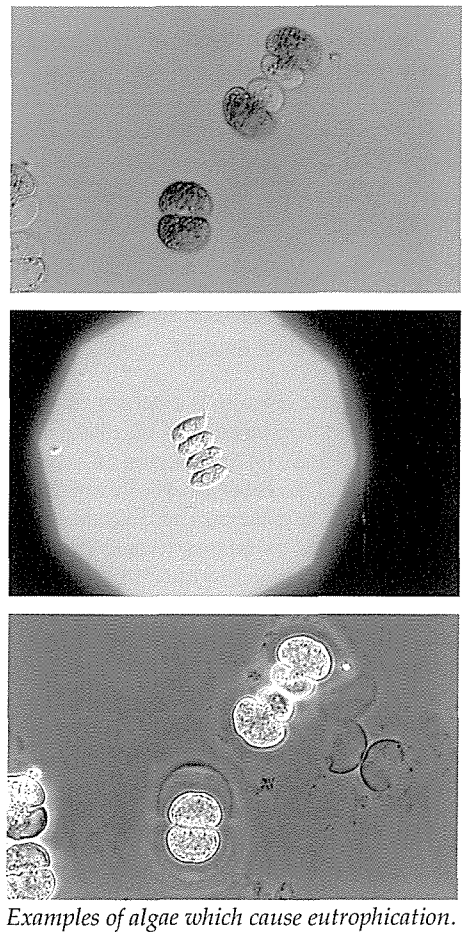
EUTROPHICATION

Of the 6 eutrophication projects financed by the Commission in 1990, 1 was completed.

REPORT ON A COMPLETED PROJECT

The development of management-orientated models for eutrophication control

This project was initiated when it became clear that overseas models for the quantification of the effect of eutrophication measures could only find restricted application under local conditions. The reason is that these models do not take into account the effect of large hydrological variability (typical of South Africa) on phosphate loads and water levels. Models



Examples of algae which cause eutrophication.

to predict eutrophication in dams, taking into account the hydrological variability, have been developed successfully as part of the project. Furthermore, these models were incorporated into a decision support system (DSS) which integrates the models and their supporting data bases in a user-friendly manner. A method to assist decision-makers in combining quantitative and qualitative data when selecting an appropriate eutrophication control strategy was also applied. The success of the project becomes evident when one takes into account the fact that during 1989 DSS was virtually exclusively used to evaluate the effect of the 1 mg/l P standard in sensitive catchments.

MARINE DISPOSAL

Due to the considerable capacity of the sea to assimilate specific wastes, most of the communities at the coast make use of the sea to some extent to dispose of their effluents. It is, however, essential that only non-toxic wastes which can be assimilated effectively by the marine evironment should be disposed of. Guidelines in this regard are available. During the year the Commission financed and completed 1 project with regard to marine disposal.

REPORT ON A COMPLETED PROJECT

The culturability of faecal coli following exposure to sea water - A pilot study

When domestic sewage is discharged into the marine environment, the numbers of culturable enteric bacteria in the effluent are reduced. The decay is usually attributed primarily to dilution and dispersion which are aided by factors such as the lethality of ultraviolet light (UVL) near the surface, osmotic shock, bactericidal and/or bacteriostatic components in sea water, competition and/or predation from marine organisms, and adsorption of the bacteria onto particulate matter with subsequent sedimentation.

The pilot study aimed at establishing the effect of exposure times to sea water on these bacteria. The indications are that the change in numbers of waste-water bacterial populations after exposure to natural sea water appears to involve three modalities, viz.:

- **phase alpha**, when the physical translocation reduces the numbers of microbes, or a shrapnel effect increases them, or an approximate balance of two effects confers an approximate and temporary equilibrium on the numbers;
- **phase beta**, when the decrease in bacterial numbers is directly proportional to the dilution of the discharged effluent; and
- **phase gamma**, when tertiary effects, principally ultraviolet light, contribute to the microbial die-off rate, in the direction of natural attrition.

It is concluded that in planning pipelines for the safe discharge of effluents, the attainment of sufficient dilutions on-shore (**phase beta**) should be the sole target in calculating the design criteria.

WATER QUALITY STUDIES

The increasing awareness of quality as a factor determining the utilisation potential of water, coupled with the gradual deterioration of the water quality, created a need for establishing a strategy in terms of which the most important aspects of water quality can be monitored and managed. The Commission currently finances 5 projects in respect of water quality studies. Of these 4 were initiated during the year under review.

DISCUSSION OF NEW PROJECTS

The applicability of hydrodynamic reservoir models for water quality management in stratified water bodies in South Africa

This two-year project is a joint effort between the consulting engineering firm Ninham Shand Inc. and the University of Cape Town.

Stratification, which commonly occurs in many dams, offers a number of potential applications, e.g. salinisation control (washing-out of the underlying saline water, timing of freshwater intake or discharges and choice of abstraction level), prediction of the destination of plant nutrients or the distribution of pollutants in a dam, the optimum placement of tunnel inlets or pump stations and the evaluation of mixing conditions in oxidation dams. The purpose of this project is to evaluate the ability of existing mathematical models to predict stratification and related processes in South African water bodies, to adapt them as needed and to demonstrate their application possibilities.

The occurrence and accumulation of selected heavy metals in freshwater ecosystems affected by mine and industrial polluted effluent

This three-year project is being undertaken by the Rand Afrikaans University.

Mining and industrial activities and residential pollution on the Witwatersrand are causing serious disturbances of freshwater ecosystems in the Elsburg, Natal and Blesbokspruit catchments. Heavy metals also occur in these tributaries in relatively high concentrations but their effect on ecosystems has as yet not been investigated. Rehabilitation of these tributary systems can contribute to the development of green belts on their banks where open-air recreational areas could be established to the advantage of the entire East Rand community. The purpose of the research is to trace the sources of the heavy metal pollution and to determine the accumulation of heavy metal ions in both the abiotic and the biotic components of the water environments.

The concentration ratios of selected radionuclides in aquatic ecosystems affected by mine drainage effluents

This project is being carried out by the Rand Afrikaans University over a period of 2 years.

The RSA produces gold and uranium on a large scale. As a result of mining activities uneconomic concentrations of uranium and radium end up on mine dumps and in water-courses. These effluents are radio-active and can therefore harm the environment and eventually also man. Relatively little is known of the effects that uranium and other radio-active substances may have on the flora and fauna of an area surrounding such

activities. The purpose of the project is to determine the short and long-term effects of the radionuclides on the agricultural activities and the links with plants and animals. The results will lay the foundation for the quantification of the impact of radiological water quality on the ecosystem and on man.

Assessment of the feasibility and impact of alternative water pollution control options on TDS concentrations in the Vaal Barrage and Middle Vaal

This project is being carried out by the consulting engineering firm Steffen, Robertson and Kirsten Inc. in terms of a two-year contract.

During the past decade several studies were undertaken to quantify certain aspects of pollution occurring within the Vaal Barrage catchment. To allow assessment of the various pollution control options for future implementation, the available data must not only be appropriately interrelated but also need to be extended.

The current study aims at supplementing the National Industrial Water and Waste-water Survey (NATSURV) project by investigating other pollution sources in the Vaal Barrage such as mines and power stations. Because of the proximity to the Vaal Barrage the study will also be extended to include significant pollution sources within the Middle Vaal region. The data collected through field tests will be used to test and refine the computer models developed to characterise salinity in the Vaal Barrage catchment. The refined models will serve as a useful tool for comparing various pollution control options for the combined catchment in terms of salinity reduction and the associated cost implications.

LIST OF RESEARCH PROJECTS

Completed projects

- The inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage (The Chamber of Mines and the University of Stellenbosch - Department of Microbiology and Virology and the Institute for Polymer Science)
- The development of management-orientated models for eutrophication control (The CSIR - Division of Water Technology and the Department of Water Affairs)
- The culturability of faecal coli following exposure to sea water - A pilot study (The CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))

Current projects

- Hydrosalinity studies in the Eastern Cape (Rhodes University - Department of Geography)
- An evaluation of the abilities of several solute and water transport models to predict the quantity and quality of water leaving the root zone (The University of Stellenbosch - Department of Soil and Agricultural Water Science)
- The evaluation of the design and use of irrigation systems in the Breë River with a view to the control of potential drainage losses (A firm of consulting engineers: Murray, Biesenbach and Badenhorst Inc.)
- The development of phosphate export models for catchments (The CSIR - Division of Water Technology)
- The quantification of the effects of land use on runoff quality in selected catchments in Natal (The CSIR - Division of Water Technology)
- The development of water quality monitoring strategies and procedures for water quality data interpretation (The CSIR - Division of Water Technology and the Department of Water Affairs)
- The evaluation of the four-electrode electrical conductivity and electromagnetic induction techniques of soil salinity measurement for use under South African conditions (The University of Natal - Department of Soil Science and Agrometeorology)
- The harvesting of algal drift from Hartbeespoort Dam water for the reclamation of fine chemicals (The CSIR - Division of Water Technology)
- The extension of the management-orientated models for eutrophication control (The CSIR - Division of Water Technology)
- The management of phosphate concentrations and algae in Hartbeespoort Dam (The Department of Water Affairs and the CSIR - Division of Water Technology)

New projects

- The applicability of hydrodynamic reservoir models for water quality management in stratified water bodies in South Africa (A firm of consulting engineers: Ninham Shand Inc. and the University of Cape Town - Department of Civil Engineering)
- The occurrence and accumulation of selected heavy metals in freshwater ecosystems affected by mine and industrial polluted effluent (Rand Afrikaans University - Department of Zoology)
- The concentration ratios of selected radionuclides in aquatic ecosystems affected by mine drainage effluents (Rand Afrikaans University - Department of Zoology)
- Assessment of the feasibility and impact of alternative water pollution control options on TDS concentrations in the Vaal Barrage and Middle Vaal (A firm of consulting engineers: Steffen, Robertson and Kirsten Inc.)
- An investigation into the contribution of ground water to the salt load of the Breë River using natural isotopes and chemical tracers (The University of the Orange Free State - Institute for Ground-water Studies)

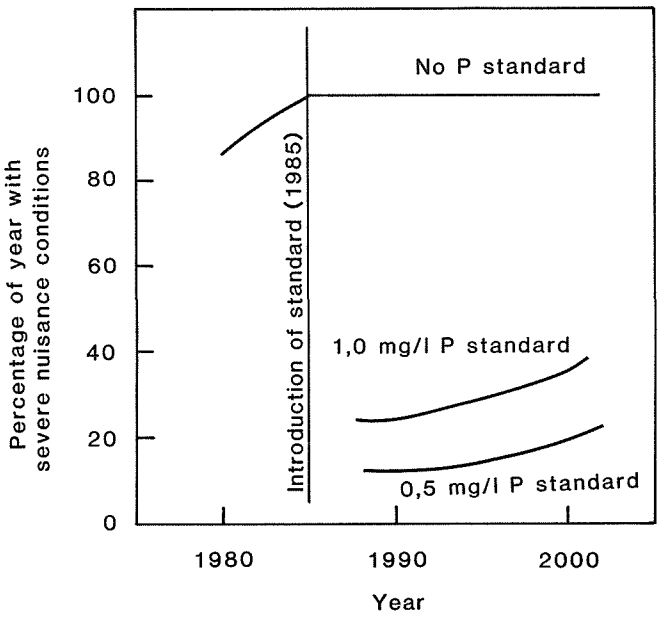
MUNICIPAL WASTE WATER

In terms of the Water Act all water not used consumptively must be returned to the water environment after treatment to the required standards as specified in the Act. Economic and efficient treatment of waste water to the required standards is becoming increasingly important as our economy and water resources are coming under pressure.

Research on municipal waste-water treatment sponsored by the WRC is aimed at:

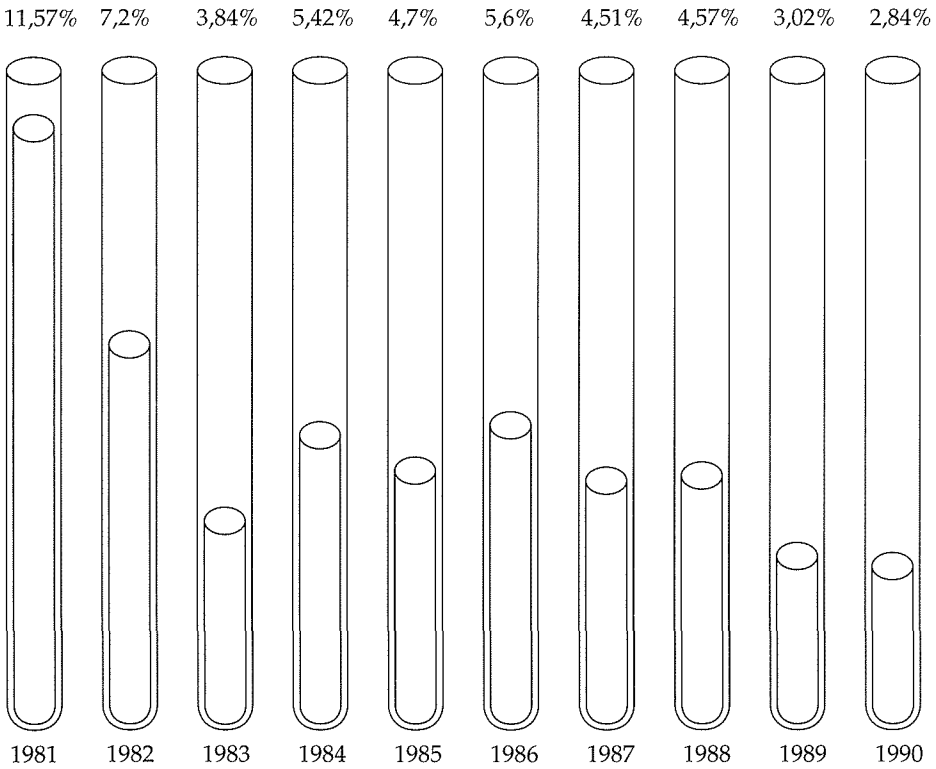
- combating pollution of the water environment;
- protecting public health; and
- producing effluents of adequate quality for direct or indirect reuse.

Since plant nutrients in sewage effluents, and especially phosphorus, cause unwanted biological growths in receiving waters with concomitant problems experienced in treating these waters to potable standards, special attention has again been paid to research on nutrient removal. The predicted effect of phosphorus removal on nuisance conditions in a eutrophied impoundment is shown in the accompanying figure.



Impact of phosphate standard on trophic status of Hartbeespoort Dam (after Grobler and Silberbauer (1984) as quoted in Water SA **15** *(3) 141-146).*
*Soluble orthophosphate expressed as mg P/*l*

FUNDING OF RESEARCH ON MUNICIPAL WASTE WATER EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



However, high-technology treatment of sewage effluents will in future constitute only part of the problem-solving effort. In order to deliberate the drafting of a new *Master Plan for Municipal Waste Water Management*, a strategy session was held in March 1990. The 5 main thrust areas in future research on municipal waste-water management were identified at this strategy planning session as (in priority sequence):

During a strategy session the 5 main thrust areas in future research on municipal waste-water management were identified and prioritised

- development of affordable and acceptable technology for developing communities;
- development of treatment strategies and technologies to address diffuse pollution;
- development of improved affordable and acceptable high technology;
- improved sludge handling and utilisation; and
- recovery of resources.

These main goals will be further addressed in subsequent strategy planning sessions to complete the new *Master Plan* in 1991.

During 1990 the Commission supported 16 projects in this field, of which 4 commenced during the year, 7 are current projects and 5 were completed.

SEWAGE TREATMENT

REPORT ON COMPLETED PROJECTS

Electrochemically-produced metal coagulants for the treatment of polluted water

Undesirable pollutants such as phosphates can be removed by chemical or biological methods during the treatment of water. During chemical flocculation metal ions are hydrolysed into hydroxides while the anions are neutralised into the corresponding salts, thus leading to possible salinisation of the water. On the other hand, electrochemically produced metal coagulants only release metal ions in the water, and consequently no salinisation takes place. The kinetics of the electrochemical process was investigated to determine the cost-effectiveness thereof. The bipolar cell configuration, with the cells linked in series, was found to be the most practical system. Although marginally better phosphate removal was effected by conventional chemical dosing than by the electrochemical process, the latter process did not give rise to salinisation with repeated water reuse. Cost-wise the two processes are also comparable.

Phosphate removal by means of electrochemically-formed iron ions

In this follow-up project on the above, it was found that the density of the current had the most significant effect on the cell efficiency. A linear correlation was found between the density of the current and cell efficiency and this could be used with the aid of Faraday's Law to determine the amount of iron which would dissolve for a particular current flowing through the iron electrodes of the cells. The electrolytic cell was tested in an activated sludge pilot plant and good phosphate removal was obtained when the iron ions were added to the effluent after secondary precipitation. After tertiary treatment a high-quality effluent was obtained in which the chemical oxygen demand, total Kjeldahl nitrogen, colour and turbidity also showed a marked improvement.

The removal of orthophosphate from water by the direct use of scrap iron

A novel process which had been developed previously by Process Chlorination (Pty) Ltd to remove dissolved orthophosphate from water or effluent by chemical means was evaluated for removing orthophosphate from sewage effluent. In this process a rotating column filled with scrap iron shavings is used. The novelty of the process lies in the fact that iron metal is used as such for precipitation of orthophosphate without having to resort to the use of iron compounds. Sewage effluent containing dissolved orthophosphate was pumped through while the column was slowly rotated to prevent fouling of the iron shavings. Two obvious advantages which stem from this are that no additional salts are added to the water in the process and that the alkalinity of the treated water is not affected by the process. A further major advantage is that no iron hydroxide is formed, as is the case when ferric chloride is used, and the precipitate that forms settles as a dense, stable sludge.

The main findings of laboratory-scale experiments showed that good orthophosphate removal could be obtained from various municipal effluents. However, when the process was conducted on a pilot-plant scale very erratic results were obtained for the removal of orthophosphate. It was decided that Process Chlorination (Pty) Ltd would now first investigate the reasons for this poor performance at their own expense before a long-term evaluation of the process could be considered.

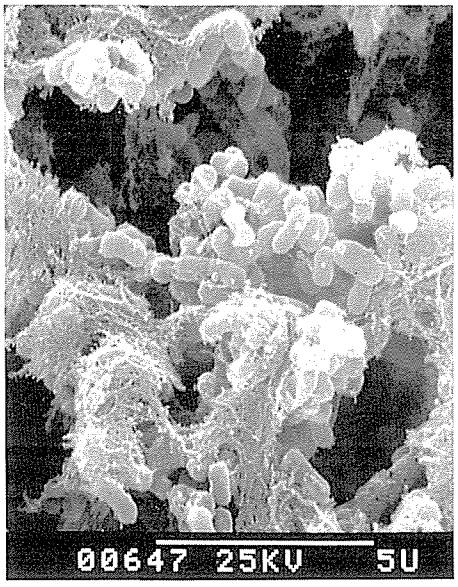
This project was launched and completed in 1990.

DISCUSSION OF NEW PROJECTS

Biological phosphate removal mechanisms in the activated sludge process

The Department of Microbiology and Plant Pathology of the University of Pretoria is currently engaged in developing a unique method for the *in situ* study of *Acinetobacter* and other bacteria which take up phosphate in the activated sludge process. This method is based on the immobilisation of organisms in an alginate substrate and for the very first time enables the researcher to study the behaviour of a specific organism species in the anaerobic, anoxic and aerobic zones of the activated sludge process.

This three-year project is aimed at determining the factors which influence phosphate uptake, thereby making a contribution towards the design of nutrient removal plants from basic principles.



Cross-section of an alginate pellet containing the immobilised bacteria (5 000 x magnification).

Full-scale study on the chemical control of sludge bulking

This one-year study is being carried out by the Department of Chemical Engineering of the University of Pretoria.

Sludge bulking remains a problem in activated sludge units with a long sludge age. This project will evaluate the efficiency of both hydrogen peroxide and ozone as non-specific bulking control agents at full scale. The project will be done at Daspoort Sewage Works once certain structural modifications which are being made to the works have been completed. Three identical units will be used simultaneously to evaluate the two bulking control agents against an untreated unit.

SEWAGE SLUDGE TREATMENT AND DISPOSAL

REPORT ON COMPLETED PROJECTS

Performance evaluation of forced aeration composting of sewage sludge

The successful outcome during 1986 of a WRC sponsored research project aimed at the local application of forced aeration composting, prompted a tripartite agreement between the WRC, the Division of Water Technology (DWT) of the CSIR and the Municipality of Stellenbosch. According to the agreement the DWT would assist the Municipality with the commissioning of their new sludge composting plant with the financial assistance of the WRC.

The operational procedure adopted during the full period of this project allowed the optimisation of the most important process variables and methods. In addition enrichment with vermiculite was also evaluated.

Results showed that a mixture (1:1 on a volume basis) of dewatered waste activated and primary sludges can be composted successfully to yield a stable and disinfected end-product with excellent soil conditioning properties. Although a ready market is available for the 10 m^3 produced daily at a selling price of R30/m^3, there is a real need for establishing the full potential of the market.

Experience at the Stellenbosch plant has highlighted some problems including the need for reliable sources of bulking material and mechanical mixing equipment and a necessity for the development of simulation models to overcome nitrogen losses and to optimise aeration for drying purposes during the rainy season. The Stellenbosch plant also offers the ideal opportunity for the collection of cost data.

Evaluation of the active sewage pasteurisation (ASP) process for sewage sludge treatment

A promising new technology for the conversion of sewage sludges to a pasteurised fertiliser product for agricultural utilisation was developed and patented by a local private company. Pasteurisation was achieved by the combined action of chemicals and heat, while the chemicals used simultaneously enriched the sludge with nitrogen and phosphorus to fertiliser standards.

A short-term contract was signed with the Division of Water Technology, CSIR (Stellenbosch) to evaluate the effectiveness of ASP as a sludge treatment method in respect of degree of disinfection and stabilisation achieved. Limited leaching studies of nitrogen and phosphorus from soil fertilised with ASP-treated sludge were included in the contract for execution by the Faculty of Agricultural Sciences of the University of Pretoria.

This contract was initiated and completed during the year and the main results are highlighted under *Pasteurisation of Sewage Sludge for Agricultural Use* in **The Year Under Review**.

DISCUSSION OF NEW PROJECTS

Aspects of sewage sludge treatment and disposal

A new three-year agreement was signed with the City Council of Johannesburg. This project aims to:

- minimise sludge production in activated sludge plants;
- evaluate co-disposal of sewage sludges with household refuse in landfills;
- investigate improved sewage sludge dewatering; and
- characterise organic toxins in sludges in order to investigate improved utilisation of sewage sludges for agricultural purposes.

Since the daily production of sewage sludge from Johannesburg plants alone is in the region of 100 t/d, the safe and successful co-disposal of dewatered sewage sludge with household refuse, or the improved agricultural utilisation of this sludge will alleviate the pressing problem of how and where to get rid of excess sludge in future.

Forced aeration composting of sewage sludge for rural communities

The supply of adequate sanitation systems in many developing countries, including South Africa, has deteriorated over the past decade due to a combination of demographic, sociological and economic factors. This has resulted in an urgent need for the development of low-cost effective and appropriate waste management technologies for the treatment and disposal of human wastes. This need is not only felt in rural areas, but also in the over-populated outskirts of urban areas (such as squatter camps) where people are settling in search of better work opportunities.

Sewage disposal in under-developed areas is generally by means of the bucket system. The night-soil arising from the buckets is conventionally disposed of in lagoons which have to be situated some distance from the community. This practice is generally accompanied by bad odours and fly breeding.

Forced aeration composting of night-soil with unpulverised refuse as bulking agent could be a suitable cost-effective process for the integrated stabilisation, disinfection and resource recovery of these two waste streams.

The aim of this two-year project being undertaken by the City Council of Grahamstown is to produce an alternative and more affordable system of sewage and domestic waste disposal, with the benefit of an end-product which is either usable in the parks or gardens of the township or saleable to the community.

LIST OF RESEARCH PROJECTS

Completed projects

- Electrochemically-produced metal coagulants for the treatment of polluted water (The University of Pretoria - Department of Chemical Engineering)
- Phosphate removal by means of electrochemically-formed iron ions (The University of Pretoria - Department of Chemical Engineering)
- Removal of orthophosphate from water by the direct use of scrap iron (Process Chlorination (Pty) Ltd)
- Performance evaluation of forced aeration composting of sewage sludge (The Municipality of Stellenbosch and the CSIR - Division of Water Technology)
- Evaluation of the active sewage pasteurisation (ASP) process for sewage sludge treatment (The CSIR - Division of Water Technology)

Current projects

- Chemical augmentation of biological phosphate removal (The City Council of Johannesburg)
- Phosphate fixation in waste waters by means of controlled struvite formation (The CSIR - Division of Water Technology)
- The development and evaluation of specific control methods for ameliorating low F/M bulking (The University of Cape Town - Department of Civil Engineering)
- Phosphate crystallisation in activated sludge systems (The CSIR - Division of Water Technology)
- Consolidation of activated sludge and water chemistry research (The University of Cape Town - Department of Civil Engineering)
- The evaluation and optimisation of the process of dual digestion of sewage sludge (The Town Council of Milnerton and the CSIR - Division of Water Technology)
- The preparation of engineering design guidelines for artificial wetlands for waste-water treatment (The CSIR - Division of Water Technology, and Sviridov, De Waal and Associates Inc.)

New projects

- Biological phosphate removal mechanisms in the activated sludge process (The University of Pretoria - Department of Microbiology and Plant Pathology)
- Full-scale study of chemical sludge bulking control (The University of Pretoria - Department of Chemical Engineering)
- Aspects of sewage sludge treatment and disposal (The City Council of Johannesburg)
- Forced aeration composting of sewage sludge for rural communities (The City Council of Grahamstown)

INDUSTRIAL EFFLUENTS

Considering the strict measures taken by the European community against environmental pollution by industry, South Africa is faced by a serious challenge in this regard, particularly in view of the country's limited water sources. As a result of the increase in population, the free-market system and the increasing pressure on industry to promote beneficiation and to export products, considerably more attention will have to be given to the treatment of effluents, which is usually low on the list of priorities, and receives too little money.

During the past 10 years the WRC spent on average more than 17% of its research funds on research on industrial effluents. This research has led to the publication of a large number of reports, publications and guides aimed at giving guidance to government and industry regarding water conservation measures, the reuse of water, and methods for the purification of effluents and the reclamation of raw materials.

In spite of partnership research, the release of publications, and the presentation of technology transfer seminars and demonstrations, relatively few of the practicable technologies have as yet been put into practice by industry. It is important that decision-makers in industry should be convinced that research results developed with their co-operation, will be of long-term benefit to them and could in many instances lead to considerable savings.

Strategies to promote technology transfer have to be developed even more intensively by the WRC

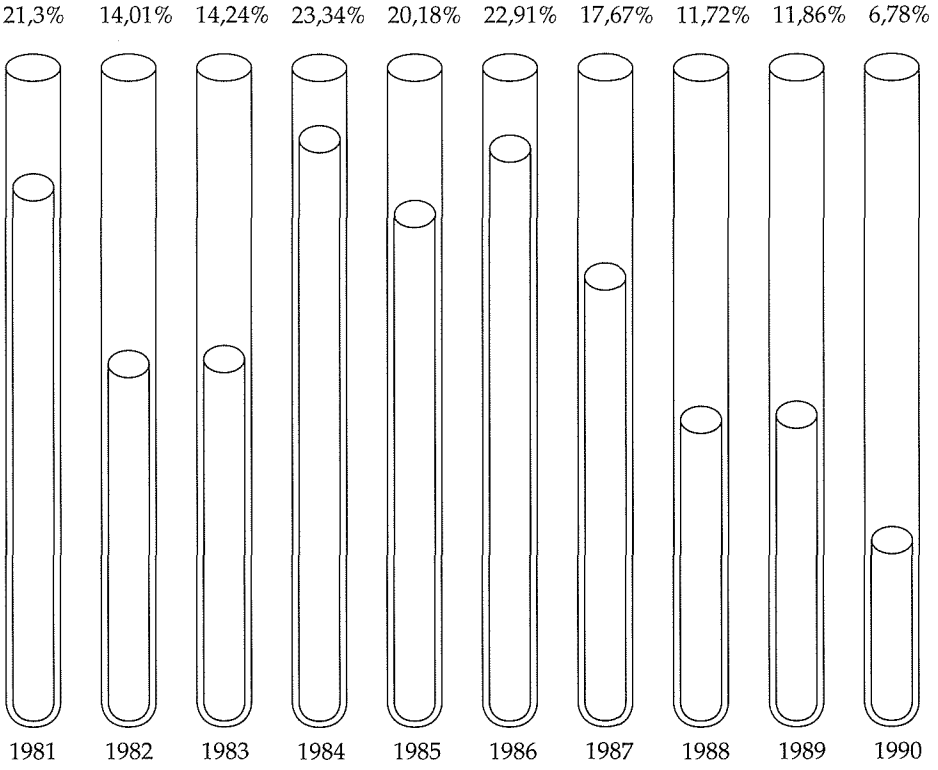
In the light of the foregoing it is clear that strategies to promote technology transfer have to be developed even more intensively by the WRC. Initiatives in this regard are already being taken.

INDUSTRIAL WATER AND EFFLUENTS

REPORT ON COMPLETED PROJECTS

Solids-liquid separation in biological systems

This project was carried out over a period of 2 years by the Department of Chemical Engineering of the University of Cape Town. The project was aimed at removing suspended matter from the outflow of biological reactors by making use of a relatively inexpensive membrane technique, viz. cross-flow microfiltration, and returning the concentrated biomass to the



FUNDING OF RESEARCH ON INDUSTRIAL EFFLUENTS EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990

reactor at the same time. In practice this therefore implies a smaller reactor than the conventional one, delivering an improved effluent.

The results were very promising. Biosludge concentrations in the aerobic and anaerobic reactors were increased to approximately 6 000 mg/*l* and 9 000 mg/*l* respectively, while suspended matter levels were achieved which were consistently lower than 50 mg/*l* with up to 98% reduction in the chemical oxygen demand (COD). A preliminary patent has been registered on a unique variation of the process.

Chemical removal of sulphates

This investigation, conducted by the Pollution Research Group of the University of Natal, showed that the addition of barium carbonate and lime to sulphate-containing mine effluents effectively removes all dissolved solids except for Group I and VIII ions. The sulphates in the effluents are captured in the form of a concentrated hydrogen sulphide stream which is amenable to further processing into valuable sulphur products while the barium salts may be effectively recycled, requiring minimal make-up. The barium salts are reduced to water-soluble barium salts with coal in a kiln and the liberated carbon dioxide is used to carbonate the barium sulphide solution to barium carbonate which is recycled. The raw materials required, namely barites and coal, exist in abundance in South Africa while the products, sulphur and water, are in demand. This process does not have a solids or brine disposal problem.

The removal of colloidal matter from gas stripliquor by coagulation and flocculation

During this investigation, conducted by the Department of Chemical Engineering of the University of Pretoria, it was found that the particles in the gas strip liquor of Sasol fall mainly within the colloidal size range and that removal of these without flocculation would be difficult. The negative zeta potential of the colloids indicates that cationic coagulants would be required. At a low flocculant dose the zeta potential of the colloids is reduced to a value smaller than the critical value of 10 mV. Flocculation and precipitation cannot be relied upon solely to accomplish sufficient colloid removal. The velocity gradient has to be kept low, since mixing at high speed could lead to the breaking up of the flocs. Recirculating the flocs is necessary since the flocs serve as nuclei for further flocculation, thereby lowering the flocculant dose needed. It is essential to filter the flocculated water and this leads to considerable savings in the flocculant dose. The addition of bentonite also leads to a lowering of the flocculant dose, without having any significant effect on costs.

Water management and effluent treatment in the textile industry: Scouring and bleaching effluents

The Pollution Research Group of the University of Natal was contracted to investigate various options which would enable the recycling and reuse of water, chemicals and/or heat energy from textile scouring and bleaching effluents.

Strong caustic effluents produced during the scouring of cotton blends were identified as the most problematic of the effluents examined in terms of the pollutant type and loading.

The most effective solution to the problem of strong caustic scouring effluents was found to be a four-stage treatment process, namely neutralisation by an acidic gas; cross-flow microfiltration to remove suspended, colloidal and waxy contaminants from the neutralised effluents; nanofiltration to separate and recover the neutral sodium (or potassium) salt from the soluble organic and divalent metal contaminants; and electrochemical treatment in a membrane cell to split the sodium or potassium salt to form hydroxide, an acidic gas and a depleted salt stream.

This treatment process was tested on a laboratory scale and pilot-plant trials were conducted at three textile factories. The WRC has been granted a patent for the process in the Republic and overseas.

DISCUSSION OF NEW PROJECTS

The optimisation of biofouling control programmes

Microbial growth in water cooling systems leads to the fouling of pipelines, causes and accelerates the biocorrosion of metals, and reduces heat transfer. Industries annually spend millions of rands, especially on the use of biocides, to overcome these problems. The principal aim of this three-year project is to develop techniques to control bio-fouling and to promote the reuse of water for cooling purposes. Techniques will be developed to identify sulphate-reducing bacteria *in situ* and to determine their role in microbially induced corrosion. An attempt will also be made to determine whether bacteria can build up resistance to biocides. The research is being carried out by the University of Pretoria, in collaboration with Anglo American Research Laboratories, the results being intended for eventual release to all industries.

The removal of suspended solids from pulp and paper effluents by employing a combined sedimentation, flotation and sand filtration process

Over the past couple of years the Division of Water Technology (DWT) of the CSIR developed a process and built a pilot plant in which co-current inclined-plate sedimentation, dissolved air flotation and sand filtration were combined in one compact system (SEDIDAFF) for the treatment of water and effluents.

This project which is being carried out by the DWT over a period of 2 years, is aimed at testing the efficacy of the system for the removal of suspended solids from the effluent of a typical fine paper mill and a typical cardboard mill. Design parameters for this type of industrial application will also be established.

Phase diagrams of complex precipitants

The aim of this three-year project which is being carried out by the Pollution Research Group of the University of Natal, is to develop a technique to prepare phase diagrams of different types of complex precipitants. Such phase diagrams will enable the operating staff of plants where scaling problems are experienced to select or adjust operational parameters in such a way as to prevent or minimise scaling in desalination or other plants. As part of this project a computer program for solubility data will also be drawn up for use in the barium carbonate process for the removal of sulphates.

The recovery of water and chemicals from ion exchange resin regeneration effluents

Ion exchange is commonly used for the partial softening and desalination of water. The resins are regenerated by means of chemicals, resulting in large salt quantities eventually landing in the water environment.

In order to reclaim these chemicals from the regeneration effluents, a three-year research project is being carried out by the Pollution Research Group of the University of Natal, in close collaboration with Eskom. Various chemical and membrane separation techniques will be evaluated. Two of these were previously developed on other effluents and patented in the name of the WRC.

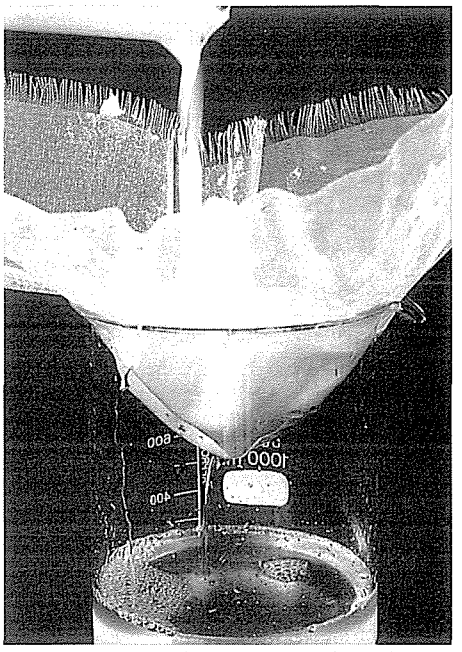
Improved oxygen transfer for high biosludge concentrations

A technique was developed by the Water Utilisation Division of the University of Pretoria to utilise fungi-enriched biosludge for protein supply and for the purification of certain pollutants in industrial effluents which are not easily degradable. However, because the flow characteristics of the biosludge are changed by the filamentous fungi, conventional activated sludge reactors do not provide sufficient oxygen transfer and internal mixing.

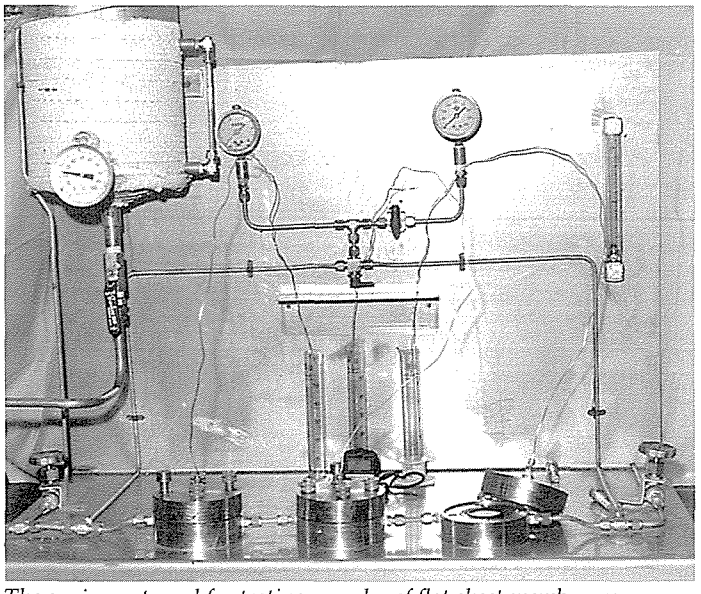
The purpose of this two-year project is to improve the oxygen transfer and mixing in high-concentration and filamentous biosludges by establishing optimum design parameters for an appropriate activated sludge reactor.

The utilisation of the fungus *Geotrichum* in waste water

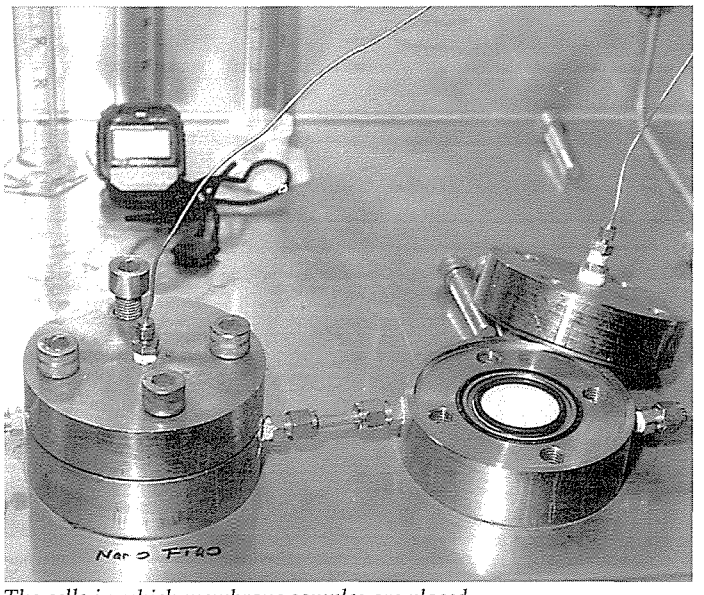
Approximately 120 000 t of protein costing R150 million is imported annually. This project, which is being carried out by the Water Utilisation Division of the



Harvesting of the fungus Geotrichum *by means of a simple sifting process.*



The equipment used for testing samples of flat sheet membranes, employed for water and chemical recovery from ion exchange resin regeneration effluents.



The cells in which membrane samples are placed.

University of Pretoria over a period of 3 years, is aimed at using a filamentous fungus *Geotrichum candidum* in a unique process for the recovery of protein and other fine chemicals from petrochemical, paper and sugar effluents. The fungus is harvested by means of a simple sifting process.

The optimum growth conditions of the fungus in each type of effluent will be determined and the production and value of the proteins, oils, vitamins and enzymes obtainable from the fungi, as well as the degree to which the effluents can be purified, will be evaluated.

Improvement in water usage control and waste-water treatment in the sorghum beer industry

The sorghum beer industry in the RSA daily consumes approximately 10 000 m^3 of water. The specific water consumption per unit of beer is considerably higher than that of the malt beer industry. Sixty per cent of the water intake ends up as an acid effluent with high loads of suspended, colloidal and dissolved organic matter. Most of the effluent is discharged to the municipal sewerage system after little, if any, pretreatment.

Consequently there is a need for an in-depth look at the water consumption pattern of the industry with a view to water conservation and *in situ* effluent treatment techniques. Improved sifting processes, chemical treatment, and aerobic and anaerobic digestion with possible protein recovery, are some of the techniques to be investigated. This project is being carried out by the University of Pretoria over a period of 2 years.

WATER ECONOMY AT POWER STATIONS

The combustion of fossil fuels to generate electrical power invariably involves the liberation of large quantities of waste heat. The waste heat may be dissipated to the environment either by conventional evaporation techniques, which, although proven efficient, are water-wasting, or through dry-cooling systems which are comparatively less efficient, but extremely conservative regarding water consumption.

To exploit coal deposits in relatively arid areas Eskom is introducing dry cooling at three of its latest power stations, viz., at Matimba near Ellisras, at Kendal near Witbank and at the Majuba plant near Volksrust. As the nominal power

Dry cooloing in the RSA will be effected on an unprecedented scale

output of each of these power stations will exceed 3 600 MW, dry cooling in the RSA will be effected on an unprecedented scale.

To broaden the necessary information base, the Commission, in collaboration with Eskom, supports research on the optimisation of dry and dry-wet cooling applicable to local conditions. Since 1979 research has been sponsored on the following:

- The effect of dry-cooling systems on the temperature of the surrounding environment.
- The effect of atmospheric conditions on the performance of dry-cooling systems.
- The potential of hot exit plume recirculation in dry-cooling stacks.
- The development of computer modelling techniques for the analytical evaluation of dry and dry-wet cooling systems.

REPORT ON A COMPLETED PROJECT

Studies of hot air recirculation in draught air cooling systems at power stations

These water tunnel model studies, conducted by the CSIR, complement an earlier project entitled Model Studies on the Minimisation of Hot Air Recirculation at Dry and Dry-wet Cooling Systems. The present one-year project was designed to gain a more detailed insight into:

- the reduction of hot eject-air recirculation as effected by moving the cooling system away from the boiler house; and
- the potential benefit that could be achieved by reducing the height above ground level of the cooling system's fan intake.

In the studies the heat exchangers were sited on the lee-side of the boiler houses as this configuration is most conducive to recirculation of the hot exit plume. It is concluded that recirculation can be very effectively reduced by separating the heat exchanger from the boiler house. On the other hand, if the heat exchanger is sited to windward of the boiler house no plume recirculation occurs at all.

The effect of the heat exchanger height on plume recirculation was investigated with the cooling stack abutting the boiler house. The research indicates that recirculation rapidly diminishes if the fan inlet height above ground level is increased from 16 m to 21 m, whereafter any further increase in height has but marginal additional benefit.

Recirculation tests conducted using two-dimensional models of heat exchangers differing in height show that no recirculation of the plume occurs under simulated calm conditions.

LIST OF RESEARCH PROJECTS

Completed projects

- Solids-liquid separation in biological systems (The University of Cape Town - Department of Chemical Engineering)
- Studies of hot air recirculation in draught air cooling systems (The CSIR - Aeronautical Systems Technology)
- Chemical removal of sulphates (The University of Natal - Department of Chemical Engineering)
- The removal of colloidal matter from gas stripliquor by coagulation and flocculation (The University of Pretoria - Department of Water Utilisation Engineering)

- Water management and effluent treatment in the textile industry: Scouring and bleaching effluents (The University of Natal - Pollution Research Group)

Current projects

- A national industrial water and waste-water survey (NATSURV) (The Department of Water Affairs and Forestry, and a firm of consulting engineers: Steffen, Robertson and Kirsten Inc.)
- The treatment of wool scouring effluents (The University of Natal - Department of Chemical Engineering; a firm of consulting engineers: Steffen, Robertson and Kirsten Inc.; and Gubb and Inggs (Pty) Ltd)
- The transfer of waste-water management technology to the meat processing industry (A firm of consulting engineers: Steffen, Robertson and Kirsten Inc. and the South African Abattoir Corporation)
- The dewatering of compressible filter cakes (The University of Natal - Department of Chemical Engineering)
- Pelletisation in upflow anaerobic sludge bed (UASB) systems (The University of Cape Town - Department of Civil Engineering)
- The effect of biocorrosion in water systems (The CSIR - Division of Water Technology)
- The biological treatment of industrial water with the simultaneous production of single cell protein (The University of Pretoria - Department of Chemical Engineering)
- Biological techniques for the treatment of pulp bleaching effluent (Sappi Management Services)
- Abattoir solid waste: Development and implementation of a treatment system (The South African Abattoir Corporation)
- Thermal feedback caused by dry cooling at power generating stations (Eskom and the CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))
- The interaction between the atmospheric boundary layer and the natural draught cooling towers at Kendal power station (Eskom and the CSIR - Division of Earth, Marine and Atmospheric Science and Technology (EMATEK))
- Evaluation of various factors affecting dry-wet cooling (Eskom and the University of Stellenbosch - Bureau of Mechanical Engineering)

New projects

- The recovery of water and chemicals from ion exchange resin regeneration effluents (The University of Natal - Department of Chemical Engineering)
- Phase diagrams of complex precipitants (The University of Natal - Department of Chemical Engineering)
- The optimisation of biofouling control programmes (The University of Pretoria - Department of Microbiology)
- The removal of suspended solids from pulp and paper effluents by employing a combined sedimentation, flotation and sand filtration process (The CSIR - Division of Water Technology)
- Improvement in water usage control and waste-water treatment in the sorghum beer industry (The University of Pretoria - Department of Chemical Engineering)
- Improved oxygen transfer for high biosludge concentrations (The University of Pretoria - Department of Chemical Engineering)
- The utilisation of the fungus *Geotrichum* in waste water (The University of Pretoria - Department of Chemical Engineering)

DRINKING WATER

Notwithstanding the modern technology developed to treat surface water for drinking purposes, and waste water as well, water can still play a role in the incidence of disease. The exact extent of the health implications and the socio-economic impact of water-borne disease can, however, not easily be determined. Because the user is entitled to a drinking water which complies with certain quality criteria and which does not pose a health risk, continued research on various aspects of drinking water is necessary.

The broad aim of research on drinking water is to gather information on all aspects of drinking-water quality

The broad aim of WRC-supported research on drinking water is to gather information on all aspects of drinking-water quality and to support the development of the technology necessary for water treatment, in order that water which does not pose a health risk and which complies with quality criteria may be supplied to the user at a reasonable price.

The main research areas are:

- developing the necessary water treatment technology;
- drinking-water quality, health aspects, quality criteria; and
- aspects in relation to urban and rural water supply.

WATER TREATMENT AND RECLAMATION

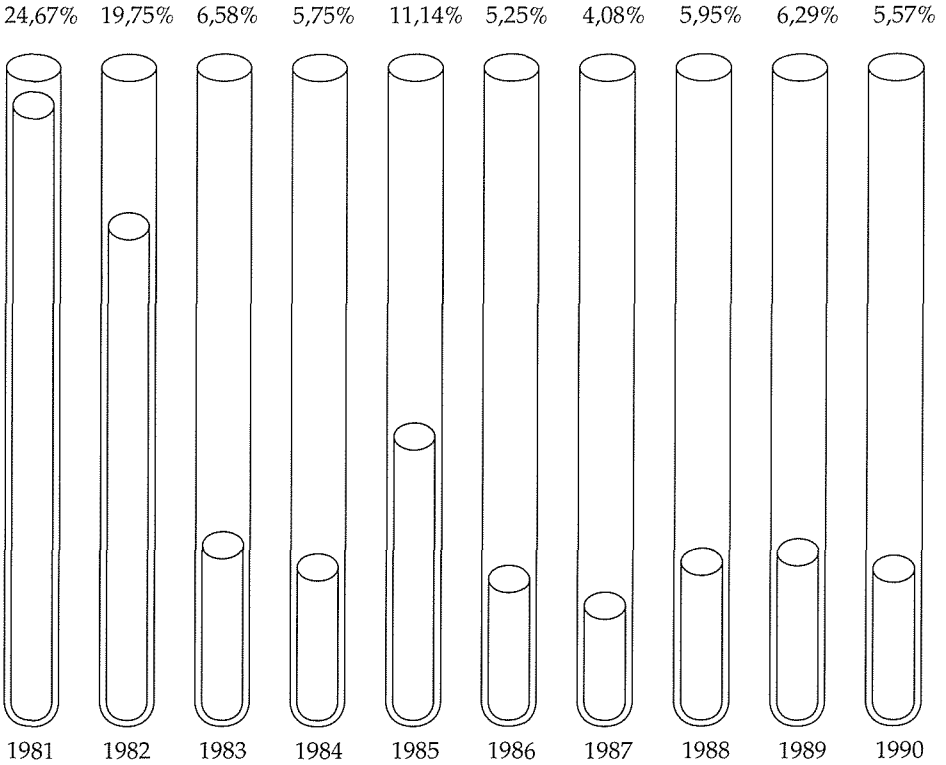
During the year the WRC supported 9 projects in this category of which 1 was completed and 2 commenced. The emphasis fell largely on the treatment of eutrophic (enriched with plant nutrients) water and 8 of the projects addressed this aspect. Techniques such as dissolved air flotation to remove the algae, and alternative disinfectants, received particular attention.

REPORT ON A COMPLETED PROJECT

The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality

This project was aimed at establishing whether a local authority, making use of its own personnel, could operate a water reclamation plant and prepare potable water from treated sewage. The results of the research indicated that this is indeed possible as water which complied with drinking-water quality criteria was in fact produced during the operation of the plant. However, the cost of the reclaimed water (based on 1986 figures) was four times higher than that of the available water sources in the Cape environs. The single largest cost factor was the use of the activated carbon which amounted to almost 33% of the total cost of 88c/m^3. It was further also emphasised that it is important for the sewage treatment process and its operation to be optimised.

FUNDING OF RESEARCH ON DRINKING WATER EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



DISCUSSION OF NEW PROJECTS

The effect of water quality on the effectiveness of chlorine dioxide in drinking-water treatment

In this study, to be conducted by the Rand Water Board over a period of 18 months, the efficacy of chlorine dioxide and chlorine as pre-oxidants and algicides will be compared for the production of high quality drinking water from eutrophic water sources. As it has been found during preliminary studies that unknown factors influence the efficacy of the oxidants, an attempt will be made to determine the nature and range of these factors. The investigation will furthermore attempt to establish whether there is a difference in the resistance of different Vaal Barrage algal species in respect of the efficacy of chlorine dioxide and chlorine.

The development of guidelines for the design and application of dissolved air flotation/filtration processes

The purpose of this project is to compile an appropriate guide for the various applications of the process. Due to the relative novelty and unfamiliarity of the process, design data are not freely available. Engineers of the consulting firms BS Bergman Inc. and Geustyn, Forsyth and Joubert Inc. are carrying out the project over 1 year.

Data regarding the design and operation of a variety of flotation plants will be processed into guidelines for the more optimal design and operation of new plants. In addition to this, the history of flotation in South Africa, as well as theoretical aspects of the flotation process, will be dealt with in the guide.

DRINKING-WATER QUALITY AND HEALTH ASPECTS

During the year the activities of the Co-ordinating Committee for Water Quality and Health Aspects were continued. During a strategy session lasting two days, considerable progress was made in determining the research needs in this field of research. The primary, secondary and tertiary aims were identified and prioritised and are to be included in a master research programme, together with further aims.

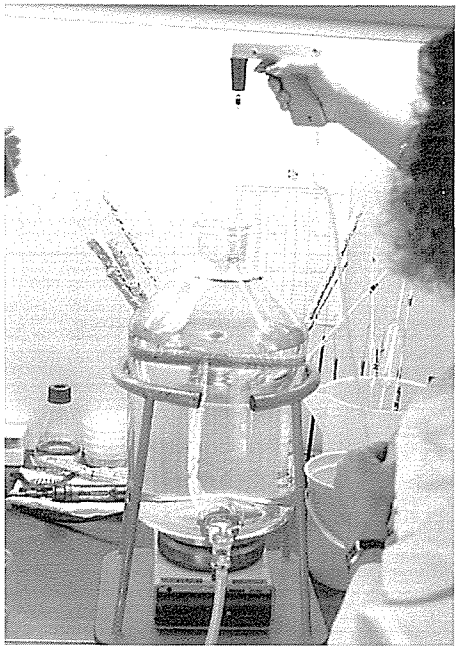
The WRC supported 8 projects during the year of which 2 were completed and 3 commenced.

DISCUSSION OF COMPLETED PROJECTS

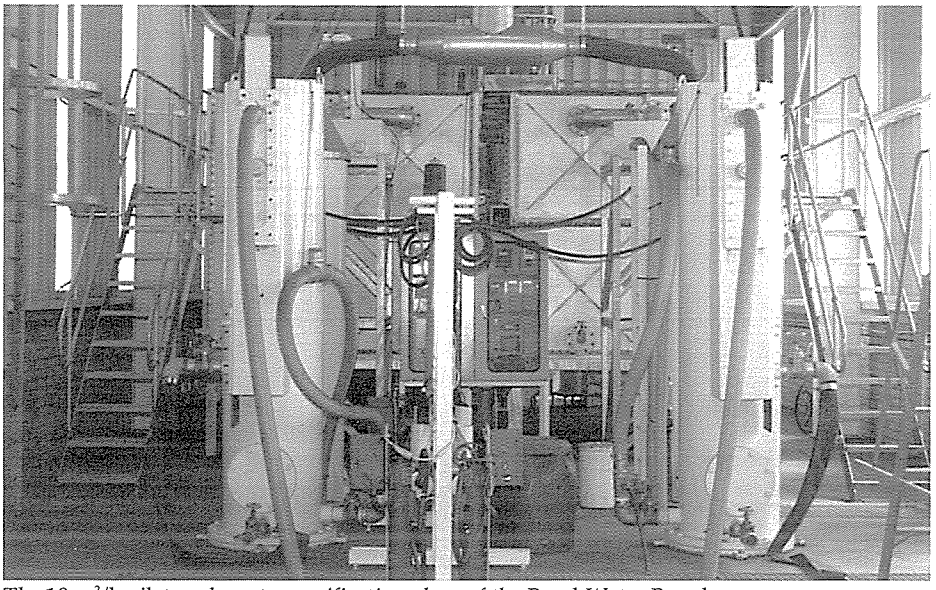
Epidemiological surveillance of potential changes in drinking-water quality in South Africa

The objective of this project conducted by the University of Cape Town was to update and extend the existing data bank of the current disease patterns and mortality rates of the Cape population; and to do comparative studies between e.g. Cape Town and the PWV area. The information in the data bank could be used as a base to study long-term effects of a change in drinking-water quality on the health of the population.

An abstract of every death registered in South Africa from 1967 onwards was obtained on computer tape from the Central Statistical Service. Detailed spatial analyses of mortality rates have been done and a mortality atlas was produced which is available on computer tape. The potential years of life lost, another public



The reactor vessel used for dosing algae and oxidants.



The 10 m^3/h pilot-scale water purification plant of the Rand Water Board.

health measure of mortality, were also calculated on a spatial basis as were life tables of the various population groups.

A national birth defect system has also been established in conjunction with the Department of National Health and Population Development. It establishes the incidence of clinically observable birth defects during the first seven days of life.

A review of data sources for potable water quality as opposed to those for impoundments has been carried out and the reporting format was discussed.

The data base is intended to be used as a tool in answering specific health related problems.

The isolation and identification of mutagens in drinking water

A mutagen is a chemical or physical agent that can induce a permanent, transmissible change in the genetic material of a cell. Mutagens are therefore important compounds as they can initiate irreversible illnesses such as cancer.

Mutagenicity is mainly introduced into drinking water by chlorinating water that contains organic material. A survey has shown the presence of nitroarene as well as non-nitroarene mutagenicity in some of South Africa's drinking waters. Nitroarenes are nitrated polycyclic aromatic hydrocarbons which are the most potent mutagens known.

The identification of the mutagens in water is a complex problem. The mutagens are present in very low concentration, are probably bound to humic material and found together with a large variety of other low-concentration organic compounds.

A new isolation strategy was investigated by the Division of Water Technology (CSIR) in this research project. This involved the isolation of mutagen precursors rather than the mutagens themselves. A number of mutagenicity extraction experiments, each based on the results of the previous one, were done on water from the Rietvlei Dam and on clarified water from the Rietvlei Dam Waterworks.

A mathematical model was designed by which the role of chlorination and cation exchange (used in the adsorption of mutagens) could be calculated.

DISCUSSION OF NEW PROJECTS

Taste and odour forming micro-organisms occurring in South African surface waters

The odour and the taste of drinking water are the most important parameters used by water users to judge the quality of water. Odour and taste problems in water are caused principally by micro-organisms such as algae and bacteria, but can also arise due to contamination with chemical compounds.

In South Africa, most of the complaints concerning odours and tastes are connected with eutrophic (enriched) surface water which results in algal growth.

The overall aim of this three-year project is to identify those micro-organisms in eutrophic water which give rise to odours and tastes. The specific compounds formed by the micro-organisms and connected with the odour and taste problems, will also be investigated, as well as whether the identified micro-organisms and compounds have toxic properties. Finally, the best technology for removing these micro-organisms and their metabolytes during the water treatment process will also be investigated.

This research is being carried out by the Division of Water Technology of the CSIR.

Bacteriophages as water quality indicators

Bacteriophages are viruses which use bacteria as their hosts.

This three-year research project will be carried out by the Department of Medical Virology of the University of Pretoria.

The overall aim of the intended research project is to evaluate the use of bacteriophages as indicators of the sanitary quality of water. To attain this goal, practical methods need to be developed to determine specific bacteriophages which cannot be observed by means of conventional methods. Thereafter the survival of the different bacteriophages and bacterial indicators in runoff will be compared. The final indication of the indicator value of the different phages will be obtained from an investigation of their survival in selected processes for the treatment of sewage and the preparation of drinking water. An attempt will be made at developing a methodology for application during the routine analysis of water quality.

The liquid consumption patterns among the black population of Cape Town

The WRC has previously funded a research project executed by the Department of Community Health at the University of Cape Town on epidemiological studies pertaining to the possible reclamation and reuse of purified sewage effluent in the Cape Peninsula. As part of this research a report entitled *A Liquid Consumption Survey of Individuals in Greater Cape Town* was produced in 1987, covering the white and coloured sectors of the population. Information on the water consumption patterns was necessary as part of the epidemiological studies. The new research project will produce a similar report dealing with the black population. With rapidly increasing urbanisation and migration to the cities this sector of the population is becoming more important.

The Medical Research Council (MRC) will collaborate in this research which will be executed over 1 year. A computer tape containing identifying demographic data and the full diet history of each individual sampled will be one of the products emanating from the MRC survey and will be utilised as input to this study. The study will examine the type of water supply, the sources of water, whether consumed at home or away, according to the age and sex of the population.

URBAN AND RURAL WATER SUPPLY

Droughts and water restrictions are two phenomena which go hand in hand and if demands on the water resources increase more rapidly than new resources are developed, restrictions can be expected to become more frequent and more severe. The need therefore to reduce losses from water distribution networks will become even more essential in future.

The wasteful use of potable water will have to be aggressively discouraged. Towards this end, the Commission continued to serve on the Acceptance Commit-

tee of the Joint Acceptance Scheme for Water Installation Components (JASWIC), which is a voluntary municipal body which has as its main task the listing of pipes and fittings suitable for use on a plumbing system. The products appearing on its lists are all subjected to testing by the SABS to ensure adequate quality and performance.

REPORT ON COMPLETED PROJECTS

Development and testing of data-logging equipment for the monitoring of water consumption patterns

The Division of Building Technology (CSIR) contracted the development of a locally produced data logger in conjunction with the Pretoria City Council.

The main objectives of the project were to develop a low-cost, event-driven data logger capable of recording the times at which events occur and the associated values; to evaluate the performance of the data logger for monitoring water consumption patterns; and to develop applications in which the data logger may be usefully deployed to gain information on the performance and the operation of water distribution systems.

After being supplied with a prototype logger for testing, the Pretoria City Council has subsequently purchased ten production data loggers for operation on its water distribution system. The software supplied with the logger proved to be inadequate and custom written software has been acquired elsewhere for the editing and interpretation of the raw data.

After two years of operation the data loggers have proven to be reliable, accurate and relatively simple to use at an affordable price, but with limited application. Future developments should include quantity logging, as opposed to flow-rate logging, and the ability to log the second channel (pressure) independently, i.e. without first being activated by a flow event.

Water loss analysis on municipal water distribution systems

This project involving the company, Castle Brass Holdings (Pty) Ltd of Krugersdorp and the Johannesburg City Council, not only quantified the volume of water leaking unobserved from the system but also analysed the losses by comparing various parameters such as peak flow rate with the minimum night flow rate. From such comparisons an idea can be formed as to the general condition of the system. During the term of the project, specific losses in $m^3/h.km$ were determined to be approximately 4 times higher than the norm accepted by the American Waterworks Association, indicating an urgent need for a well-organised loss prevention programme.

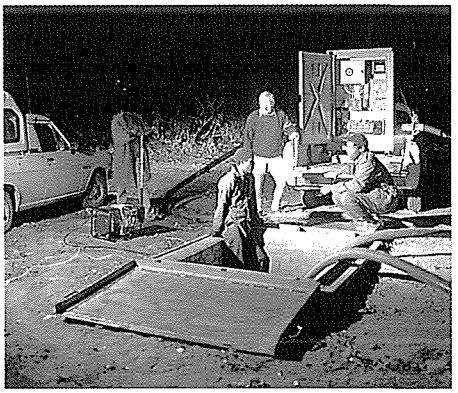
In addition the project tested and evaluated methods and techniques for conducting a water loss control programme and the success of the project has paved the way for other local authorities to follow suit. All four of South Africa's major local authorities have leak detection programmes in one form or another.

Sophisticated equipment for the detection of underground leakage has been introduced to South Africa and 5 commercial concerns have come into existence as a direct result of the work done under the auspices of the WRC

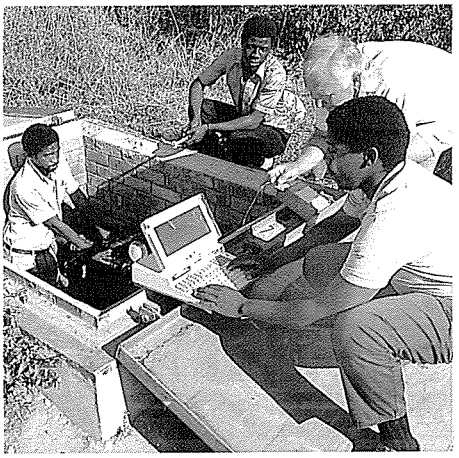
Sophisticated equipment for the detection of underground leakage has been introduced to South Africa and five commercial concerns have come into existence as a direct result of the work done under the auspices of the WRC.

The project ran over a period of three and a half years.

Logging bulk flow into a reservoir zone.



Determining the minimum night flow.



Downloading recorded flow data.

DISCUSSION OF A NEW PROJECT

The effect of water quality and chemical composition on corrosivity in mild steel pipelines

Corrosion of pipelines is a major cost component of municipal and industrial assets. In terms of a new agreement with the Rand Water Board, methods to measure corrosion rates in municipal water distribution systems are to be researched.

Existing corrosion indices which are normally used to indicate the chemical stability of water will be correlated against measured data, while the characteristics required to limit corrosion to a minimum will be identified. The project aims to develop treatment practices which will inhibit corrosion tendencies without causing scaling or other harmful effects, especially at the furthest extremities of a distribution system. The project will run for 2 years.

LIST OF RESEARCH PROJECTS

Completed projects

- The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality (The Municipality of Cape Town)
- Development and testing of data-logging equipment for the monitoring of water consumption patterns (CSIR - Division of Building Technology)
- Water loss analysis on municipal water distribution systems (Castle Brass Holdings (Pty) Ltd and the Johannesburg City Council)
- Epidemiological surveillance of potential changes in drinking-water quality (The University of Cape Town - Department of Community Health)
- The isolation and identification of mutagens in drinking water (The CSIR - Division of Water Technology)

Current projects

- Technological development of water reclamation on the basis of the Windhoek plant (The Municipality of Windhoek and the CSIR - Division of Water Technology)
- Dissolved air flotation for the treatment of eutrophied surface water for potable use (The CSIR - Division of Water Technology)
- A combined flotation-powdered carbon process for potable water treatment (The CSIR - Division of Water Technology)
- A comparative study on chlorine dioxide and other oxidants in potable treatment (The Western Transvaal Regional Water Company; the CSIR - Division of Water Technology; and Floccotan (Pty) Ltd)
- The evaluation of full-scale flotation-filtration and chlorine dioxide plants (The OFS Gold Fields Water Board)
- The development of a combination of sedimentation, flotation and sand filtration processes for water treatment (SEDIDAFF) (The CSIR - Division of Water Technology)
- The possible chronic health effects of consumption of reclaimed water on the consumers at Windhoek (The South African Institute of Medical Research)
- The assessment of water quality problems due to microbial growth in drinking-water distribution systems (The CSIR - Division of Water Technology)
- Human viruses in water (The University of Pretoria - Department of Medical Virology)
- The effects of reduced water consumption on domestic sewer systems (CSIR - Division of Building Technology)
- The flow rates and patterns of water consumption and unaccounted-for water in urban areas (The University of Pretoria - Department of Civil Engineering and the City Council of Pretoria)
- The preparation of guidelines on cost-effectiveness of rural water supply and sanitation projects (The CSIR - Division of Water Technology)
- The effects of varying water quality on the corrosion of different pipe materials in the PWV/Klerksdorp areas (The CSIR - Division of Materials Science and Technology)

New projects

- The effect of water quality on the effectiveness of chlorine dioxide in drinking-water treatment (The Rand Water Board)
- The development of guidelines for the design and application of dissolved air flotation/filtration processes (BS Bergman and Partners Inc. and Geustyn, Forsyth and Joubert Inc.)
- The liquid consumption patterns among the black population of Cape Town (The University of Cape Town - Department of Community Health)
- Taste and adour forming microorganisms occurring in South African surface waters (The CSIR - Division of Water Technology)
- Bacteriophages as water quality indicators (The University of Pretoria - Department of Medical Virology)
- The effect of water quality and chemical composition on corrosivity in mild steel pipelines (The Rand Water Board)

TREATMENT TECHNOLOGY

Reverse osmosis is increasingly being used in the supply of drinking water

Good quality drinking water can be produced from brackish water or even sea water by applying a variety of processes such as distillation, ion exchange, electrodialysis or reverse osmosis. Of these techniques reverse osmosis, which is a relatively inexpensive pressure-driven process, is increasingly being used in the supply of drinking water.

On the other hand, electrodialysis which is an electrically driven process is used mainly for the treatment and purification of industrial effluents in order to prevent possible pollution of scarce drinking-water sources and the aquatic environment in general.

The WRC supports 17 projects on treatment technology. These include among others the development of membranes for the desalination of drinking water and for the purification of industrial effluents. Funds are made available to the Universities of Stellenbosch and Natal, the Division of Water Technology of the CSIR, the Chamber of Mines Research Organisation and Membratek (Pty) Ltd. The fact that the latter is currently the sole supplier of locally manufactured desalination apparatus and membranes results in a saving in terms of foreign exchange.

WISA-MTD

The South African Membrane Separation Interest Group, which was initiated by the WRC, was recently affiliated to the Water Institute of South Africa (WISA) and admitted as a Technical Division. It will in future be known as the Membrane Technology Division of WISA or WISA-MTD. The Division is currently planning an international conference on "Membrane Technology in the Treatment of Industrial Effluents" to be held in the RSA in 1992.

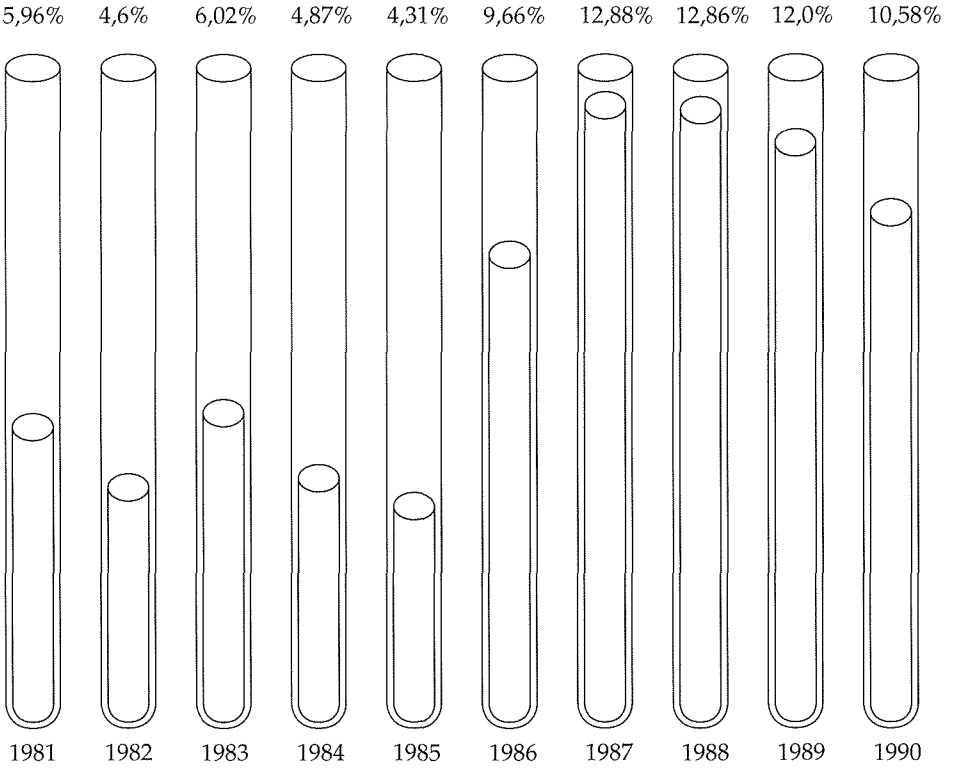
OFFICIAL COMMISSIONING OF THE DESALINATION PLANT AT BITTERFONTEIN

The new South Namaqualand Water Scheme at Bitterfontein was officially inaugurated on 26 October 1990 by Mr GJ Kotzé, the Minister of Water Affairs and Forestry. The ceremony was also attended by members and staff of the WRC.

This scheme is the first of its kind in the RSA, making use of a reverse osmosis desalination plant to convert the local brackish water into drinking water of a good quality. The water is pumped from six boreholes in the Bitterfontein area and the inhabitants of both Bitterfontein and nearby Nuwerus have been provided with desalinated drinking water since April 1990.

The WRC has since 1971 financially supported research on the desalination of water being conducted at the Institute for Polymer Science at the University of Stellenbosch. A membrane manufacturing industry has been established locally in

FUNDING OF RESEARCH ON TREATMENT TECHNOLOGY EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1981 TO 1990



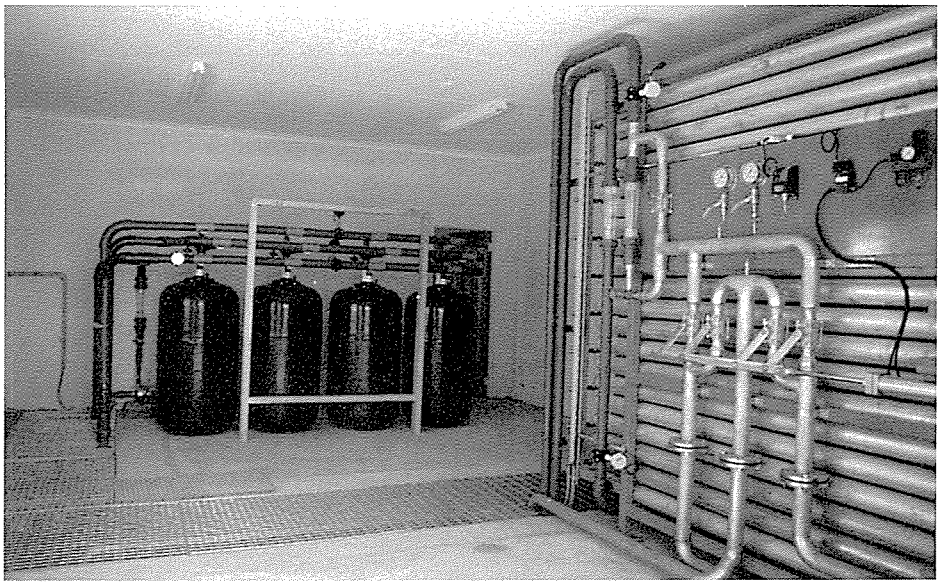
collaboration with Membratek (Pty) Ltd and represents the culmination of years of research and development to operate a fully South African desalination plant on a large scale.

A membrane manufacturing industry has been established locally

DESALINATION

The gold mining industry consumes approximately 4 000 M*l* of water and 200 M*l* Rand Water Board water daily for underground activities mainly for dust suppression, water spraying and underground cooling. The used water which accumulates underground is of poor quality and needs to be treated before it can be recirculated as service water. The Chamber of Mines carries out a number of research projects funded by the WRC, which are aimed at providing a high-quality service water. Electrodialysis is one of the processes used in the case of water having a relatively low calcium sulphate content. On the other hand a slurry precipitation and recycle reverse osmosis process is used to treat water with a high calcium sulphate content.

Eight desalination research projects are currently being financed of which 1 was initiated during the year. Research on the desalination of sea and mining waters is supported.



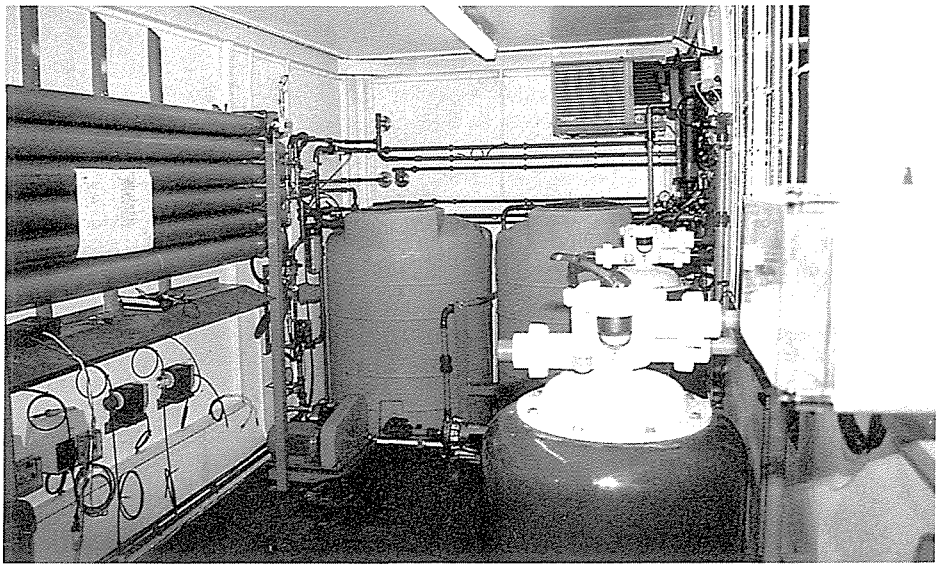
The Bitterfontein tubular reverse osmosis plant for producing potable water.

The mobile pilot-scale sea-water desalination plant of Membratek and De Beers research laboratory.

DISCUSSION OF A NEW PROJECT

Pilot-scale desalination of sea water by means of reverse osmosis

The aim of this research is to gain experience in the design, construction and operation of a sea-water desalination process by means of reverse osmosis, and is to be conducted at Elizabeth Bay, to the south of Lüderitz Bay, Namibia, over a period of approximately 10 months. A pilot-scale desalination plant was recently installed in a mobile container by Membratek (Pty) Ltd and the Diamond



Research Laboratory of the De Beers Company. The plant incorporates a wide range of pretreatment apparatus and is controlled by a computer system. Provision has been made for different types and configurations of membranes. Pretreatment of feed water, the possible improvement of reverse osmosis technology and design criteria for large-scale desalination plants will also be investigated.

MEMBRANE DEVELOPMENT

For the past 12 years the WRC has already been supporting research and development with regard to desalination membranes, being carried out at the Universities of Stellenbosch and Natal, as well as at Membratek (Pty) Ltd. The latter organisation co-operates very closely with the Institute for Polymer Science at the University of Stellenbosch in developing, testing and marketing membrane systems and desalination apparatus for different industries.

REPORT ON A COMPLETED PROJECT

The removal of algae from water by ultrafiltration

This preliminary study, carried out by Membratek (Pty) Ltd, was aimed at investigating the possibility of using ultrafiltration to remove algae from drinking-water supplies, to study the operational parameters and their effect on the membranes, to investigate the criteria for scale-formation and to determine the economic viability of the system. Tubular ultrafiltration removed algal suspensions successfully from various water sources and algal deposits on the membranes could be removed by inexpensive mechanical methods. It was found that the linear flow rate in the membrane tube and the reclaimed volume had a considerable effect on the permeate flow. It was also concluded that the use of ultrafiltration, coupled with UV radiation or ozonation, presented a viable alternative to conventional water treatment methods.

DISCUSSION OF NEW PROJECTS

Modelling of tubular reverse osmosis systems

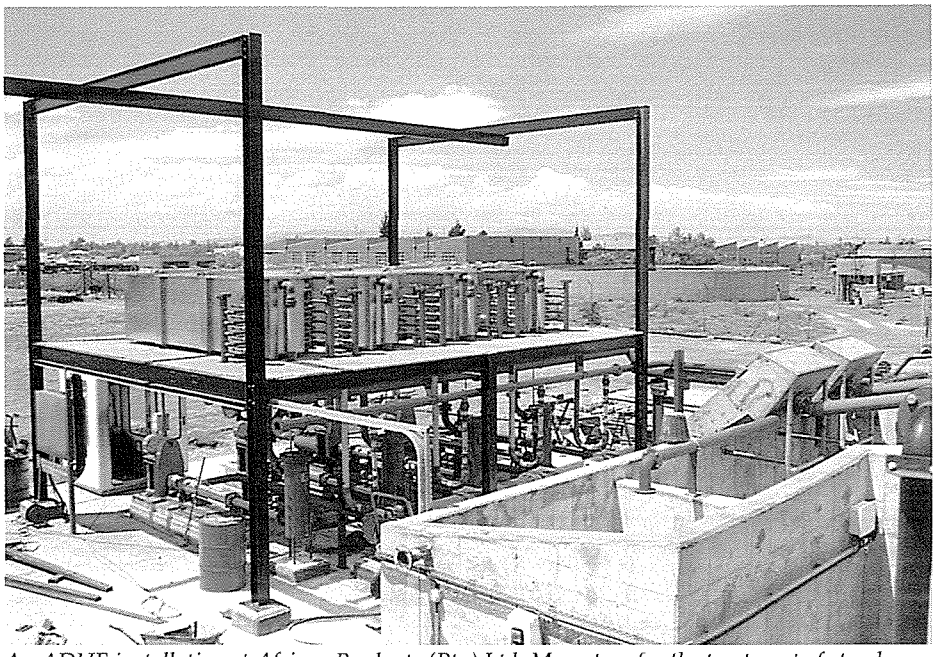
It is expected that in future the use of reverse osmosis to desalinate brackish and sea water and to purify industrial effluents will find increasing applications. From the experience gained at Eskom's Lethabo power station it became evident that there were serious gaps in the knowledge of the design and operation of such a large plant where use is made of a large number of parallel series of reverse osmosis modules. The complex interactions between certain factors such as pipe shape, module configuration, flow rates and pressure distribution cause complications, which lead to operational problems resulting in under-utilisation of the plant. This three-year project which is being carried out by the Department of Chemical Engineering of the University of Natal, aims at developing techniques which may contribute towards a better understanding of the problems associated with large tubular reverse osmosis plants. Attempts will also be made to improve the operation of existing plants and to optimise the design of new plants.

The improvement of present polyether sulphone ultrafiltration membrane technology

The expansion of the molecular mass cut-off points of ultrafiltration membranes will broaden the field of application of these membranes considerably. The purpose of this one-year study is to optimise the cut-off points of the tubular ultrafiltration membranes to such an extent that separation and production properties can thereby be improved. The first phase of the project which is being carried out by Membratek (Pty) Ltd, namely the development of suitable polymer formulations for membrane manufacturing techniques, has been completed by the Institute for Polymer Science in Stellenbosch. A start has already been made with the second phase of the project, namely technology transfer of manufacturing techniques to the production line and the subsequent evaluation of membranes in actual process streams.

The application of the anaerobic digestion/ultrafiltration (ADUF) process to brewery effluents

The brewing industry produces large quantities of effluent having a high specific pollution load (SPL) which could



An ADUF installation at African Products (Pty) Ltd, Meyerton, for the treatment of starch effluent.

in future increase due to industry's endeavours to reduce water intake. A reduction in SPL is essential in order to reduce the load on municipal treatment works and traditionally the aerobic digestion process has been favoured to effect a COD reduction in brewery effluents.

The recent locally developed anaerobic digestion/ultrafiltration (ADUF) process, when trial tested on paper mill, yeast and wine distillery effluents, revealed COD reduction capabilities of up to 98% at processing rates which are approximately ten times higher than those of conventional anaerobic digestion processing. The increased reactor efficiency coupled with a low-cost ultrafiltration system makes the ADUF process a viable proposition for the treatment of brewery effluents.

To promote the application of locally developed technology the current one-year study aims at establishing the economic and technical viability of the ADUF process for treating brewery effluents and to generate design data for process units through appropriate pilot-plant studies. The study will be carried out by Membratek (Pty) Ltd.

Capillary membrane modules after tap-water filtration tests.

LIST OF RESEARCH PROJECTS

Completed project

- The removal of algae from water by ultrafiltration (Bintech (Pty) Ltd)

Current projects

- Membrane development and fabrication for reverse osmosis and ultrafiltration (The University of Stellenbosch - Institute for Polymer Science)
- The feasibility of reverse osmosis for water reclamation on large scale (The Municipality of Port Elizabeth; the CSIR - Division of Water Technology; and Bintech (Pty) Ltd)
- The treatment of inorganic brines and concentrates (The University of Natal - Department of Chemical Engineering)
- The development of fixed and dynamic membrane systems for the treatment of brackish water and effluents (The University of Stellenbosch - Institute for Polymer Science)
- The development of low-cost ultrafiltration modules (Bintech (Pty) Ltd)
- The development of seeded reverse osmosis technology (The Chamber of Mines; Iscor; and Bintech (Pty) Ltd)
- The concentration of industrial effluents with sealed-cell electrodialysis (The CSIR - Division of Water Technology)
- The development of polymers for the formation of dynamic membranes and the evaluation thereof for the treatment of industrial effluents (The University of Natal - Department of Chemical Engineering; the University of Stellenbosch - Institute for Polymer Science; and the CSIR - Division of Water Technology)
- Design criteria for crossflow microfiltration (The University of Natal - Department of Chemical Engineering)
- Technical support for the application of dynamic membrane plants for the treatment of industrial effluents (The University of Natal - Department of Chemical Engineering)
- The evaluation of membrane technology for electroplating effluent treatment (The CSIR - Division of Water Technology)
- The development of low-cost ultrafiltration systems (Bintech (Pty) Ltd)

New projects

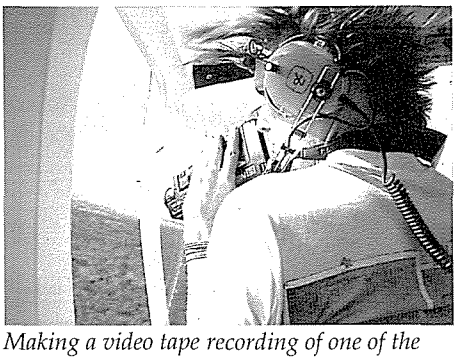
- Pilot-scale desalination of sea water by means of reverse osmosis (Membratek (Pty) Ltd)
- The improvement of present polyether sulphone ultrafiltration membrane technology (Bintech (Pty) Ltd)
- Modelling of tubular reverse osmosis systems (The University of Natal - Department of Chemical Engineering)
- The application of the anaerobic digestion ultrafiltration (ADUF) process to brewery effluents (Bintech (Pty) Ltd)

CONSERVATION OF AQUATIC ECOSYSTEMS

1990 saw the entrance of the WRC into the sphere of aquatic ecosystem research

1990 saw the entrance of the WRC into the sphere of aquatic ecosystem research. In total 5 projects commenced in January 1990, ranging from the freshwater requirements of estuaries through the legal aspects of water for the environment to the assessment of instream flow requirements, both biotic and abiotic, of rivers.

The Kruger National Park Rivers Research Programme, of which Dr Reid of the WRC is programme manager, has attracted wide interest from the related research community. To date all of 20 research projects, 5 of which are WRC funded, are on-going in this programme with funding being forwarded by the WRC, Foundation for Research Development (FRD), Department of Water Affairs and Forestry and the private sector.



Making a video tape recording of one of the rivers in the Kruger National Park for research purposes.

CO-ORDINATING COMMITTEE FOR WATER ECOSYSTEMS RESEARCH (CCWER)

In order to ensure that no unnecessary duplication of research takes place, as well as to co-ordinate research in the environmental aquatic field, the WRC initiated the formation of a Co-ordinating Committee for Water Ecosystems Research (CCWER). The major goal of the CCWER can be stated as follows: Recognising that water ecosystems such as rivers, lakes, wetlands and reservoirs are legitimate users of water, the major goal in water ecosystems research is to develop expertise, knowledge and information which contribute to the rational and sustained use and management of these ecosystems.

Objectives of the CCWER

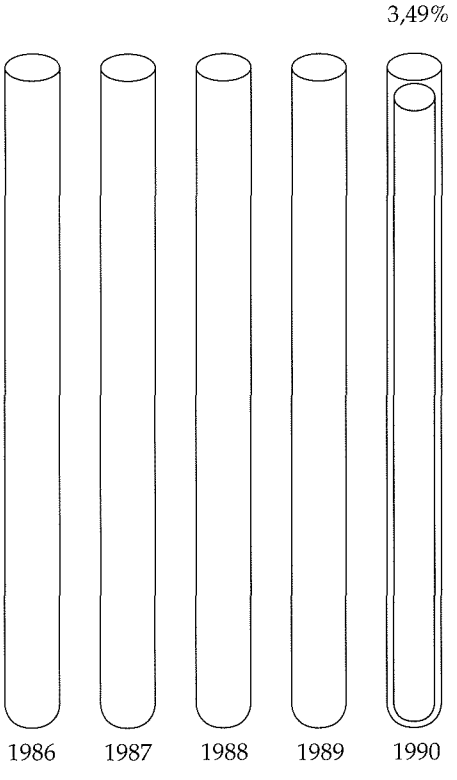
The CCWER will act, at senior management level, as an umbrella co-ordinating body for water ecosystems research. As such this Committee will review all relevant research with the purpose of:

- endeavouring to eliminate unnecessary duplication of research;
- ensuring the optimum utilisation of scarce manpower, facilities and funding;
- recommending to funding agencies and appropriate/relevant institutions that priority research requirements receive the required attention.

Functions of the CCWER

In order to act in an advisory capacity to the research community, as well as to make recommendations regarding priority and initiation of research, the functions of the CCWER can be stated as follows:

FUNDING OF RESEARCH ON CONSERVATION OF AQUATIC ECOSYSTEMS EXPRESSED AS A PERCENTAGE OF TOTAL WRC RESEARCH EXPENDITURE FOR 1990



- identify requirements, gaps and problem areas in water ecosystems research;
- prioritise research and announce this prioritisation to the funding agencies and research community;
- compile, and regularly update, a register of current research projects;
- inform the community at large as regards water ecosystem research;
- adjudicate research projects with inter- and intra-institutional implications; and
- continually seek better methods for closer liaison within a national water ecosystem research co-ordination effort.

The members of the new CCWER are drawn from a wide spectrum of resource managers, research managers and researchers. They face an important and vital task in that the efficient and effective co-ordination and promotion of water ecosystems research will be a critical factor in meeting the acceptable environmental water requirements of our ecosystems in the future.

DISCUSSION OF NEW PROJECTS

The freshwater requirements of estuarine plants

Estuaries have an absolute requirement for freshwater. Their flora and fauna, adapted to a varying freshwater input through rivers and ground water, rely on this input for a large number of key roles, including lowering of salinities, controlling the hydrodynamics, rates of flocculation and sedimentary processes.

Besides some restricted observations and measurements, however, few studies have attempted to understand and quantify the role of freshwater in estuarine ecology.

A three-year research project, undertaken by the Department of Botany, University of Port Elizabeth, will establish a basic understanding of the manner in which freshwater controls the plant ecology of estuaries.

The relationship between low flows and the river fauna in the Letaba River

There are few South African rivers whose flow regime has not been altered by impoundments and abstraction of water. However, very few data are available for estimating the effect of such man-made alterations on the environment.

The Letaba River in the Northern Transvaal is one of the rivers that has been seriously affected by such man-made changes.

A two-year research project undertaken by the Division of Water Technology (CSIR) will study the relationship between flow and fauna in this river and will provide useful guidelines as to the minimum flows required to maintain the natural fauna.

A pre-impoundment study of the Sabie-Sand River system, Eastern Transvaal, with special reference to predicted impacts on the Kruger National Park

The Sabie-Sand River system is probably one of the most pristine river systems in South Africa. It is known, however, that a number of dams are due to be built in this system.

A combined research effort by the Universities of Cape Town and Rhodes will, over a period of three and a half years, establish present chemical, physical and biological characteristics of this river system. Research will then also focus on the assessment of probable ecological impacts, and disturbances and/or advantages resulting from the future regulation schemes.

The assessment of the instream flow requirements of rivers

There exists, at present, no reliable method for the assessment of ecological water requirements in South Africa.

The aim of this research, undertaken by the University of Cape Town over a three-year period, is to establish one or more scientifically acceptable methods for assessing the instream flow requirements of the country's rivers. Local expertise in instream flow incremental methodology will also be created. In a separate approach, historical flow records will be used to establish instream needs. The above two approaches will be compared and recommendations will be made as to how instream flow assessments should be approached.

The water rights of nature conservation

In order to address the protection of nature's water requirements satisfactorily in the existing legislation, an in-depth study on the development of the South African Water Act over the years is required.

The aim of this one-year project - carried out by a lawyer - is to investigate the existing legislation with a view to establishing guidelines for future research, which could possibly lead to practical amendments of the law.

LIST OF RESEARCH PROJECTS

New projects

- The water rights of nature conservation (Legal consultant: M Uys)
- The freshwater requirements of estuarine plants (University of Port Elizabeth - Department of Botany)
- The relationship between low flows and the river fauna of the Letaba River (CSIR - Division of Water Technology)
- A 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 of Freshwater Studies)
- The assessment of the instream flow requirements of rivers (University of Cape Town - Freshwater Research Unit)

GENERAL

SOCIO-ECONOMIC EFFECTS OF WATER RESTRICTIONS

The drought of the previous decade which ended during the 1987/88 season resulted in extensive water restrictions being imposed in large areas of the RSA during the period March 1983 until September 1987. This is one of the most important measures which can be taken by the Department of Water Affairs and Forestry and water boards during periods of restricted water supply. Such circumstances should, however, never result in restrictions having unacceptable socio-economic and financial consequences for any sector of the South African economy.

In spite of the fact that some or other form of water restriction is regularly in force in the RSA the state of affairs during the 1983 to 1987 drought was that little data were available on the socio-economic consequences of the restrictions. This drought therefore presented the ideal opportunity for conducting research in this field, resulting in research agreements being conluded with three organisations in 1985. The effect of the water restrictions on 8 economic sectors was investigated in depth and the relevant reports were submitted to the Commission between 1987 and 1989.

As the restrictions in force in Natal had already been lifted in June 1984 the said research was able to give a complete picture of the consequences for this province. The water restrictions pertaining to the other areas included in the investigation, namely:

- the Vaal River system
- the Riet River State Water Scheme
- the Vaalharts State Water Scheme

were only completely lifted in October 1987, so that with reference to these areas the period March 1985 to September 1987 could not be included in the research. To fill this gap the University of the Orange Free State is currently in the final stages of completing a research project, aimed at determining the total socio-economic and financial implications of water restrictions for the areas mentioned. The following are further objectives:

- To give a qualified and/or descriptive exposition of the total nature and extent of the tangible and non-tangible implications of water restrictions.
- To determine the relationships between the nature and extent of water restrictions for the various sectors.

GEOLOGICAL ASPECTS

A new development is the Commission's involvement in research on certain geological aspects. Through this involvement the Commission contributes to an information base which, for example, may lead to lower dam construction costs.

DISCUSSION OF A NEW PROJECT

The erodibility of different rock formations under varying flow conditions

This project is being carried out over a period of 30 months by die Department of Geology of the University of Pretoria.

The methods which are currently employed to determine pro-actively the extent of erosion damage in different rock formations in unclad spillways and non-spillway sections of dams, do not meet all the requirements. A pilot study indicated that the mechanism of erosion of unconsolidated materials in spillway furrows is relatively well-known. In the case of rock mass, however, where the erodibility is to a great extent determined by seam properties and the removability of boulders, relatively little research has as yet been done in spite of the fact that this is a problem experienced world-wide. Progress has, however, been made towards the understanding of the mechanism of rock erosion and the rock parameters which play a role, but as far as the characterisation of a rock mass in terms of its erodibility and the correlation with flow conditions is concerned, a great deal remains to be done. The project, therefore, addresses the following aims:

- Identifying the geological and hydraulic parameters which influence the erodibility of a rock formation.
- Developing a procedure to characterise a rock mass in terms of erodibility.
- Establishing a correlation between flow speed and expected degree of erosion.

LIST OF RESEARCH PROJECTS

Current project

- Determination of the socio-economic and financial implications of the water restrictions in force from 1983 up to its annulment in 1987 (The University of the Orange Free State - Department of Agricultural Economy)

New project

- The erodibility of different rock formations under varying flow conditions (The University of Pretoria - Department of Geology)

RESEARCH SUPPORT SERVICES

THE SOUTH AFRICAN WATER INFORMATION CENTRE (SAWIC)

The South African Water Information Centre, which provides bibliographic information on water-related topics, is funded by the Water Research Commission and operated by the Division of Information Services of the CSIR.

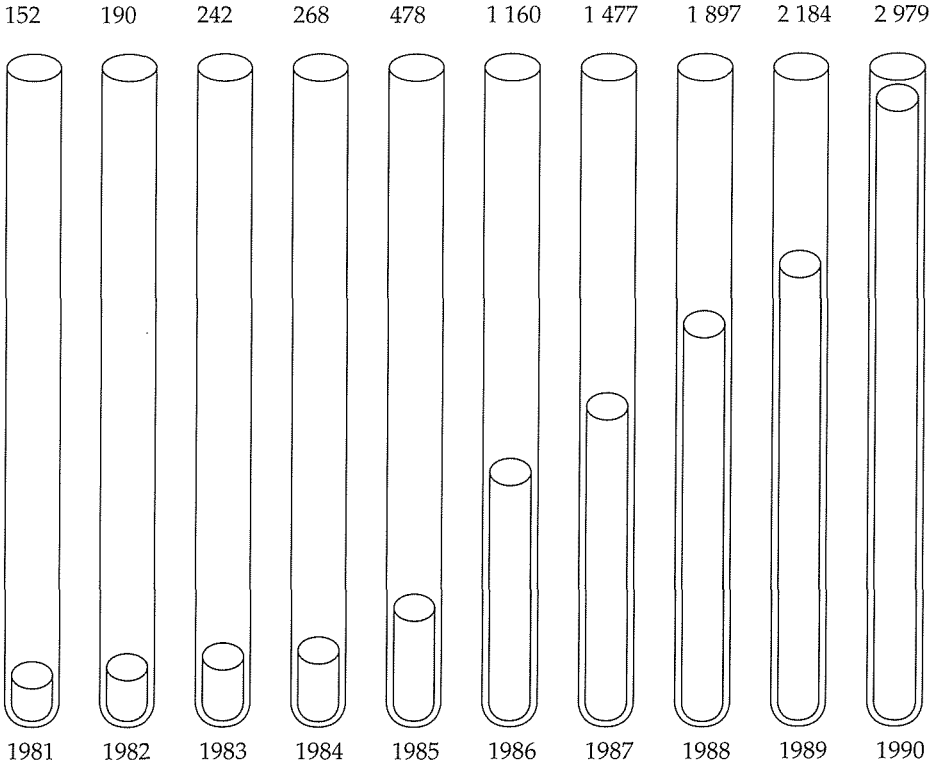
Information is supplied from WATERLIT, a bibliographic data base which is developed and run by SAWIC. The data base currently contains more than 176 000 references from 452 scientific and technical journals as well as from theses, books, conference proceedings and reports. Approximately 11 000 items are added to the data base each year.

Information is supplied on request to a wide spectrum of users for various reasons, prominent amongst which are literature surveys carried out before undertaking new projects and problem-solving. Monthly alerting profiles serve to keep users up to date on the latest developments in their fields. Searches are available through the Division of Information Services at the CSIR in Pretoria, Durban, Port Elizabeth and Stellenbosch, the library of the Division of Water Technology of the CSIR in Pretoria, the library of the Department of Water Affairs and Forestry in Pretoria (for staff of the Department of Water Affairs and Forestry) and the library of the JLB Smith Institute of Ichthyology in Grahamstown. A new more sophisticated computer system will be introduced for WATERLIT by December 1990, and a structure is being developed to enable users to obtain direct access to the system and undertake their own searches.

Due to lack of funding the FISHLIT data base will no longer be maintained by SAWIC. As from 1 April 1990 the monthly alerting service on FISHLIT has been discontinued. The data base will remain on the CSIR mainframe until April 1991 and searches will still be available through SAWIC and the JLB Smith Institute at a cost of R50,00 per search until that date.

After the introduction of selective charges, the number of WATERLIT profiles fell from 239 in June 1989 to a low of 180 in August 1989. Following increased marketing activity the number has increased to 204. The number of searches has decreased by 32% in the past year but it is hoped that the planned marketing strategy will rectify this situation.

In September 1989 a very successful publication, *Selected Bibliography on Wastes* was produced, containing references from WATERLIT, an overseas data base and other relevant sources. Copies of the documents referred to are also available directly from SAWIC.



FUNDING OF RESEARCH SUPPORT SERVICES BY THE WRC FOR 1981 TO 1990, EXPRESSED IN 10^3 RAND

Table 1 contains information on the users of WATERLIT for 1990, and **Table 2** contains information on the most frequently requested topics for 1990.

TABLE 1

Types of organisations making use of the WATERLIT retrospective search service

Category	% of total number 1990
Private sector	21,0
Educational institutions	40,5
Government and semi-state organisations	16,5
CSIR	22,0

TABLE 2

Summary of subject topics used for profiles and retrospective searches (1 July 1989 to 30 June 1990)

	% of total Searches	Profiles
Industrial water		
Waste water and effluents	22,6	20,1
Industrial wastes		
Solid wastes and composting		
Aquaculture		
Mariculture	11,8	10,8
Pollution		
Marine pollution	11,4	5,4
Water treatment		
Desalination	11,1	2,9
Dams		
Water supply		
Water distribution and quality control	9,3	4,9
Hydrology		
Hydraulics engineering	7,5	13,7
Estuaries		
Limnology	7,0	28,4
Aquatic weed control		
Freshwater fish		

COMPUTING CENTRE FOR WATER RESEARCH (CCWR)

The number of registered users on the Computing Centre for Water Research (CCWR) grew from 79 in 1989 to 108 in 1990. These users were drawn from 28 institutions and a total of 51 departments within those organisations. The extent of communication between these users can be gauged by the some 23 000 file transfers and 2 600 information requests which have been serviced on the CCWR system since January 1988.

The CCWR has been widely acknowledged for assisting researchers and consultants. To date 4 doctoral theses, 8 master's theses and 112 papers or reports have acknowledged the CCWR.

The present contracts on financing the CCWR expire at the end of 1991. To focus on the road ahead beyond 1991 a Future Forum in the form of a two-day workshop was organised in August 1990. During this forum it was recommended that the mission, goals and objectives of the CCWR be modified somewhat.

These now read as follows:

■ Mission

The CCWR supports collaboration and disseminates knowledge, data and information among researchers and practitioners through advanced computing and communication technology in order to enhance water resources management.

■ Goals

The CCWR must strive to contribute to the following goals in the long term:

- the co-ordination, promotion and encouragement of water research;
- the provision of incentive and aid to water researchers;
- the improvement of the efficiency of research projects and practice; and
- the dissemination and application of knowledge.

■ Objectives

The CCWR will strive towards its goal by fulfilling the following objectives:

- The provision of a facility for:

- enhanced data and information interchange among data supply organisations, researchers and practitioners;

- the development of appropriate data products and the provision of these to researchers and practitioners; and

- the provision of appropriate applications software for water research purposes.

- The provision of facilities for interdisciplinary and interorganisational research.

In these statements it is reflected that research is not a goal in itself but through a process of technology transfer, in which the practitioner plays a vital role, research must address the needs of society.

HYDROLOGICAL INFORMATION SYSTEMS (HIS)

Although the current agreement between the Department of Water Affairs and Forestry and the WRC was supposed to have ended on 31 December 1990, it has been extended to 31 March 1991, after which date a new agreement will come into force to proceed with the development of HIS.

The development of HIS by the Department of Water Affairs and Forestry is receiving assistance from the WRC on two main aspects:

- system development on the mainframe; and

- capture of historic data collected before 1980.

The development needs of such a complex and comprehensive data bank are extremely difficult to project: hardware and software technologies are dynamic and user requirements are not static.

However, the Infomet methodology, selected by the Department of Water Affairs and Forestry for the development of their corporate data base, is now also implemented on HIS and in many ways HIS serves as the forerunner. This has also resulted in a more realistic estimate of the time needed to complete the HIS project and at the same time a better framework for gauging progress has been established.

During 1990 considerable attention was given to training in LINC and DMS usage and agreed programming standards were implemented leading to more effective teamwork.

Some highlights of the progress made this year are:

- The "old" chemical data bank has been successfully converted into the new Water Quality data bank.

- The integration of the ground-water data base with the PC based HYDROCOMP is nearing completion.

TRANSFER OF INFORMATION AND TECHNOLOGY

The promotion of information and technology transfer is one of the most important objectives of the Commission. 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 Commission has developed a number of activities

For the promotion of its programme of information and technology transfer, the Commission 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 Commission's publications cater for three levels, viz. pure scientific, popular scientific and practical scientific.

WATER SA

Water SA is the Commission'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; and
- 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 1990 and which emanated from research supported wholly or in part by the Commission.

CONFERENCES, SEMINARS, WORKSHOPS AND DEMONSTRATIONS

From time to time the Commission, 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

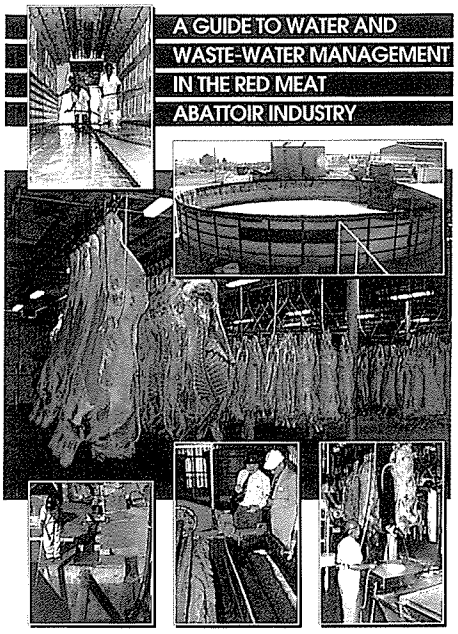
In this regard the accent falls on information transfer, and press releases, radio and television are used to this end.

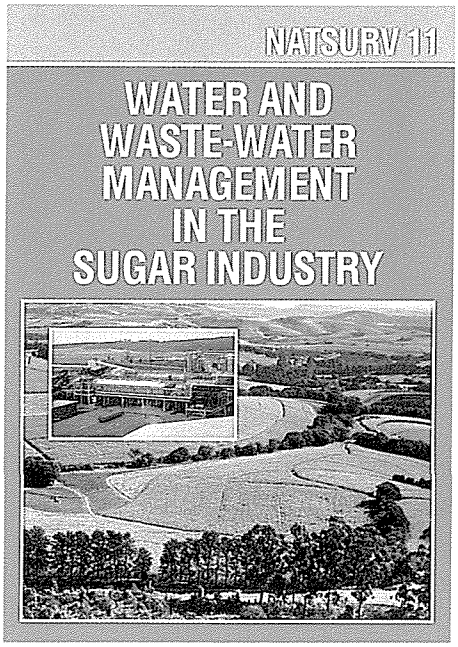
UTILISATION OF OVERSEAS EXPERTISE

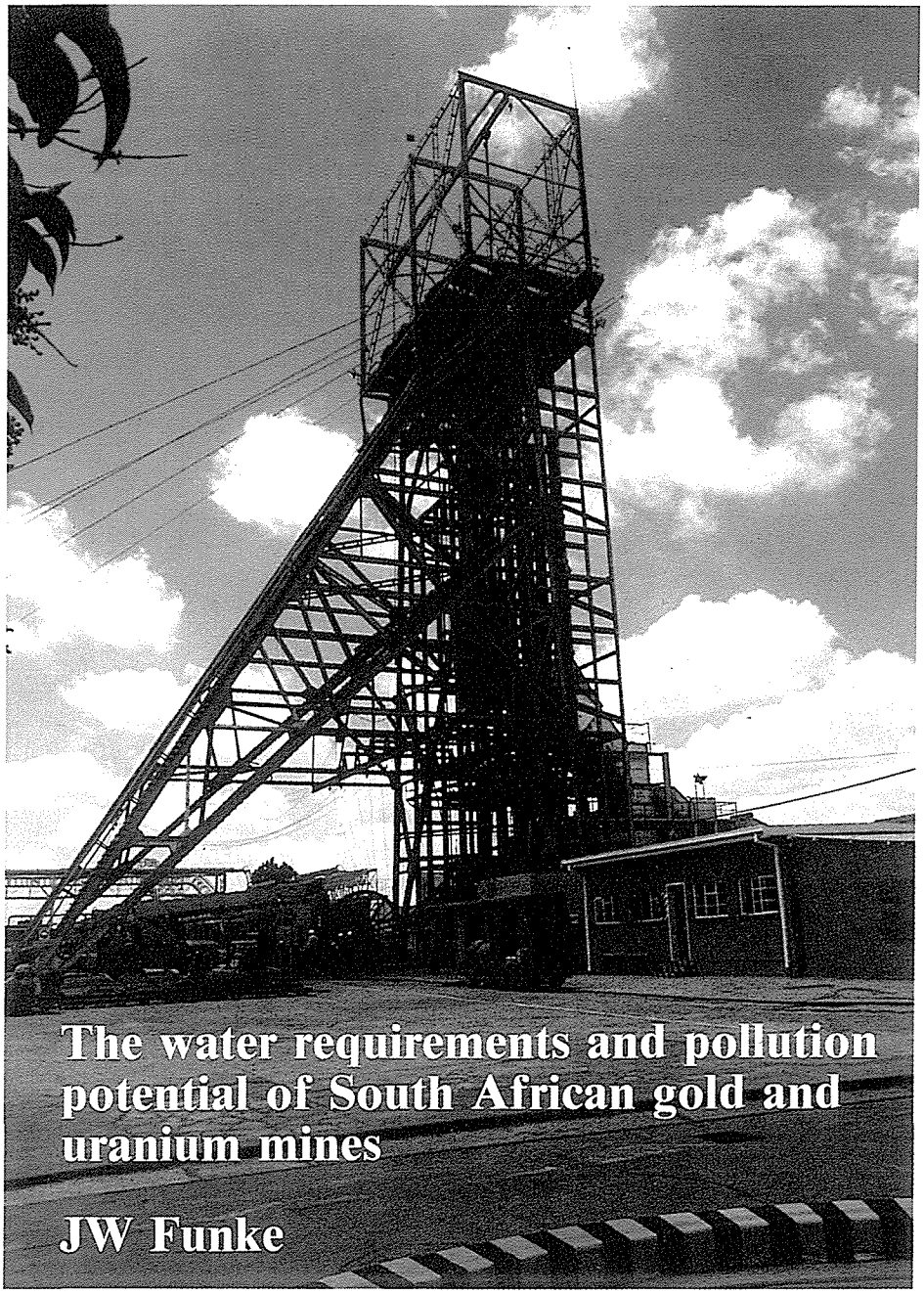
It is in the national interest that overseas expertise and knowledge be used where these are not available locally, and the Commission has developed various methods to achieve this. Overseas specialists, for example, are engaged as consultants and the Commission from time to time sends personnel and 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.







FINANCIAL STATEMENTS

The Statement of Income and Expenditure and the Balance Sheet have been drawn up in terms of section 14 (2) of the Water Research Act, 1971 (Act No. 34 of 1971), as amended and certified by the Auditor-General and cover the period 1 January 1989 to 31 December 1989.

The Commission derives its income from rates and charges on water usage and on scheduled irrigation land. The tariffs for the 1990 financial year were 1,15c/m^3 for water supplied for urban, industrial or domestic use, and 125c/ha of land scheduled for irrigation.

STATEMENT 1

BALANCE SHEET AS AT 31 DECEMBER 1989

1988	LIABILITIES		1989
R		R	R
	Accumulated funds -		
	Balance at 31/12/88	27 614 587,55	
27 614 588	Plus: Income over expenditure, 1989	2 562 841,48	30 177 429,03
	Current liabilities -		
	Sundry creditors -		
	Revenue paid in advance	298,01	
	Project advances	-	
289 124	Bank overdraft	-	298,01
R27 903 712			R30 177 727,04

1988	ASSETS		1989	
R		R	R	R
	*Capital assets -			
5 000	Land (Cost)		5 000,00	
	Motor vehicles	148 080,21		
148 000	Less: Depreciation	30 413,81	117 666,40	
	Office equipment	299 522,52		
245 170	Less: Depreciation	14 029,91	285 492,61	
	Office furniture	160 363,39		
130 713	Less: Depreciation	7 473,41	152 889,98	561 048,99
15 518 514	Loans			18 406 107,88
	Investments -			
	Cash investment	6 158 717,01		
	Plus: Accrued interest	206 011,48	6 364 728,49	
5 523 340	Unlisted shares		755 938,74	7 120 667,23
	Current assets -			
	Sundry debtors -			
6 259 240	Outstanding revenue		1 713 952,13	
-	Net project advances	1 927 982,80		
3 150	Subsistence and transport advances	5 593,97		
52 256	Motor financing	16 893,86		
600	Deposits	600,00	1 951 070,63	
150	Cash on hand		150,00	
17 499	Cash in bank		424 730,18	4 089 902,94
R27 903 712				R30 177 727,04

* Capital assets purchased by organisations by means of research grants are not included.

Pretoria, 29 May 1990

(Signed) PE ODENDAAL
Executive Director

The accounts of the Water Research Commission have been audited in terms of section 5 and 18(2) of the Auditor-General Act, No. 52 of 1989, read with section 14(1) of the Water Research Act, No. 34 of 1971, and in my opinion the annual financial statements are a fair representation of the financial position of the Commission as at 31 December 1989 and the result of its operations for the year then ended.

Pretoria, 23 November 1990

(Signed) RP WRONSLEY
Auditor-General

STATEMENT 2

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1989

1988	EXPENDITURE	1989
R		R
2 009 482	Salaries and allowances	**3 046 401,61**
53 825	Subsistence	**96 058,81**
6 588	Motor transport	**11 912,86**
197 295	General transport	**221 062,20**
5 679	Commission members' allowances	**7 670,00**
17 317	Postal and telegraph services	**17 295,86**
40 030	Telephone services	**58 558,22**
42 835	Printing and stationery	**72 632,91**
36 275	Advertisements	**19 913,95**
314 101	Publications and information	**333 206,57**
16 765	Technology and information transfer	**36 508,18**
47 159	Lease and maintenance of office equipment	**72 940,76**
-	Computer software	**3 540,43**
13 228	Entertainment	**17 796,18**
164 362	Office rental	**492 498,30**
8 720	Maintenance of and alterations to offices	-
15 078	Electricity	**48 399,30**
3 712	Maintenance and lease of furniture	**1 695,36**
10 016	Typing and translation services	**3 100,97**
18 101	Insurance and licenses	**27 631,72**
188 330	Collection fees	**223 259,14**
3 378	Audit fees	**9 750,66**
67 078	Legal costs	**77 868,03**
33 741	Registrations and subscriptions	**33 160,11**
36 916	Miscellaneous petty expenses	**33 120,67**
110 941	Interest on loan	-
36 987	Depreciation	**51 917,13**
10 810 066	Research projects and research support services	**10 675 113,87***
257 232	Contracting of researchers and expertise	**345 695,23**
107 000	Research and other grants	**100 000,00**
124 014	Specialist and consultation services	**496 688,04**
9 873 628	Income over expenditure	**2 562 841,48**
R24 669 879		**R19 198 238,55**

1988	INCOME	1989	
R		R	R
	Rates		
	Government irrigation schemes with		
249 470	canal systems		**243 381,83**
220 654	Irrigation Board schemes		**227 134,86**
	Charges		
	Metered water from Government		
18 555 775	schemes		**13 096 487,91**
5 161 370	Municipalities		**4 206 140,32**
28 496	Interest on rates and charges in arrears		**12 227,22**
	Interest on investments		
	Received	**491 315,19**	
330 644	Accrued	**206 011,48**	**697 326,67**
123 470	Sundry income		**74 328,28**
	Interest on loan		
-	Erf Sewe-Nul-Ses Rietfontein (Pty) Ltd		**641 211,46**
R24 669 879			**R19 198 238,55**

* Only includes expenditure for which audited statements are received

STATEMENT 3

STATEMENT OF EXPENDITURE AND ADVANCES OUTSTANDING IN RESPECT OF RESEARCH PROJECTS AND RESEARCH SUPPORT SERVICES AS AT 31 DECEMBER 1989

PROJECT	EXPENDITURE		TOTAL ADVANCES OUTSTANDING AS AT 31/12/89
	1989	TOTAL TO 31/12/89	
1. RESEARCH PROJECTS	R	R	R
Technical development of water reclamation on the basis of the Windhoek plant	-	812 635,99	1 812,62
Research on the inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage	31 419,74	202 189,29	3 144,71
Research on enhancement of biological phosphate removal from sewage by altering process feed composition	2 043,94	264 077,77	* (2 043,94)
A national industrial water and waste-water survey	-	2 900 603,12	594 085,00
An investigation into rainfall recharge to ground water	-	576 804,82	1 062,69
Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat	14 000,00	246 454,48	2 545,52
Research on the practical scheduling of irrigation in the Northern Transvaal	66 127,74	293 284,15	32 695,00
Research on the quantification and limitation of water losses associated with centre pivot irrigation systems	74 886,63	294 139,26	1 197,62
Research on applied hydrological process and modelling studies for the determination of water and sediment yield	166 047,57	1 141 100,00	-
Research on thermal feedback caused by dry cooling at power generating stations	84 240,00	288 168,00	* (740,00)
Research into the treatment of wool scouring effluents	121 650,41	1 199 907,63	*(86 687,63)
Research on and development and full-scale evaluation of preventative and remedial methods for the control of activated sludge bulking	15 855,00	216 099,99	-
The technical performance evaluation of a full-scale industrial waste-water treatment plant: Textile dyehouse effluent treatment by hyperfiltration	-	44 162,72	2 412,28
Research on improving irrigation management based on soil water monitoring and detailed knowledge of profile available water capacities	-	287 099,33	4 041,10
Research on the socio-economic effects of water restrictions on industries and local governments	-	98 234,63	4 223,03
Research on the exploitation potential of Karoo aquifers	15 250,27	744 999,40	-
The development of management orientated models for eutrophication control	48 668,54	266 261,33	*(21 491,00)
The development of a computer program to simulate water flow in distribution canals	1 777,21	143 258,25	3 033,73
Research on chemical characterisation of South African municipal sludges	1 437,67	64 066,93	* (512,98)
Research on the evaluation of the impact of the phosphate standard on the water quality and trophic status of Hartbeespoort Dam	12 641,24	246 177,89	* (9 277,89)
Research on the effects of urbanisation on catchment water balance	-	539 669,16	235 000,00
Research on drip irrigation of tomatoes	127 895,15	510 952,28	2 383,42
Research on epidemiological surveillance of potential changes in drinking-water quality	49 770,69	369 283,77	* (2 686,34)
Research on the development of polymers for the formation of dynamic membranes and the evaluation thereof for the treatment of industrial effluents	1 660,69	524 851,48	14 011,87
Research on the evaluation and optimisation of the process of dual digestion of sewage sludge	100 126,30	385 025,99	98 388,90

STATEMENT 3 (CONTINUED)

PROJECT	EXPENDITURE		TOTAL ADVANCES OUTSTANDING AS AT 31/12/89
	1989	TOTAL TO 31/12/89	
	R	R	R
Computer and laboratory optimisation studies on dry and dry-wet cooling	7 690,88	790 796,69	-
Research on the feasibility of reverse osmosis for water reclamation on large scale	80 876,82	616 876,82	*(33 076,82)
The development of a portable toxicity detector for water	15 496,75	35 764,96	*(11 261,71)
Hydrosalinity studies in the Eastern Cape	212 860,08	752 069,80	12 990,20
Research on the evaluation of the abilities of several solute and water transport models to predict the quantity and quality of water leaving the root zone	73 052,05	238 154,17	7 145,83
Development of phosphate export models for catchments	55 796,59	68 183,30	22 566,70
The development of methods to assess the impact of agricultural practices on water resources in Southern Africa	176 797,00	522 860,10	96 039,90
Research on the effects of reduced water consumption on domestic sewer systems	31 870,27	92 783,54	* (3 493,54)
Research on the development of a stochastic daily climate model for South African conditions	52 451,56	143 276,04	14 678,53
Research on the treatment of inorganic brines and concentrates	212 095,50	514 355,43	*(62 555,43)
Research on dissolved air flotation for the treatment of eutrophied surface water for potable use	(2 518,26)	99 500,00	-
Development of water quality monitoring strategies and procedures for water quality data interpretation	98 810,85	192 618,78	12 381,22
Research on the isolation and identification of mutagens in drinking water	30 226,14	82 443,68	* (4 043,68)
Research into water consumption rates and patterns and unaccounted-for water in urban areas	49 841,25	83 611,70	* (6 611,25)
Research on the development of an adjustable low pressure flow-rate control valve for flood irrigation	9 433,17	47 375,33	* (1 856,01)
Research on the development of criteria for sprinkler irrigation systems to combat surface sealing of soils	93 562,54	165 783,94	21 957,06
An investigation into methods of developing operational rules for individual irrigation systems	162 195,14	466 555,72	6 497,37
Research on ground-water abstraction in residential areas	75 094,54	176 289,64	*(26 689,64)
Research on the use of electromagnetic exploration techniques for the development of ground-water resources	22 838,94	109 531,51	17 761,06
Research on phosphate crystallisation in activated sludge systems	31 610,23	118 096,81	*(18 033,81)
Research on the evaluation and development of techniques for the determination of geohydrological parameters by use of geo-electrical methods	33 564,58	68 000,00	* (9 185,00)
Research on economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State	82 918,21	162 653,42	* (8 795,42)
The development of fixed and dynamic membrane systems for the treatment of brackish water and effluents	560 360,18	1 112 932,11	53 567,89
Research on geohydrological investigation and evaluation of the Zululand coastal aquifer	62 249,00	167 854,30	74 767,70
Research on the reconstruction of the climatic history of the last 2 000 years in the summer rainfall regions of Southern Africa	44 506,00	87 543,00	1 055,00
Research on precipitation and airflow in cumulus clouds	235 989,00	310 964,11	* (1 964,11)
Research on the development of techniques for the evaluation and effective management of surface and ground-water contamination in the Orange Free State Gold Fields	314 889,78	553 723,18	81 989,81
Research on the enhancement of the national ground-water data base facilities	142 060,06	242 147,55	8 852,45
Research in maximising irrigation project efficiency in different soil-climate-irrigation situations	157 187,90	253 650,54	8 212,10

STATEMENT 3 (CONTINUED)

PROJECT	EXPENDITURE		TOTAL ADVANCES OUTSTANDING AS AT 31/12/89
	1989	TOTAL TO 31/12/89	
	R	R	R
Research on the storage and utilisation of rain water in soil for the stabilisation of plant production in semi-arid regions	200 206,14	352 200,53	*(80 493,53)
Research on the factors affecting the water use efficiency of irrigated crops, with special reference to the physiological responses of these crops	256 918,99	469 712,83	23 581,01
Research on the estimation and evaluation of moisture stress in crops by means of remote control aerial surveillance	62 332,00	62 332,00	45 668,00
Research on the preparation of guidelines on cost-effectiveness of rural water supply and sanitation projects	112 410,37	155 495,69	16 204,31
Research on the preparation of engineering design guidelines for artificial wetlands for waste-water treatment	-	14 000,00	36 000,00
An investigation of the hydrological response to third world settlements in peri-urban areas of Natal/KwaZulu	-	32 873,00	10 490,00
The development of a systems model for the Mgeni catchment	57 439,00	80 354,11	62 845,89
Hydrological modelling studies in the Eastern Cape	286 662,57	326 007,51	98 192,49
The development of a model to simulate flow in alluvial rivers	67 207,36	114 553,27	531,33
Research on the quantification of the effects of land use runoff quality in selected catchments in Natal	71 729,27	128 419,37	14 980,63
Research on the design criteria for crossflow microfiltration	210 161,44	380 573,51	*(71 373,51)
Research on the removal of gas stripliquor by coagulation and flocculation	5 893,37	19 650,00	-
Transfer of waste-water treatment management technology to the meat processing industry	-	-	80 250,00
Research on the filtration of compressible cakes	23 552,68	23 552,68	7 347,32
Research on solids-liquid separation in biological systems	18 340,35	40 856,71	* (806,34)
Research on a combined flotation-powdered carbon process for potable water treatment	43 934,08	65 748,94	13 251,06
The development of seeded reverse osmosis technology	100 000,00	200 000,00	-
Research on the concentration of industrial effluents with sealed-cell electrodialysis	53 279,02	95 683,58	*(41 510,50)
A comparative study on chlorine dioxide and other oxidants in potable water treatment	70 922,38	92 443,73	*(26 943,73)
Research on chemical augmentation of biological phosphate removal	9 393,41	9 393,41	34 606,59
Research on pelletisation in upflow anaerobic sludge bed (UASB) systems	39 012,22	69 284,92	14 057,78
Research on phosphate fixation in waste waters by means of controlled struvite formation	61 866,89	93 100,40	*(12 100,40)
Consolidation of activated sludge and water chemistry research	96 694,44	136 678,24	*(11 548,44)
Research on the assessment of water quality problems due to microbial growth in drinking-water distribution systems	95 916,50	127 466,41	* (1 966,41)
Research on the effect of biocorrosion in water systems	42 772,75	71 513,28	24 786,72
Research on the effects of varying water quality on the corrosion of different pipe materials in the PWV/Klerksdorp areas	134 296,57	223 695,67	*(84 296,57)
Research on the development and testing of data logging equipment for the monitoring of water consumption patterns	68 833,30	86 120,77	12 379,23
Research on the evaluation of the design and use of irrigation systems in the Breë River with a view to the control of potential drainage losses	203 675,09	268 138,21	97 764,62
Research on the water use efficiency of certain irrigated temperate pasture species	113 529,00	204 878,39	12 221,61
Model studies on the minimisation of dry and dry-wet cooling systems	-	84 592,83	75 407,17
Research on the effect of water quality and chemical composition on the corrosivity in mild steel pipelines	-	-	-
Research on the relationship between climate and crop factors	53 567,51	53 567,51	52 432,49

STATEMENT 3 (CONTINUED)

PROJECT	EXPENDITURE		TOTAL ADVANCES OUTSTANDING AS AT 31/12/89
	1989	TOTAL TO 31/12/89	
	R	R	R
Research on soil-plant-water relations in the upper reaches of plant available soil water	122 303,25	122 303,25	24 696,75
Research on moisture sensors to facilitate water management	84 998,50	84 998,50	15 970,50
Research on the biological treatment of industrial water with the simultaneous production of single cell protein	-	-	63 000,00
Research on harvesting Hartbeespoort Dam algal scums for fine chemicals	25 215,27	25 215,27	18 784,73
Research on human viruses in water	38 836,27	38 836,27	64 663,73
Research on the extension of the management orientated models for eutrophication control	43 053,88	43 053,88	7 946,12
Research on the evaluation and development of geophysical techniques for characterising the extent and degree of ground-water pollution	206 827,00	206 827,00	3 200,00
Research on a preliminary survey of pesticide levels in ground water from a selected area of intensive agriculture in the Western Cape	32 347,08	32 347,08	16 152,92
Research on the evaluation of the four-electrode electrical conductivity and electromagnetic induction techniques of soil salinity measurement for use under South African conditions	50 187,00	50 187,00	15 313,00
Research on hydrological systems model development	150 279,00	150 279,00	231 721,00
A comparative study of two and three dimensional ground-water models	161 498,31	161 498,31	11 501,69
An investigation into the oscillation method for the determination of aquifer transmissivity	51 647,38	51 647,38	3 352,62
An investigation of the potential use of NOAA satellite remotely sensed data for identification of regional-scale fracture zones for ground-water supply purposes in Southern Africa	56 953,15	56 953,15	*(16 953,15)
Technical support for the application of dynamic membrane plants for the treatment of industrial effluents	139 055,27	139 055,27	*(80 955,27)
The investigation into the evaluation of membrane technology for electroplating effluent treatment	61 916,11	61 916,11	13 083,89
Research on biological techniques for the treatment of pulp bleaching effluent	40 000,00	40 000,00	*(20 000,00)
Research on abattoir solid waste: Development and implementation of a treatment system	-	-	-
Research on the prediction of South African summer rainfall variability from ocean surface temperatures	33 589,25	33 589,25	1 800,75
Research on relationships between lightning and precipitation	69 941,00	69 941,00	59,00
The evaluation of full-scale flotation-filtration and chlorine dioxide plants	-	-	-
Research on the effect of water quality on the effectiveness of chlorine dioxide in drinking-water treatment	-	-	-
The development of a combination of sedimentation, flotation and sand filtration processes for water treatment (SEDIDAFF)	965,70	965,70	14 034,30
Research on low-cost ultrafiltration systems	-	-	60 000,00
Research on the interaction between the atmospheric boundary layer and the natural draught cooling towers at Kendal power station	66 197,00	66 197,00	9 803,00
Research on and evaluation of various factors affecting dry-wet cooling	301 169,24	301 169,24	*(51 569,24)
Research on development and evaluation of specific control methods for ameliorating low F/M bulking	32 426,29	32 426,29	96 743,71
Research on phosphate removal by means of electrochemically formed iron ions	20 851,10	20 851,10	28 148,90
Determination of the socio-economic and financial implications of the water restrictions in force from 1983 up to its annulment in 1987	25 930,91	25 930,91	23 569,09
Research on the management of phosphate concentrations and algae in Hartbeespoort Dam	55 137,05	55 137,05	4 262,95

STATEMENT 3 (CONTINUED)

PROJECT	EXPENDITURE		TOTAL ADVANCES OUTSTANDING AS AT 31/12/89
	1989	TOTAL TO 31/12/89	
	R	R	R
Research on flood and furrow irrigation: A critical evaluation of design procedures and the computerisation of the most suitable approaches	155,00	155,00	61 845,00
TOTAL	8 491 332,25	26 880 271,34	2 151 628,97
2. RESEARCH SUPPORT SERVICES			
South African Water Information Centre	534 832,10	1 884 668,91	*(149 558,07)
The establishment of a National Hydrological Information System	1 321 148,52	4 199 556,64	-
The establishment of a Computing Centre for Water Research	327 801,00	867 023,51	*(74 088,10)
TOTAL	2 183 781,62	6 951 249,06	(223 646,17)
GRAND TOTAL	10 675 113,87	33 831 520,40	1 927 982,80

* Excess expenditure over advances for projects

STATEMENT 4

BUDGET 1991

ESTIMATED INCOME	R	R
Rates and charges in terms of Section 11 of the Water Research Act		32 130 000
Loan		-
Interest on investment		800 000
Erf Sewe-Nul-Ses Rietfontein (Pty) Ltd		670 000
Sundry income		-
TOTAL ESTIMATED INCOME		R33 600 000
ESTIMATED EXPENDITURE		
Administrative expenses:		
Salaries and allowances	3 762 000	
Subsistence and travelling expenses	642 000	
Postal, telegraph and telephone	101 000	
Printing, stationery, advertisements and publications	796 000	
General expenditure	1 550 000	6 851 000
Research expenses:		
Research projects:		
Research on the effects of urbanisation on catchment water balance	180 000	
Research on drip irrigation of tomatoes	170 000	
Hydrosalinity studies in the Eastern Cape	269 450	
Development of phosphate export models for catchments	55 000	
The development of methods to assess the impact of agricultural practices on water resources in Southern Africa	339 500	
Development of water quality monitoring strategies and procedures for water-quality data interpretation	105 000	
Research on the development of criteria for sprinkler irrigation systems to combat surface sealing of soils	136 100	
Research on economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State region	25 800	
Research on geohydrological investigation and evaluation of the Zululand coastal aquifer	259 000	
Research on the reconstruction of the climatic history of the last 2 000 years in the summer rainfall regions of Southern Africa	56 000	
Research on maximising irrigation project efficiency in different soil-climate-irrigation situations	251 800	
Research on the storage and utilisation of rain water in soil for the stabilisation of plant production in semi-arid regions	199 000	
Research on the factors affecting the water-use efficiency of irrigated crops, with special reference to the physiological responses of these crops	298 000	
Research on the estimation and evaporation of moisture stress in crops by means of remote control aerial surveillance	70 000	
The development of a systems model for the Mgeni catchment	110 000	
Hydrological modelling studies in the Eastern Cape	310 000	
The development of a model to simulate flow in alluvial rivers	72 000	
Research on the quantification of the effects of land use on runoff quality in selected catchments in Natal	25 000	
Research on the design criteria for cross-flow microfiltration	225 000	
Research on the filtration of compressible cakes	20 447	
Research on chemical augmentation of biological phosphate removal	30 000	
Research on pelletisation in upflow anaerobic sludge bed (UASB) systems	83 700	
Research on the assessment of water-quality problems due to microbial growth in drinking-water distribution systems	10 033	
Research on the effects of varying water quality on the corrosion of different pipe materials in the PWV/Klerksdorp areas	33 875	
Research on water-use efficiency of certain irrigated temperate pasture species	72 000	
Research on the effect of water quality chemical composition on the corrosivity in mild steel pipelines	50 000	
Research on the relationship between climate and crop factors	33 000	

STATEMENT 4 (CONTINUED)

	R
Research on soil-plant-water relations in the upper reaches of plant available soil water	92 000
Research on moisture sensors to facilitate water management	159 000
Research on the biological treatment of industrial water with the simultaneous production of single cell protein	35 400
Research on human viruses in water	129 000
Research on the extension of the management orientated models for eutrophication control	97 000
Research on a preliminary survey of pesticide levels in ground water from a selected area of intensive agriculture in the Western Cape	68 000
Research on the evaluation of the four-electrode electrical conductivity and electromagnetic induction techniques of soil salinity measurement for use under South African conditions	54 000
Research on hydrological systems model development	479 000
A comparative study of two and three dimensional ground-water models	184 500
Technical support for the application of dynamic membrane plants for the treatment of industrial effluents	55 000
The investigation into the evaluation of membrane technology for electroplating effluent treatment	20 000
Research on the prediction of South African summer rainfall variability from ocean surface temperatures	130 000
Research on relationships between lightning and precipitation	94 000
The evaluation of full-scale flotation filtration and chlorine dioxide plants	70 360
Research on the effect of water quality on the effectiveness of chlorine dioxide in drinking-water treatment	20 000
The development of a combination of sedimentation, flotation and sand filtration processes for water treatment (SEDIDAFF)	6 000
Research on the interaction between the atmospheric boundary layer and the natural draught cooling towers at Kendal power station	12 000
Research on and evaluation of various factors affecting dry-wet cooling	299 700
Research on development and evaluation of specific control methods for ameliorating low F/M bulking	137 100
Research on the management of phosphate concentrations and algae in Hartbeespoort Dam	10 000
Research on flood and furrow irrigation: A critical evaluation of design procedures and the computerising of the most suitable procedures	119 000
A regional investigation into ground-water quality deterioration in the Olifants River catchment above the Loskop Dam, with specialised investigations in the Witbank Dam sub-catchment	440 000
Research on the freshwater requirements of estuarine plants	105 400
Research on the relationship between low flows and the river fauna in the Letaba River	163 000
Research on a pre-impoundment study of the Sabie-Sand River system, Eastern Transvaal, with special reference to predicted impacts on the Kruger National Park	181 400
Research on assessment of the instream flow requirements of rivers	136 300
Research on the quantitative structuring of national water planning objectives for use in decision support systems in South Africa	114 400
Research on the preparation of a review document on sediment transport in South Africa including revision of the sediment production map of Southern Africa	215 000
Research on the surface water resources of South Africa 1990	890 000
Research on the adaptation and calibration of an urban runoff quality model	163 100
Research on the utilisation of geographical information systems (GIS) and integrated environmental management (IEM) in the planning and management of water resources within river catchments	200 000
An investigation into the quality of water for animal production	140 000
Research on the erodability of different rock formations under varying flow conditions	102 000
Research on the use of saline water for irrigation purposes and an assessment of salt tolerance criteria of crops	204 800
Research on the applicability of hydrodynamic reservoir models for water-quality management in stratified water bodies in South Africa	167 332
Research on interpolation and mapping of daily model parameters for South Africa	137 000
Research on techniques for seasonal and long-term rainfall forecasting in South Africa	138 000
Research on the influence of different water nitrogen regimes on crop canopy development, water flow resistance and crop yield, with a view to improvement of irrigation models	174 000

STATEMENT 4 (CONTINUED)

	R	R
Research into the recovery of water and chemicals from ion exchange regeneration effluents	82 500	
Research on phase diagrams of complex precipitants	55 000	
Research on the integration of remote sensing, digital image processing and geographical information systems technologies for regional scale ground-water resources assessment in South Africa	109 000	
Research on the development and evaluation of geohydrological and isotope hydrological methodologies for the identification of areas potentially suitable for waste disposal	115 000	
Research on the occurrence and accumulation of selected heavy metals in freshwater ecosystems affected by mine and industrial effluents	61 400	
Research on the concentration rates of selected radionuclides in aquatic ecosystems affected by mine drainage effluents	76 100	
Research on biological phosphate removal mechanisms in the activated sludge process	51 000	
Research on the utilisation of the fungus *Geotrichum in* waste water	70 000	
Research on aspects of sewage sludge treatment and disposal	9 000	
Research on the optimisation of biofouling control programmes	89 800	
Research on monitoring the effect of catchment development on urban runoff and water balance	375 000	
Research on taste an odour forming micro-organisms occurring in South African surface waters	100 000	
Research on bacteriophages as water-quality indicators	64 100	
A study on a mine-water treatment and monitoring plant: The Aquarius Plant	200 000	
Research on hydrological investigation of stormwater runoff from the Khayelitsha urban catchment in the False Bay area, South-western Cape	223 000	
Research on pollution loads, dispersion and effects of urban runoff from the Motherwell township into the Swartkops River, Eastern Cape	81 800	
Research on modelling of tubular reverse osmosis systems	180 000	
Research of alternative water pollution control options on TDS concentrations in the Vaal Barrage and middle Vaal	300 000	
Research on improved oxygen transfer for high biosludge concentrations	29 100	
The development of guidelines for the design and application of dissolved air flotation/ filtration processes	37 500	
Research on the removal of suspended solids from pulp and paper effluents by employing a combined sedimentation, flotation and sand filtration process	44 800	
The compilation of a comprehensive guide for ground-water sampling in South Africa	8 500	
Research on forced aeration composting of sewage sludge for rural communities	30 400	
Research on improvement in water-usage control and waste-water treatment in the sorghum beer industry	24 000	
Research on the development of an effective and environmentally safe larviciding programme for the control of the blackfly *Simulium chutteri*, along the Orange River	94 000	
Contribution of ground water to the salt load of the Breë River, using natural isotopes and other tracers	129 500	
Pilot-scale desalination of sea water by means of reverse osmosis	10 000	
Expected projects	7 771 500	
	19 854 497	
Contracting of researchers and expertise	-	
Research and other grants	50 000	
Specialist and consultation services	600 000	
Loan (Company for Research on Atmospheric Water Supply)	4 602 000	
Research support services	1 634 000	26 740 497
TOTAL ESTIMATED EXPENDITURE		33 591 497
Expected investment balance		8 503
		R33 600 000

STATEMENT 5

STATEMENT OF RECEIPTS AND PAYMENTS FOR THE YEAR ENDED 31 DECEMBER 1990

RECEIPTS	1990	
	R	R
Balance on 1 January 1990 -		
Investment at Corporation for Public Deposits	6 158 717,01	
Cash on hand	150,00	
Cash in bank	424 730,18	6 583 597,19
Rates -		
Government irrigation schemes with canal systems		275 979,89
Irrigation Board Schemes		303 248,64
Charges -		
Metered water from Government schemes		23 195 366,02
Municipalities		4 842 933,52
Interest on rates and charges in arrears		37 864,80
Interest on investments		1 303 969,48
Sundry income		188 969,95
Subsistence and transport advances recovered		133 370,48
		R36 865 299,97

PAYMENTS	1990	
	R	R
Salaries and allowances		3 263 368,17
Motor transport		16 622,57
Subsistence		115 952,73
Subsistence and transport advances		364 818,70
General transport		302 431,65
Commission members' allowances		11 526,00
Postal and telegraph services		19 401,74
Telephone services		58 695,59
Printing and stationery		64 686,93
Advertisements		16 950,07
Publications and information		375 461,97
Technology and information transfer		86 193,48
Office equipment: Purchases		34 973,19
Office equipment: Computer software		13 678,76
Lease and maintenance of office equipment		90 169,40
Entertainment		25 180,57
Office rental		565 903,72
Electricity		52 874,36
Office furniture: Purchases		9 894,28
Maintenance and lease of furniture		4 634,24
Typing, translation and services rendered		14 309,89
Insurance and licenses		25 284,90
Collection fees		286 553,90
Audit fees		34 378,49
Legal costs		85 013,12
Registrations and subscriptions		30 226,43
Miscellaneous petty expenses		18 574,76
Project advances		15 002 335,00
Research projects		95 230,79
Research and other grants		9 000,00
Specialist and consultation services		479 909,54
Loans		2 289 239,61
Research support services		1 767 696,39
Balance as at 31 December 1990 -		
Investment at Corporation for Public Deposits	10 812 686,49	
Cash on hand	150,00	
Cash in bank	421 292,54	11 234 129,03
		R36 865 299,97

WATER RESEARCH COMMISSION
Pretoria, 20 February 1991

(Signed) PE ODENDAAL
EXECUTIVE DIRECTOR

ANNEXURE

PUBLICATIONS EMANATING FROM RESEARCH FINANCED WHOLLY OR PARTIALLY BY THE COMMISSION

This **Appendix** contains a list of publications released in 1990.
Requests for publications should be directed, as far as possible, to the authors.

PUBLICATIONS FOR 1990

ARTICLES AND PAPERS

- Angus, GR and Schulze, RE (1990) A hydrological interpretation of soil information from the SIRI Land Type Survey. *Agricultural Engineering in SA* **22** (1) 178-192.
- Angus, GR and Schulze, RE (1990) Elands River Basin. Department of Agricultural Engineering, University of Natal, Pietermaritzburg. ACRU Report **37**.
- Bezuidenhout, LM, Schoonbee, HJ and De Wet, LPD (1990) Heavy metal content in organs of the African sharptooth catfish, *Clarias gariepinus* (Burchell), from a Transvaal lake affected by mine and industrial effluents. Part 1. Zinc and copper. *Water SA* **16** (2) 125-130.
- Boden, DI (1990) The relationship between soil water status, rainfall and the growth of *Eucalyptus grandis*. Paper presented at the 19th IUFRO World Congress, Montreal. August.
- Bosch, C, Maré, J and Loos, MA (1990) Evaluation of anionic detergents and sodium benzoate as inhibitors of *Thiobacillus ferro-oxidans* in South African coal discard. Poster presentation, 6th Biennial Congress of the South African Society of Microbiology, Cape Town.
- Botes, JHF en Oosthuizen, LK (1990) 'n Ontleding van die risiko-doeltreffendheid van besproeiing-skeduleringstrategieë vir koring in die benede PK le Rouxdamgebied met behulp van veralgemeende stogastiese dominansie. Referaat gelewer tydens die Landbou-ekonomie Vereniging van Suider-Afrika, Durban. 17-18 September. Ook in *Agrekon* **29** (4).
- Brözel, VS and Cloete, TE (1990) Biocide fingerprints of commercially available bactericides in SA. Paper presented at the Congress of the Technical Association of the Pulp and Paper Industry of SA, Johannesburg. July.
- Brözel, VS and Cloete, TE (1990) Evaluation of agars for enumeration of heterotrophic aerobes in cooling water. Paper presented at the Biennial Congress, SA Society for Microbiology, Stellenbosch. March.
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