1987 Annual Report

WRC

Water Research Commission

1987 Annual Report

Water Research Commission

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PRETORIA
0001

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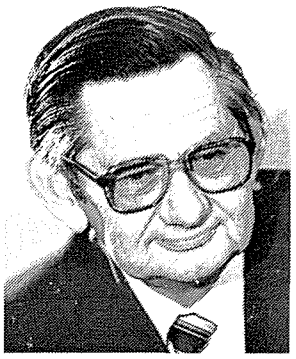
Members of the Water Research Commission as on 31 December 1987

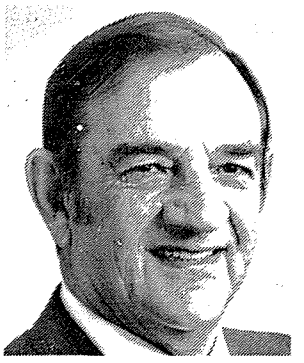


Mr GCD Claassens
Director General:
Department of Water Affairs

CHAIRMAN:
Dr JP Kriel
Consultant: Special Water Studies; and former Secretary of the Department of Water Affairs

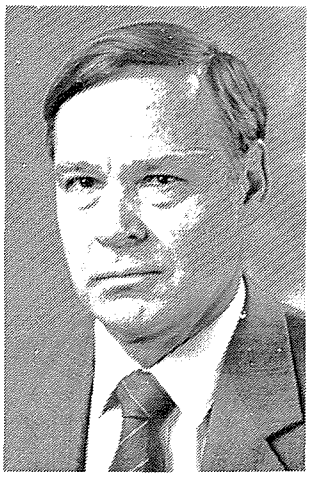
Dr CF Garbers
President:
Council for Scientific and Industrial Research

Mr JG du Plessis
Former Director General:
Department of Water Affairs

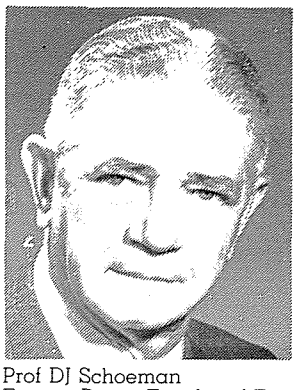


Mr AJ Raubenheimer (DMS)
Former Minister of Water Affairs

Dr N Stutterheim (OMS)
Co-opted member. Chairman: Board of the University of the Witwatersrand; and Chairman: Telephone Manufacturers of SA.



EXECUTIVE DIRECTOR:
Mr PE Odendaal



Prof DJ Schoeman
Former Dean: Faculty of Engineering
University of Pretoria

Dr DW Immelman
Former Director General:
Department of Agricultural Economics and Marketing

Dr WL van Wyk
Former Deputy Director General:
Department of Mineral and Energy Affairs

Contents

Contents

Water Research Commission
P O Box 824
PRETORIA
0001
22 April 1988

Dear Mr Kotzé

We take pleasure in submitting to you, herewith, the report of the Water Research Commission. This report covers the period 1 January to 31 December 1987.

The balance sheet and statement of revenue and expenditure for the financial year to 31 December 1987, as certified by the Auditor General, are furnished in Chapter 20 of this report.

Yours respectfully

J P Kriel
CHAIRMAN

P E Odendaal
EXECUTIVE DIRECTOR

Mr G J Kotzé, MP
Minister of Environment Affairs and of Water Affairs
Private Bag X9039
CAPE TOWN
8000

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

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

(b) the use of water for
(i) agricultural purposes;
(ii) industrial purposes; or
(iii) 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".

Senior personnel

Professional

CHIEF ADVISER:
Dr WHJ Hattingh

SENIOR ADVISERS:
Dr OO Hart
(Industrial water)

Mr JE McGlashan
(Municipal effluents and sludge; marine disposal of effluents)

Dr MJ Pieterse
(Water quality studies; salinisation re mining activities; Editor *Water SA)*

Dr CF Schutte
(Water treatment and reclamation; desalination; dry cooling)

CHIEF ADVISER:
Mr DS van der Merwe

SENIOR ADVISERS:
Mr HC Chapman
(Urban hydrology and water economy)

Mr DWH Cousens
(Surface hydrology and water resources)

Mr HM du Plessis
(Salinisation; eutrophication)

Dr GC Green
(Water consumption by agriculture)

Dr PJT Roberts
(Ground water; rainfall stimulation; meteorological sciences)

Administrative

DIRECTOR: ADMINISTRATION
Mr HC Lombaard

DIRECTOR: FINANCE
Mr PM van der Schyff

1 The year under review

WATER research covers a particularly extensive field as would appear from the following list of Water Research Commission (WRC) supported research areas:

- Surface hydrology
- Ground water
- Hydrometeorology
- Rainfall stimulation
- Irrigation
- Salinisation
- Eutrophication
- Sewage
- Sludge handling
- Marine disposal of effluents
- Water treatment and reuse
- Water quality and health aspects
- Water economy in urban areas
- Socio-economic studies
- Industrial water

Water research is a multi-disciplinary activity par excellence because of the wide field it encompasses and therefore financing of research by the WRC is at a large number of organisations. In 1987 the WRC supported 85 projects in terms of research agreements, with the following organisational distribution:

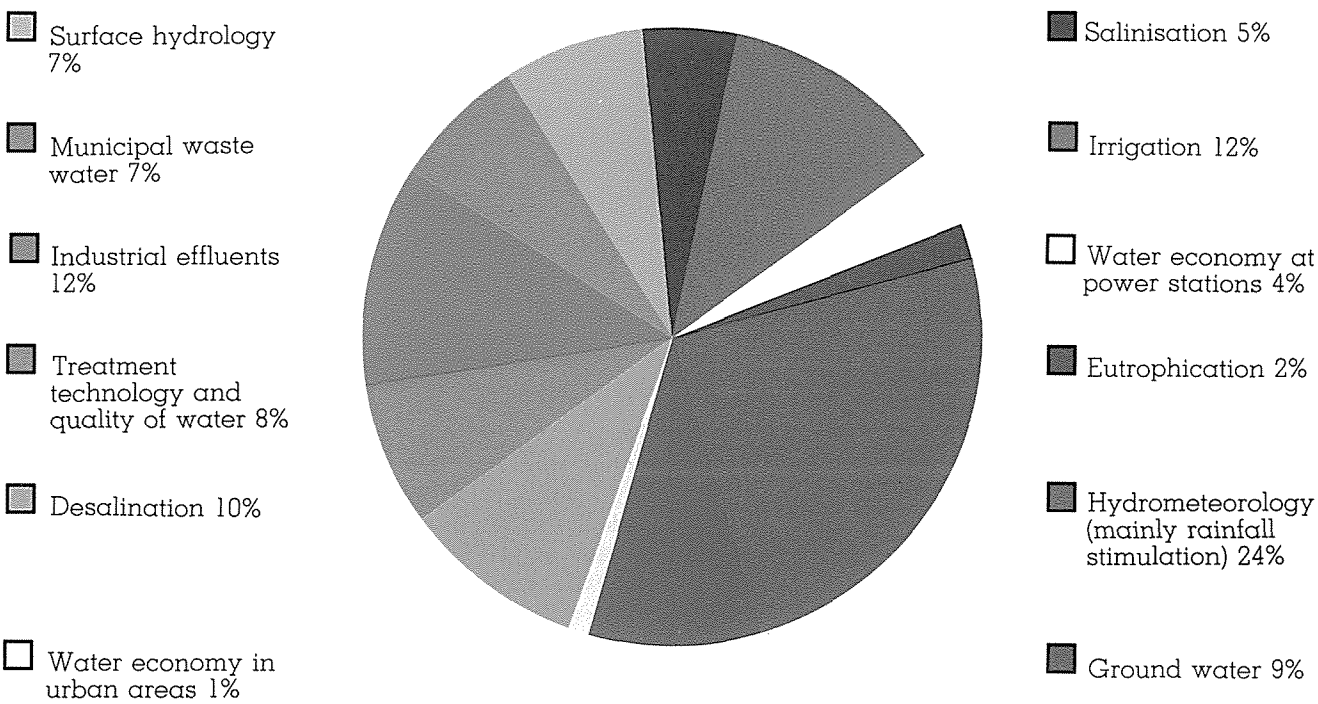
Universities	50
CSIR	25
Local authorities	8
State departments	6
Private organisations	9
Autonomous bodies	6
	104

More organisations than projects are listed because very often more than one body is involved with a particular project.

In addition to the direct funding of research projects, the WRC also funds four research support services. These services are directed at increasing the productivity and efficiency of water research and at providing the water industry with easy access to research knowledge and different types of data. These services are the following:

- *The South African Water Information Centre* which is operated by the CSIR on behalf of the WRC. A computerised bibliographic data base is maintained to provide SDI (selective dissemination of information) services and retrospective literature searches.
- *The Hydrological Information System* which is being developed by the Department of Water Affairs in terms of a contract over a 7-year period.
- *The Computing Centre for Water Research* which is jointly financed by IBM (now ISM) and the WRC and housed at the University of Natal. Computing facilities and software are available to the water research community via the major national computer networks.
- *A Ground-water Data Base* which is being developed on behalf of the WRC by the Institute for Ground-water Studies at UOFS in collaboration with the Department of Water Affairs.

Table 1 indicates the allocation of WRC funds to the various research areas over the past decade. Although this table provides some indication of



Allocation of funds (%) to various research areas during 1987

WRC research priorities, it should be borne in mind that certain research areas have already received considerable attention or are largely funded from other sources. The amounts indicated therefore, are not a true reflection of the relative importance of the research areas concerned.

Details of WRC activities and funding of research in the different research areas are given in the other chapters of this report. This chapter briefly addresses some policy aspects and noteworthy developments in a number of research fields.

Technology transfer and commercialisation of research results

Technology transfer - i.e. the application of research findings - remains one of the main aims of the WRC, since this is the final dividend on research investment.

Since there is no magic formula to ensure the transfer of technology, the WRC has pursued several parallel approaches, of which the following are the most important:

- Addressing well-defined research needs;
- Involving potential end users in the research;
- The establishment of centres of expertise from where research findings and advice can be channelled into practice;
- Demonstrations;
- Various forms of publication;
- The development of user friendly computer programmes; and
- Symposia, conferences, etc.

Commercialisation of research results is another important avenue of technology transfer which will be explored increasingly by the WRC in the future. Should an entrepreneur be found in the private sector to market technology, it will not only promote technology transfer, but also create the potential to earn royalties for the WRC, both locally and overseas. These royalties can then be used to fund further research. A WRC first in this connection was the commercialisation of reverse osmosis and ultrafiltration systems by the company Bintech, based on the findings of WRC-supported research at the Institute of Polymer Science at the University of Stellenbosch. These systems are used for desalination and for the treatment of effluents.

Over the past two years the WRC made application for several patents with a view to commercialisation. In the case of cross-flow microfiltration and the tubular filter press the WRC recently entered into an agreement with a company in England for international commercialisation, while a South African company will handle the local commercialisation. The technology for the reclamation of sodium hydroxide from certain effluents will be marketed by a South African firm.

A publication on the problems of sludge bulking in sewage purification is being marketed successfully by an overseas company on behalf of the WRC, while negotiations with another foreign company are under way for the marketing of a computer program for use in water treatment for the correct softening and stabilisation of water to prevent corrosion and scaling problems in pipes and equipment.

National survey of water use and management in South African industries

In 1984 the WRC entered into an agreement with consulting engineers to conduct a national survey of industrial water usage and management. This survey, which is being conducted in collaboration with the Department of Water Affairs, is the only one of its kind in the world, to our knowledge, and is compiling a data bank on the use of water, raw materials, electricity and the production of waste materials. This information will enable industrialists to set rational goals and can also be used by authorities for planning and control purposes. It is envisaged that this survey will be completed in 1989.

A characteristic of the survey is the spirit of co-operation by industry. Participating industries benefit directly from the survey: Factory management receives copies of survey reports; where appropriate, suggestions for more efficient water management, based on the expertise and experience of the project team, are given; and 17 manuals on water management in priority industries are to be published - three have already been published viz. manuals on malt breweries, the metal finishing industry and the soft drink industry.

This data bank, which is already well advanced, is an important national asset, which will undoubtedly promote the rational use of water in South Africa.

The tubular filter press sludge dewatering process

The prototype tubular filter press for the dewatering of waterworks sludges installed at the Umgeni Water Board's HD Hill Water Treatment Plant in Pietermaritzburg was officially opened by the Minister of Water Affairs, Mr G J Kotzé, on 27 November 1987.

This sludge dewatering technology was developed by the Pollution Research Group of the University of Natal under a Water Research Commission funded project, while the Umgeni Water Board provided the capital for the prototype. Engineers of the Board were also responsible for the design and construction of the plant.

Waterworks sludges cause serious pollution problems and therefore create a need for new and economical methods for dewatering sludges to

facilitate acceptable disposal. The tubular filter press has the potential to meet this need. This technology can also be applied to dewater a wide variety of inorganic and organic sludges.

Workshop on water supply and sanitation for small communities

In March 1987 the WRC organised a workshop and invited experts in the field to discuss problems relating to water and sanitation for small communities. Discussions focussed on the existing activities and research programmes in this respect, as well as on problems that are experienced.

A general conclusion was that there is a definite lack of mutual communication and information exchange, although a large number of organisations are active in this field. The action taken involves the compilation of a consolidated information document which will summarise existing activities and sources of reference in South Africa, thereby promoting mutual communication and consultation.

Research on drinking-water quality

Drinking-water quality has a direct effect on man's health and it is therefore important to monitor the quality carefully. Some of the RSA's surface water resources which are utilised for drinking water, are deteriorating in quality. This is brought about by pollution, repeated reuse of water with accompanying build-up of pollutants and the increasing number of chemicals appearing on the market, and with the risk of some of these chemicals ending up in the water environment.

In view of the above the WRC has lately developed various research programmes such as an investigation into the incidence and concentration of certain contaminants in drinking water, the influence of water quality on man, water treatment technologies and monitoring strategies for water quality.

Successful application of ground-water models

A large part of WRC supported ground-water research has been done by the Institute for Ground-water Studies of the UOFS. As a result of this research the Institute has achieved a level of expertise which is at present being applied country-wide and also abroad.

This expertise is related in particular to the application of mathematical models which simulate ground-water systems, and which were developed through WRC research projects. These models have already been applied in the following areas:

- Modelling the Omaruru delta aquifer for water supply to Swakopmund and Rössing mine;
- Modelling ground-water influx into longwall panels at Coalbrook, Sigma, Bosjesspruit, Matla and Usutu collieries;
- Modelling water supply to Morotele Power Station;
- Modelling water supply and sea-water intrusion at Richards Bay;
- Modelling radioactive waste management at Vaalputs in the north-western Cape;
- Feasibility study of salt production from sea water on the west coast of South Africa;
- Modelling water supply for irrigation from Karoo rock formations south of Bloemfontein;
- Modelling ground-water movement in the Gouriqua area west of Mossel Bay; and
- Modelling ground-water utilisation from the Nile River, in the Sileim Khowi Qa'ab area, Sudan, North Africa.

Coordination of hydrological research

Several strategies have been developed by the WRC to fulfil its coordination role. One of these is the establishment of coordinating committees for specific research areas, with representation by interested parties. These committees deal with the determination of research needs and priorities, *evaluating progress, making recommendations for* further research and the promotion of technology transfer.

In 1987 steps were taken to coordinate hydrological research more effectively. Coordination in this field was previously managed by the Coordinating Committee for Hydrological Research. The committee's sphere of interest extended over such a wide area, however, that it could no longer perform its task satisfactorily. The sphere of interest was therefore divided into three fields, each of which are now served more effectively by separate committees:

The Coordinating Committee for Hydrological Research (CCHR);
The Coordinating Committee for Research on Hydrometeorology (CCRH); and
The Coordinating Committee for Geohydrological Research (CCGR).

Surface hydrology: application of research results

Over the past ten years hydrological research supported by the WRC has given considerable attention to the development and coordination of hydrological flood estimation techniques for large and small catchment areas. Valuable contributions for upgrading knowledge in this regard were made *inter alia* by the University of the Witwatersrand, the University of Natal, Rhodes University and the University of Zululand.

In the course of 1987 the University of Natal completed its work on improving the SCS technique

of flood estimation for small catchments. In order to promote technology transfer of these results a series of workshops will be held in 1988.

Many of the research results on flood estimation are already used as standard reference material by those who require it in practice, like managers, planners and consulting engineers, and form part of the syllabus of some educational institutions.

As a result of the success which has been achieved with this research, and because of other priorities in the field of hydrological research, flood research for small catchments will in future be accorded a lower priority.

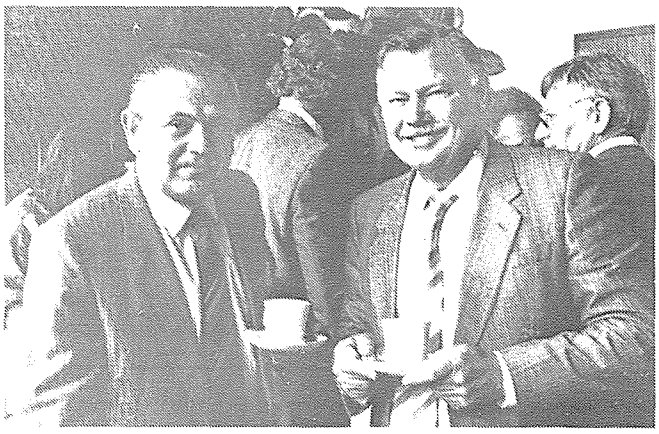
Research on rainfall stimulation

The WRC currently supports two research projects on rainfall stimulation - one at Nelspruit and the other one in collaboration with the Weather Bureau at Bethlehem. The reason for two projects is that the dominating cloud formations and resultant rainfall mechanisms differ considerably in these two areas. Clouds of the Nelspruit area are subject to maritime and orographic influences, while the influences in the Bethlehem area are mainly of a continental nature.

In order to obtain an idea of how the transfer of cloud characteristics between these two areas along the continental divide takes place, the radar equipment at Nelspruit will be transferred to Carolina early in 1988 so that observations can be made in this transition area.

Technology transfer in irrigation

The delay which occurs between the release of research results and the application thereof has received the attention of the WRC on several

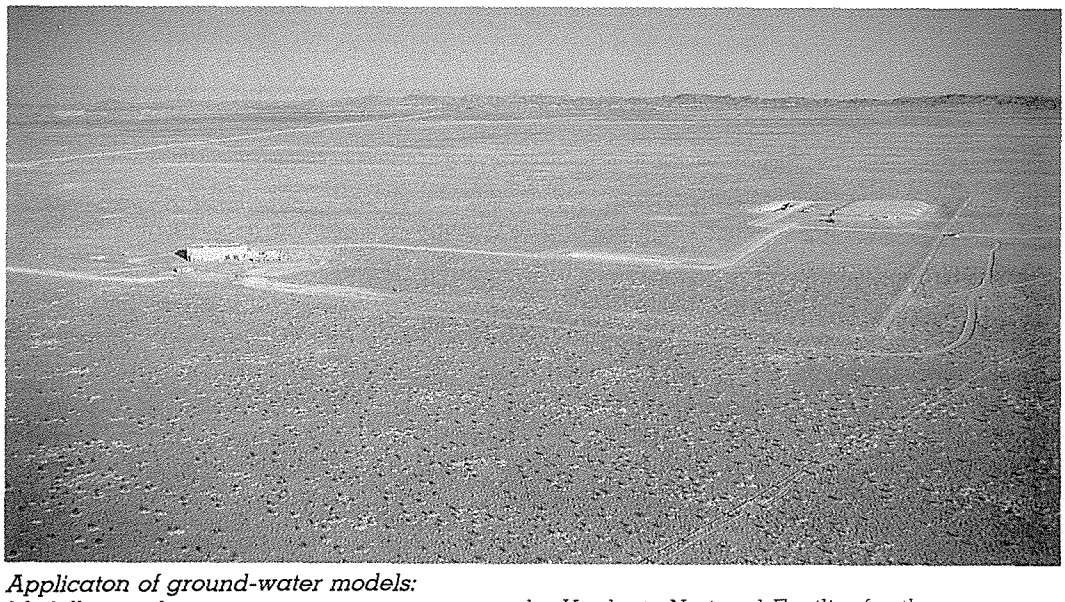


At the workshop for technology transfer in irrigation were from left, Mr D S van der Merwe (WRC) and Mr H Hamman (Department of Agriculture and Water Supply).

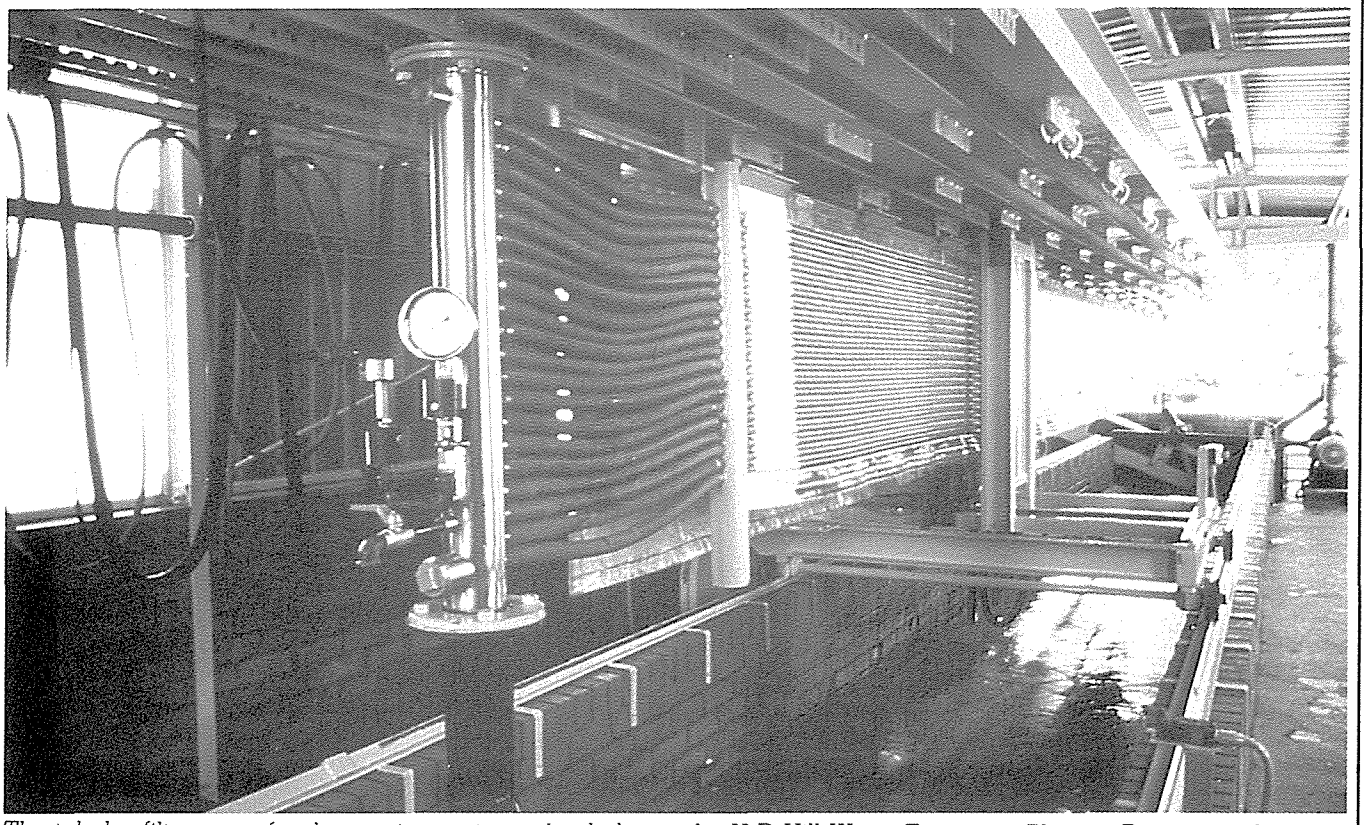
occasions. This has been confirmed in an investigation by the Winter Rainfall Regional Office of the Department of Agriculture and of Water Supply in 1985. The findings were that certain validated irrigation research findings were used by only 15% of the farmers concerned after four years.

Delays in the application of research results can lead to ineffective utilisation of resources by the irrigation community. It contributes to insufficient feedback to researchers from the field, with the result that the researcher cannot evaluate his results within the framework of a total farming system.

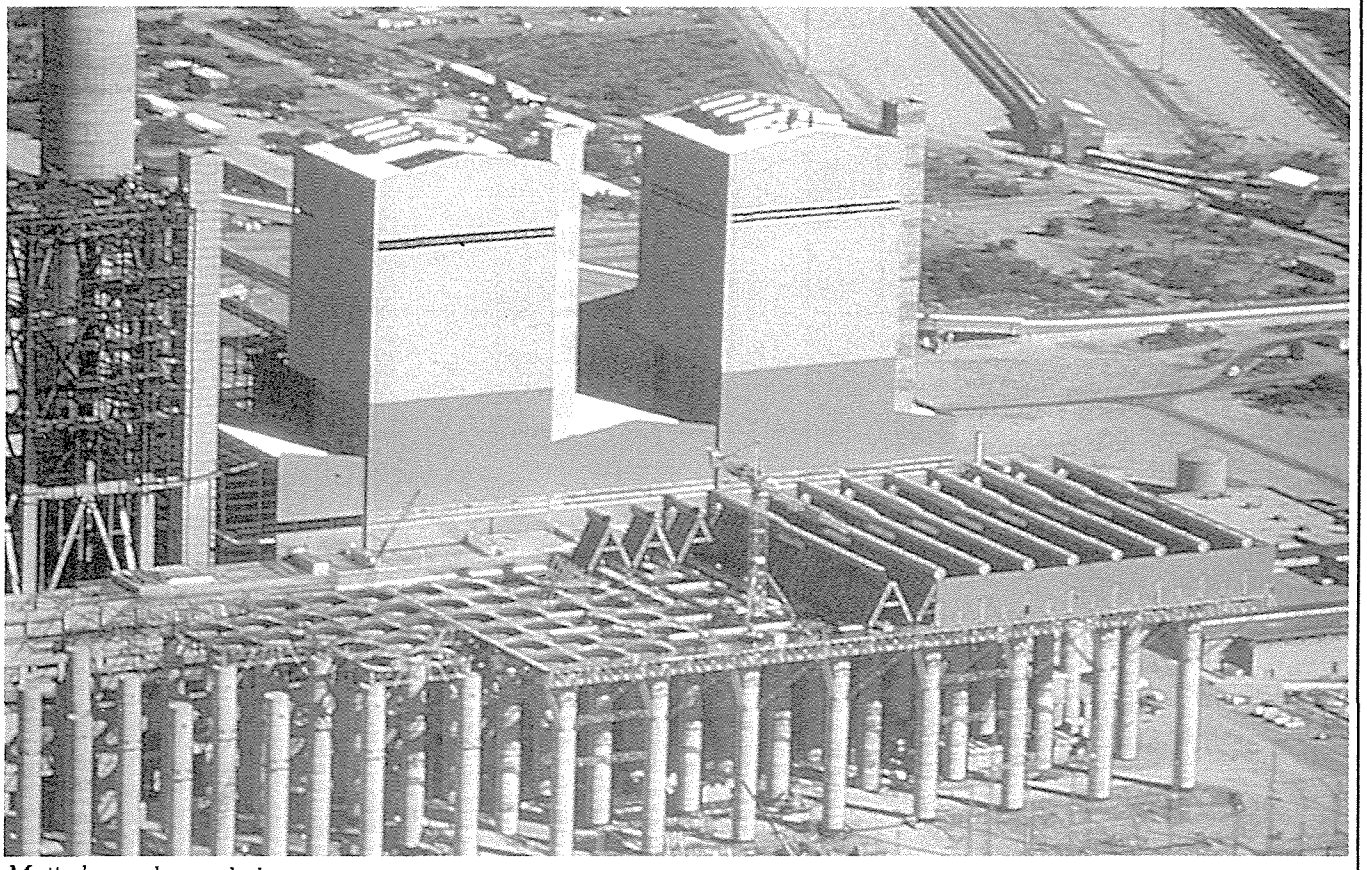
Against this background the WRC, in collaboration with members of the Coordinating Committee for Irrigation Research (CCIR), held a workshop in 1987 to evaluate the state of technology transfer in agriculture objectively and to have in-depth



Applicaton of ground-water models:
Modelling radioactive waste management at the Vaalputs National Facility for the Disposal of Radioactive Waste near Springbok in the Northern Cape.



The tubular filter press for dewatering waterworks sludge at the H D Hill Water Treatment Plant in Pietermaritzburg.



Matimba, a dry-cooled power station is presently under construction at Ellisras in the Transvaal. The first two units were commissioned in 1987 (Photo courtesy Bureau for Mechanical Engineering (BMI)).

Table 1
Expenditure on research areas in R $\times 10^3$* over the last decade

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987 (Estimated)
1. Hydrometeorology (mainly rainfall stimulation)	229 (7%)	227 (10,5%)	254 (9,5%)	297 (9%)	1 223 (30%)	2 285 (38%)	1 846 (28,3%)	2 030 (27,7%)	2 243 (25,8%)	2 361 (24,4%)
2. Surface hydrology	216 (7%)	274 (10%)	337 (12,5%)	404 (13%)	234 (5,5%)	321 (5,5%)	569 (8,7%)	545 (7,5%)	623 (7,2%)	717 (7,4%)
3. Ground water	586 (18,5%)	345 (13%)	238 (9%)	202 (6%)	96 (2%)	102 (2%)	456 (7,0%)	610 (8,3%)	611 (7,0%)	883 (9,1%)
4. Irrigation	119 (4%)	167 (6%)	175 (6,5%)	250 (10%)	486 (12%)	578 (10%)	708 (10,8%)	823 (11,2%)	1 050 (12,1%)	1 128 (11,7%)
5. Salinisation	–	–	–	–	106 (2,5%)	749 (12,5%)	221 (3,4%)	235 (3,2%)	244 (2,8%)	472 (4,9%)
6. Eutrophication	169 (5%)	69 (2,5%)	54 (2%)	–	59 (1,5%)	89 (1,5%)	133 (2%)	83 (1,1%)	137 (1,6%)	178 (1,9%)
7. Municipal waste water sewage sludge, and marine disposal	690 (22%)	262 (10%)	257 (9,5%)	365 (11,5%)	318 (8%)	264 (4%)	370 (5,7%)	386 (5,3%)	491 (5,6%)	670 (6,9%)
8. Industrial effluents	243 (7,5%)	297 (11%)	411 (15%)	495 (15,5%)	487 (12%)	626 (10,5%)	1 290 (19,8%)	1 305 (17,8%)	1 719 (19,8%)	1 107 (11,5%)
9. Treatment technology and water quality	689 (22%)	754 (28%)	581 (22%)	643 (20%)	650 (16%)	256 (4%)	339 (5,2%)	194 (2,7%)	423 (4,9%)	727 (7,5%)
10. Desalination	199 (6%)	180 (7%)	163 (6%)	188 (6%)	187 (4,5%)	361 (6%)	317 (4,9%)	316 (4,3%)	589 (6,8%)	931 (9,6%)
11. Water economy in urban areas	22 (1%)	27 (1%)	110 (4%)	136 (4%)	158 (4%)	139 (2%)	41 (0,6%)	621 (8,5%)	284 (3,3%)	108 (1,1%)
12. Water economy at power stations	–	20 (1%)	109 (4%)	177 (5%)	87 (2%)	228 (4%)	233 (3,6%)	173 (2,4%)	271 (3,1%)	381 (4,0%)
Total	3 162	2 672	2 689	3 157	4 091	5 998	6 523	7 321	8 685	9 663

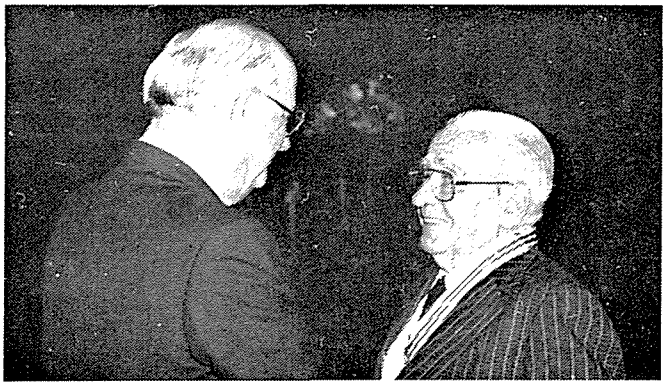
*Expenditure in terms of contracts for the execution of research projects.

discussions on research requirements, action programmes and/or training in this regard. A total of 63 participants, representing government departments, statutory bodies, universities, and the private sector attended the workshop. Subjects under review were the suitability of irrigation technology for transfer, problems regarding means of communication and the acceptance of the technology by developed and developing irrigation communities. A report on the recommendations of this workshop will be reviewed by the CCIR for further action.

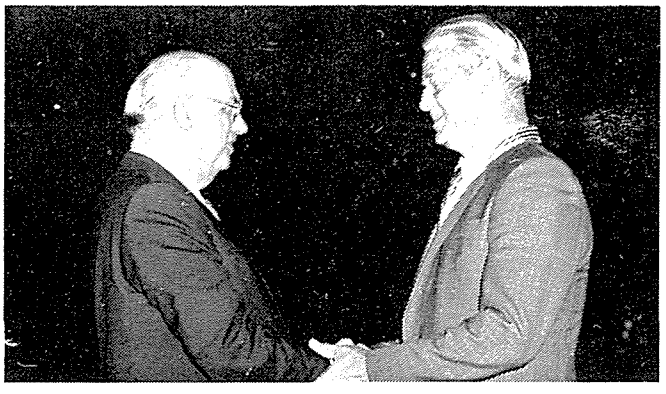
Research on leak detection in water supply systems

Although some facets of leak detection and related equipment still have to be researched, the current state of affairs is that completed WRC projects have provided sufficient guidelines to establish leak detection as a water economy measure. The research took place in Johannesburg and Pretoria where 19 and 6 suburbs respectively formed a part of the investigation. As a result of the success which was achieved in these suburbs, both City Councils intend investigating the rest of their water reticulation systems as well.

A minimum investment of R60 000 for leak detection equipment is required to launch a successful leak detection operation. As a result of WRC initiatives, the municipalities of Durban, Pietermaritzburg, Bloemfontein and Cape Town have already made this investment, while six commercial organisations were established to undertake investigations for smaller city and town councils.



On the photograph above Dr G J Stander is seen receiving the Order for Meritorious Service Class I: Gold from the State President Mr P W Botha, and on the other photograph Dr N Stutterheim is honoured in the same way.



Dry cooling

Research on dry cooling at power stations reached a milestone in 1987 when the first two stages of the Matimba Power Station at Ellisras were commissioned. The total output of the power station, which makes use of a direct air-cooled condensing system, will eventually be 3 800 MW, which is approximately ten times as big as the next largest similar power station in the world.

A joint research effort by the WRC, Eskom, CSIR and the University of Stellenbosch was initiated about eight years ago. A number of factors which were still unknown at the time because of the size of the power station, were investigated during this period to ensure optimum performance upon commissioning of the station.

Socio-economic effects of water restrictions

The WRC initiated an investigation into the socio-economic effects of water restrictions which were imposed as a result of the drought in Natal, the Vaal River system and the Riet River and Vaalharts Government Water Schemes. The research was done by the Institute for Social and Economic Research of the UOFS, the Bureau for Market Research of the University of South Africa and the Centre for Applied Social Sciences of the University of Natal.

The total estimated effect of the restrictions over the period March 1983 to March 1985 was R468 million. A large part of the amount, approximately 44%, was, however, the result of expenses for permanent improvements to properties, such as boreholes and paving.

More details appear in **Chapter 17.**

State President Awards

A former chairman and chief executive officer of the WRC, Dr G J Stander, and a present member, Dr N Stutterheim both received the Order for Meritorious Service, Class I: Gold from the State President, Mr P W Botha in 1987.

The award to Dr Stander was based on his outstanding initiatives in improving the standard of water research in South Africa, while Dr Stutterheim received his award for his important contributions over many years and in many areas for the advancement and application of engineering in South Africa.

2 Research on hydrometeorology

IN view of the fact that South Africa's water supply is derived from the atmosphere and is subject to highly variable conditions in the atmosphere, the Commission supports research that concentrates on those aspects of atmospheric sciences that have an impact on the water resources.

In this field of hydrometeorology two of the research projects deal with rainfall stimulation, one with the revision of the temporal and spatial distribution of precipitation statistics and one with the stochastic generation of climatic data. An important event during the year was the establishment of the Coordinating Committee for Research on Hydrometeorology (CCRH) which will play a prominent role in the promotion and coordination of those aspects of the atmospheric sciences which are directly related to water.

Rainfall stimulation

It is now common knowledge that the demand for water is likely to exceed the total national supply by about the year 2020 and there are important regions such as the Vaal River catchment where demand has already exceeded the available water resources of that region. The implication is that there are about three decades in which to find substantial additional supplies of water for South Africa. These additional supplies of water must come from the so-called unconventional sources of water such as rainfall stimulation, towing icebergs from the Antarctic, desalination of sea water and the importation of water from neighbouring countries. It has been estimated that the average annual runoff in all the rivers in South Africa is less than 1% of the moisture moving over the country in the form of water vapour in the atmosphere and it would be irresponsible not to investigate the feasibility of tapping more of this vast amount of water of excellent quality over the land where it is required before it moves back over the oceans.

The Commission supports a rainfall stimulation research project in the Lowveld and along the escarpment, based at Nelspruit and also contributes to the Bethlehem precipitation research project of the SA Weather Bureau, Department of Environment Affairs, which is situated on the Highveld. Research at these two sites will make it possible to assess the potential for rainfall stimulation on either side of the continental divide across which water is transferred in terms of the major inter-basin transfer schemes.

The results of the research done so far in the vicinity of Nelspruit and Bethlehem indicate that the dominant rain-forming mechanisms in the clouds that produce most of the rainfall differ in many respects. It is therefore necessary to determine how far the characteristics of the clouds in the two areas extend into the larger scale area along the continental divide where cloud treatment for runoff augmentation is most likely to be applied in the future. For this reason, the research team at Nelspruit will be extending their observation of clouds into the area around Carolina and Ermelo from October 1987. In addition, negotiations are under way between the Department of Environment Affairs and the Water Research Commission to bring about closer integration of the activities of the research teams at Nelspruit and Bethlehem.

Completed project

Research on the revision of the temporal and spatial distribution of precipitation statistics in southern Africa

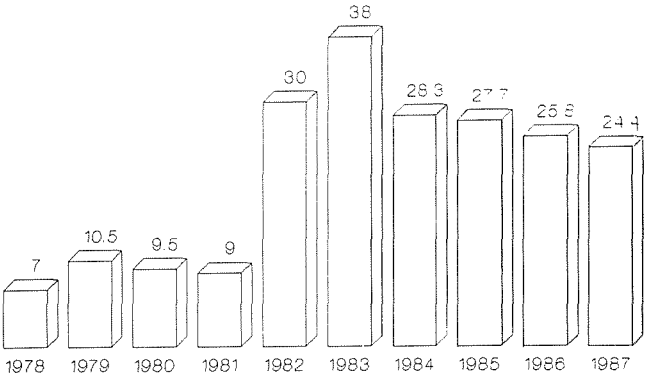
The project was carried out by the University of Natal. It involved the revision of the mean annual precipitation map series using the latest available data and techniques. New mean annual precipitation maps at a scale of 1:250 000 were made available while the spatial and temporal distributions of precipitation, regions of homogeneous rainfall and other statistics such as medians, variability and monthly precipitation were re-evaluated. The statistics are available through the Computing Centre for Water Research (CCWR) (See **Chapter 18.**)

New research project

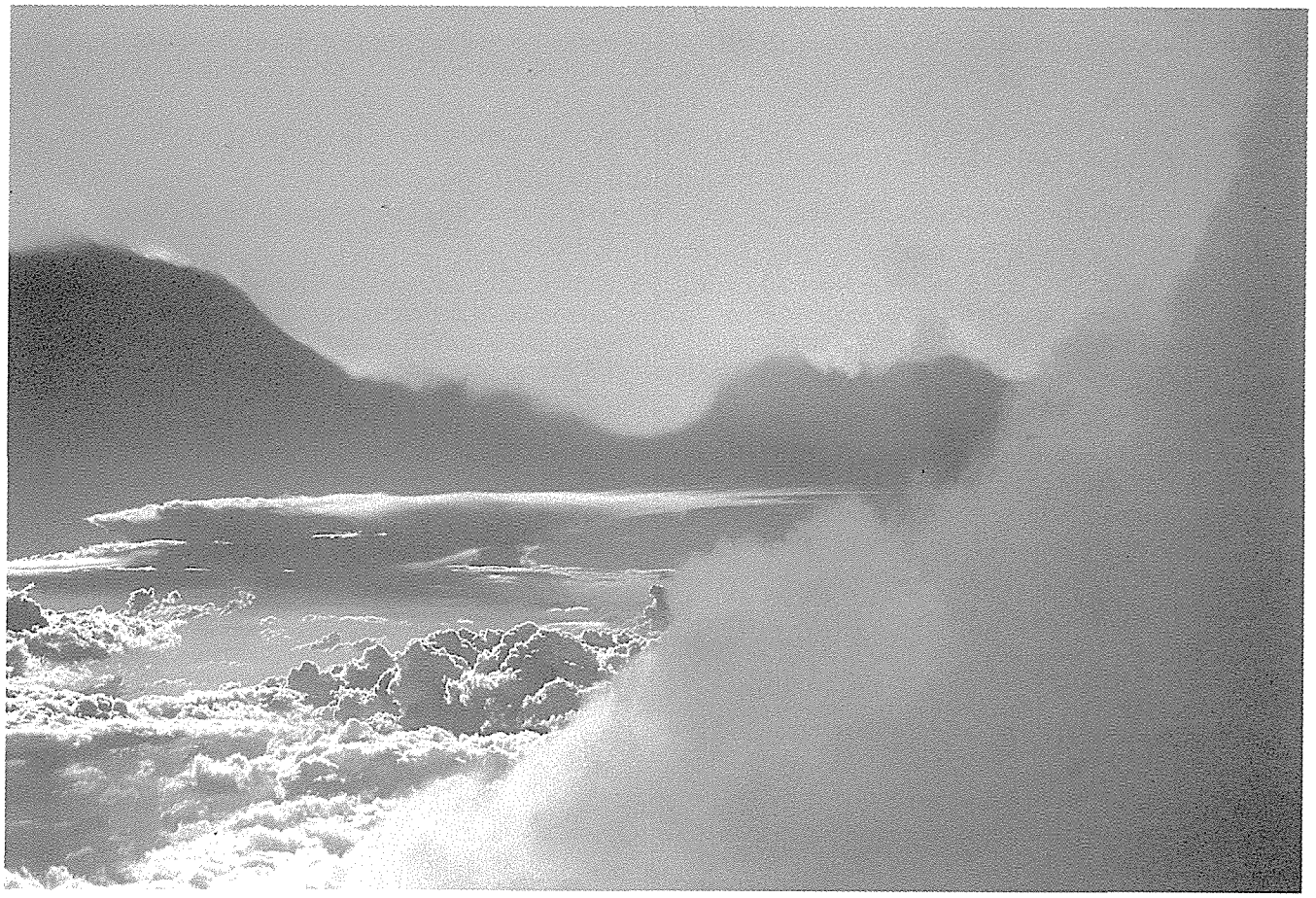
The development of a stochastic daily climate model for South African conditions

This new 3-year research project was initiated during the year in terms of an agreement between the Commission and the University of Cape Town. This research project represents a continuation of the research effort on droughts.

A very useful contribution to the assessment of drought risk was made by a previous research project entitled *Research on Drought Occurrence*



Funding of research on Hydrometeorology expressed as a percentage of total WRC research expenditure (1978 to 1987).



Clouds associated with thunderstorms are the focus of attention.

undertaken during the period 1981–1984 by the University of Stellenbosch in terms of an agreement with the Water Research Commission. One of the most important results of this research project was the provision of a daily rainfall model which permits the generation of long representative rainfall sequences which can be used in the assessment of various forms of drought risk for any area in South Africa. However, only rainfall is simulated by the model.

The new project being carried out by the Department of Mathematical Statistics of the University of Cape Town is aimed at extending the daily rainfall model to cover a description of simultaneous joint probability of other important variables such as sunshine duration, temperature, relative humidity, evaporation, wind run and solar radiation.

Coordinating Committee for Research on Hydrometeorology (CCRH)

The first meeting of the CCRH was held on 13 July 1987 and the objective on this coordinating committee is to assist the Commission in its task of promoting and coordinating those aspects of atmospheric research that are related to water. The CCRH has close links with the National Committee for Weather Climate and Atmosphere Research of the CSIR which deals with atmospheric sciences in general whereas the goal of research which is of interest to the CCRH can be stated as:

> "To acquire an adequate understanding (for predictive purposes) of the ways in which the atmosphere controls the amount and variability of the national water supply so that management procedures can be improved and the potential for augmentation assessed".

The research will cover aspects such as:

- Energy studies relating to radiation, evaporation, and evapotranspiration within the context of the water budget at catchment scale and larger, and modification of these by intervention;
- Atmospheric studies relating to extraction of moisture from the atmosphere;
- Precipitation studies related to the water budget including measurement, statistical and physical properties, energy, modification and prediction for water resource control, planning and management;
- Atmospheric studies related to extreme events

(such as water resource droughts and flood-producing rains) including measurement, statistical properties, severity and prediction;
- Climatology including prediction and changes on a nationwide and regional scale with an emphasis on forecasting for water resource applications; and
- Any other matters relating to hydrometeorology.

The members of the new CCRH face an important task. In the light of the fact that South Africa's limited water supplies are derived from the atmosphere and that atmospheric conditions play such an important role in determining the variability of both supply and demand, the efficient coordination and promotion of this type of research will be an important factor in meeting the water resource needs of tomorrow.

List of research projects

Completed project

- Research on the revision of the temporal and spatial distribution of precipitation statistics in southern Africa (The University of Natal - Department of Agricultural Engineering).

Existing projects

- Bethlehem precipitation research project (The Department of Environment Affairs - Weather Bureau).
- Programme for atmospheric water supply at Nelspruit (The Company for Research on Atmospheric Water Supply (CRAWS), subcontracting the Council for Scientific and Industrial Research and CloudQuest (Pty) Ltd.).

New project

- The development of a stochastic daily climate model for South African conditions (The University of Cape Town - Department of Mathematical Statistics).

3 Research on surface hydrology

HYDROLOGICAL research aims at aiding the optimum development and management of the surface water resources of South Africa. To do this, the following three primary goals are addressed:

- to assess the temporal and spatial characteristics of surface water resources accurately and thereby to get a more accurate assessment of present resources;
- to predict the future water supply and demand situation adequately, thereby getting a better idea of future resources; and
- to develop the scientific means of evaluating alternative water resources management options.

These are general goals applicable to all organisations undertaking surface water research, including the Water Research Commission.

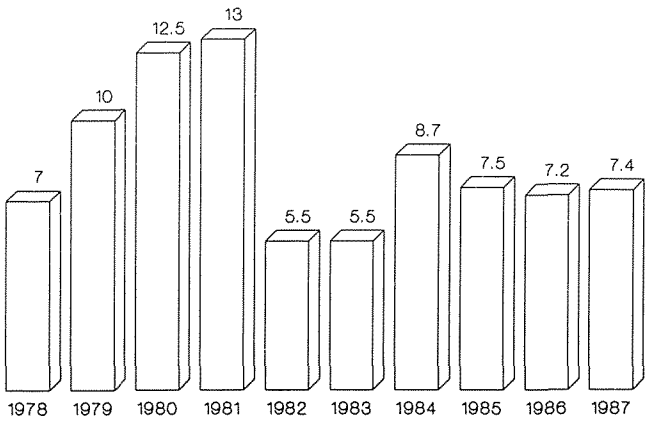
During the past year, the Water Research Commission continued its emphasis on the development of research support services, some of which are particularly relevant to hydrology. These are reported on in **Chapter 18**. Information of relevance for the coordination, planning and direction of hydrological research should become more readily available from now on.

The Commission sponsored five hydrological research projects during 1987. One was completed and one new project was initiated.

New research project on surface hydrology

The development of methods to assess the impact of agricultural practices on water resources in southern Africa

This new 5-year project is being undertaken by the University of Natal through their Department of Agricultural Engineering. Recent developments, for example, the increased number of farm dams and tillage and conservation practices which are designed to improve infiltration and reduce runoff, have made significant advances with respect to utilising the rainfall where it falls. Water resources and agricultural management, especially with regard to catchment management strategies, are therefore inextricably linked. The impact of alternative management options regarding the agricultural/water resources interface needs to be researched and established on a sound scientific basis. Methods to assess the impact of agricultural practices on water resources more accurately need to be developed. These methods will provide a valuable tool for the planning and management of water resources and agriculture at national, regional and local scales.



Funding of research on Surface Hydrology expressed as a percentage of total WRC research expenditure (1978 to 1987).

The project intends to develop such methods and to build them into a decision support system. This will enable decision makers to quantify, compare and optimise the effectiveness of water use associated with:

- land-use planning in agriculture and forestry;
- utilising limited quantities of irrigation water on greater areas of irrigable land (deficit irrigation); and
- assessing the impact on water resources of promoting the use of rainfall *in situ* (dryland farming) as opposed to promoting runoff.

Completed project

Research on design stormflow and peak discharge for small catchments in southern Africa

This project was carried out by the University of Natal. It involved, firstly, updating and revising the SCS (Soil Conservation Service of America) manual for the estimation of flood events from small catchments in southern Africa and secondly, research into the use of joint associations of rainfall and catchment antecedent conditions for improving flood estimation. A new and much improved manual can now be made available to South African hydrological practitioners. This work represents the culmination of some ten years effort by the University of Natal and the WRC into small catchment flood estimation techniques, in particular the SCS method. Because of its great practical application possibilities the results are to be released as one of the reports in the WRC's technology transfer series.

Coordinating Committee for Hydrological Research (CCHR)

The CCHR, its composition and function were redefined during 1987. It now consists of representatives of the following organisations:

- The Water Research Commission
- The Department of Water Affairs

Typical small catchment flood for which new estimation procedures have been finalised, based on the SCS technique.

- The Department of Agriculture and of Water Supply
- The Department of Environment Affairs
- The University of the Witwatersrand
- The University of Natal
- Rhodes University
- Council for Scientific and Industrial Research (CSIR)
- The Computing Centre for Water Research (CCWR)

The composition of this committee is reviewed every three years.

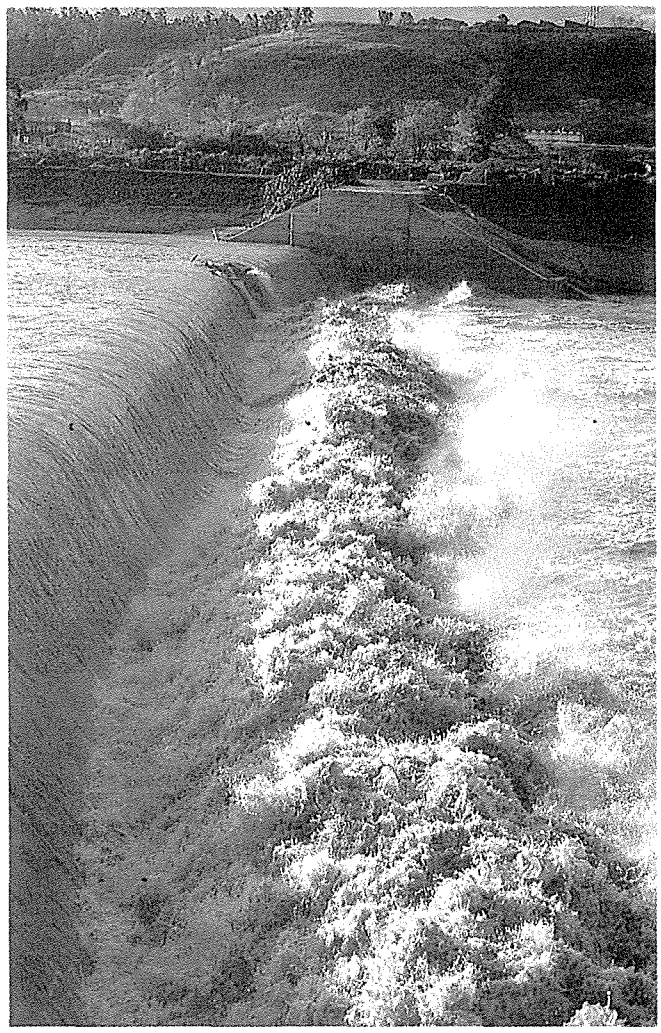
The functions of this committee have been defined as:

- the identification of research needs in the area of surface hydrology;
- the recommendation of priorities for the research needs;
- the development, revision and updating of a master research plan;
- the documentation of current and past research;
- the monitoring of research progress; and
- the formulation of recommendations for technology and information transfer actions.

While the CCHR has no decision-making authority *per se* it does make recommendations to the WRC to help with the coordination of research which is a prescribed responsibility of the WRC. Coordinating committees are viewed by the WRC as one of the important means of coordinating water research in South Africa.

Consultants

Dr F I Morton from Canada, a very well known hydrologist specialising in evapotranspiration, visited South Africa in November as a consultant to the WRC and the Department of Environment Affairs. During his stay he visited various organisations where projects are being undertaken on behalf of the WRC and shared his expertise



Large catchment floods have also been a significant feature of South African hydrology during 1987/1988.

with them. Additionally, he delivered the keynote address at the Forestry Symposium, marking fifty years of research in mountain catchments of South Africa, and many seminars.

Prof W J R Alexander of the University of Pretoria, Department of Civil Engineering, was contracted by the WRC as a consultant during 1987 to undertake the development of a multi-objective, computer-based, decision support system for the planning and management of water resources. The system consists of a number of computer programs covering such aspects as flood frequency analyses, systems models, optimisation and others.

List of research projects

Completed project

- Research on design stormflow and peak discharge rates for small catchments in southern Africa (The University of Natal - Department of Agricultural Engineering).

Existing projects

- Hydrological research in catchments of the eastern and southern Cape (Rhodes University - Department of Geography).
- Applied hydrological process and modelling studies for the determination of water and sediment yield (The University of Natal - Department of Agricultural Engineering).
- Research on the effects of urbanisation on catchment water balance (The University of the Witwatersrand - Department of Civil Engineering, Water Systems Research Programme).

New project

- The development of methods to assess the impact of agricultural practices on water resources in southern Africa (The University of Natal - Department of Agricultural Engineering).

4 Research on ground water

GROUND water is important in South Africa because about two thirds of the surface area of the country relies heavily on ground water for household use, stock watering, irrigation on a limited scale and supplying relatively small municipalities. However, the total volume of ground water used is only about 15% of the total water used in South Africa. It has been estimated by the Department of Water Affairs that it would be practically and economically feasible to increase the contribution from ground-water sources to approximately 5 400 million m^3/a which represents about three times the volume of ground water used in 1980.

In order to make better use of our national ground-water resources, the Commission has been financing research programmes designed mainly to cover the following aspects:

- improvement of techniques for determining the exploitation potential of ground water;
- development of techniques for obtaining adequate estimates of the rate at which the ground-water reserves are being replenished in various parts of the country;
- investigations of the potential of integrating ground water and surface water supplies in conjunctive use systems especially in the PWV area where extensive dolomitic compartments are found;
- development of mathematical models as aids to the assessment and management of various South African ground-water systems. Attention is paid to both quantitative and pollution aspects; and
- the development of a South African national data bank for ground-water data.

During the year two new research programmes were initiated, both involving investigations of the use of geophysical techniques in ground-water location and management. In addition, an important development during the year was the establishment of the Coordinating Committee for Geohydrological Research (CCGR) which is expected to play a major role in the coordination and promotion of ground-water research in South Africa.

New research projects

Research on the use of electromagnetic exploration techniques for the development of ground-water resources

This project is being carried out by the Department of Geology at the University of Pretoria in terms of an agreement with the Commission. The duration of the project will be three years.

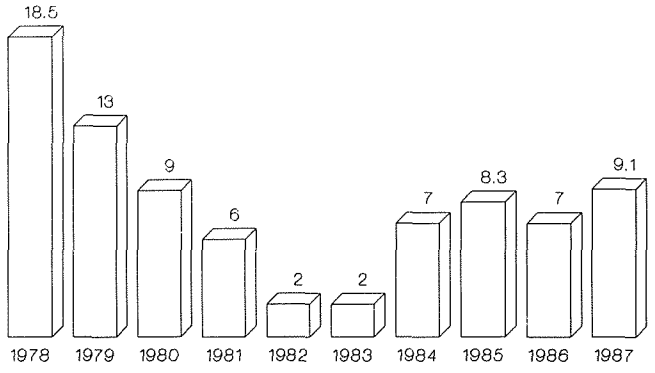
The use of geophysical techniques plays an important role in the development of ground-water resources but there is an urgent need to research the benefits and limitations of various geophysical techniques under a variety of South African conditions. The main objectives of the project are:

- The evaluation of the time-domain electromagnetic method for the location and mapping of primary and secondary aquifers beneath relatively thick deposits of sand in the Kalahari desert and the comparison of the results of using this technique with the results obtained from direct current soundings already carried out in the study area.
- The evaluation of various frequency-domain electromagnetic techniques for the location of relatively shallow secondary aquifers.
- Evaluation of the applicability of the above techniques to dolomitic areas. The frequency-domain techniques can be used to cover large surface areas in a relatively short time and represent cost-effective methods of carrying out geoelectric mapping surveys.
- To develop a physical modelling laboratory to test field results and model simulations.

Evaluation and development of techniques for the determination of geohydrological parameters by using geoelectrical methods

A new project is being carried out by the National Physical Research Laboratory of the CSIR over a 2-year period.

The main objective of this research project is to study the relationships between geoelectrical and geohydrological properties of selected primary and secondary aquifers in South Africa and to evaluate the applicability of the relationships.



Funding of research on Ground Water expressed as a percentage of total WRC research expenditure (1978 to 1987).

Ground Water

Packer testing at the Atlantis aquifer.

Coordinating Committee for Geohydrological Research (CCGR)

Until recently, research related to ground water was coordinated by the WRC Coordinating Committee for Hydrological Research (CCHR). However, hydrology is a multidisciplinary subject that covers a wide variety of aspects and it was feared that some of these aspects were not receiving the amount of attention that they deserved. Two of these aspects were ground-water research and hydrometeorology and separate coordinating committees have now been formed to cover these aspects. They are the Coordinating Committee for Geohydrological Research (CCGR) and the Coordinating Committee for Research on Hydrometeorology (CCRH). More information about the CCRH is provided in **Chapter 2**.

The main functions are the same as for the CCHR (see **Chapter 2**).

In order to carry out these functions efficiently, the WRC invited various research and end-user organisations (those who will utilise the results of the research, see **Chapter 2**) to serve on the CCGR.

The major task of the members will be to make recommendations to the WRC about coordination of geohydrological research. In particular, the CCGR will be dealing with research that contributes to the optimum development and management of the ground water resources of southern Africa. The research will cover aspects such as:

- instrumentation, methods and techniques;
- process studies;
- location and development of ground-water resources;
- geohydrological studies and modelling of specific ground-water systems;
- regional geohydrological studies;
- pollution of ground water;
- the effects of mining activities; and
- artificial recharge

List of research projects

Existing projects

- An investigation into rainfall recharge to ground water (A firm of consulting engineers; Steffen, Robertson and Kirsten).
- The development of a National Data Bank for groundwater data (The University of the Orange Free State - Institute for Groundwater Studies in collaboration with the Department of Water Affairs).
- Modelling of the ground-water quality in the Atlantis aquifer (The University of the Orange Free State - Institute for Groundwater Studies).
- Research on the exploitation potential of Karoo aquifers (The University of the Orange Free State - Institute for Groundwater Studies).

New projects

- Research on the use of electromagnetic exploration techniques for the development of ground-water resources (The University of Pretoria - Department of Geology).
- Evaluation and development of techniques for the estimation of geohydrological parameters by using geoelectrical methods (CSIR - National Physical Research Laboratory).

5 Research on irrigation

IRRIGATION farming will continue to be the largest consumer of water resources in South Africa for many years to come. There is little doubt that the development and application of improved irrigation technology could bring about a much more effective use of irrigation water. This implies that agricultural productivity under irrigation could be enhanced significantly without a concomitant increase in the use of irrigation water.

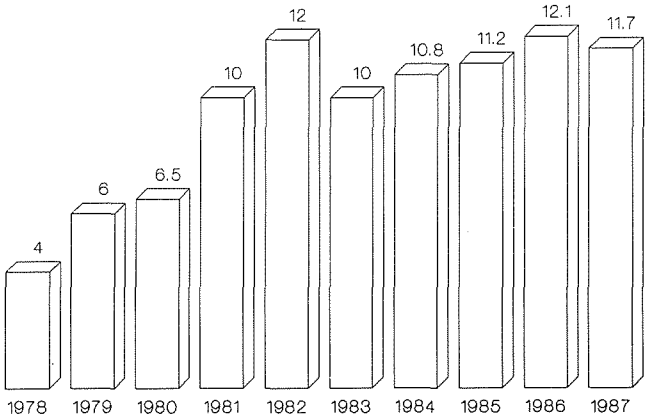
Irrigation research in South Africa, which includes that financed by the WRC, is contributing a wealth of information and knowledge which can be used to improve existing irrigation technology. The immediate challenge is to incorporate this knowledge and promote the application of the improved technology. This challenge is being met in increasing measure by the irrigation research programme supported by the WRC. Several existing and planned projects now provide for direct participation by the end user, the irrigation farmer. This has the dual advantage of a quicker approach to an acceptable technology, and the creation of a greater awareness of, and demand for, an improved and proven technology. Projects are also incorporating economic analysis to a greater extent than before, in recognition of the fact that economic profitability is probably the most important of all incentives for the adoption of more efficient irrigation methods.

Workshop on technology transfer in irrigation

This workshop was arranged by the WRC and held under the auspices of the Coordinating Committee for Irrigation Research (CCIR) in September 1987. The 63 participants from various interested organisations were given the task of identifying needs for research and other actions within the following problem areas:

- suitability of irrigation technology for transfer to various target groups and for application;
- existing communication channels and methods;
- adoption of irrigation technology by developed irrigation communities; and
- adoption of irrigation technology by developing irrigation communities.

The recommendations of the workshop will be considered by the CCIR after which a report on the workshop will be published.

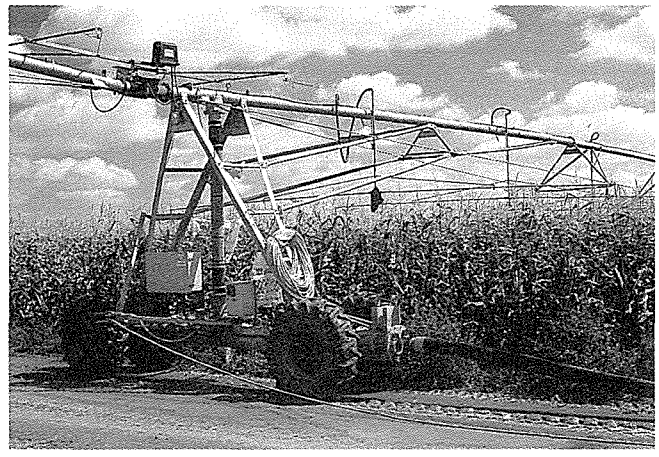


Funding of research on Irrigation expressed as a percentage of total WRC research expenditure (1978 to 1987).

Report released

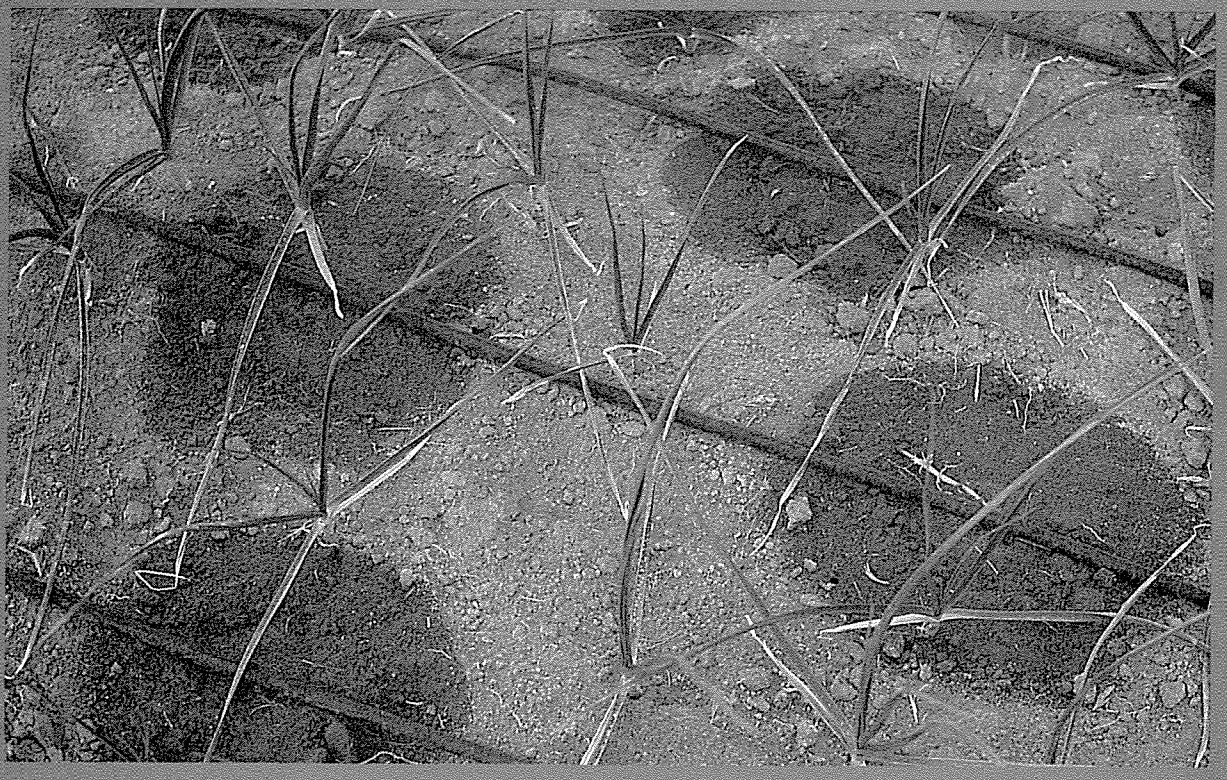
Evapotranspiration and water use studies by means of weighing lysimeters

The first phase of ongoing research by the Soil and Irrigation Research Institute of the Department of Agriculture into the soil/plant/atmosphere continuum as it relates to water use by crops was concluded with the report entitled *Evapotranspiration and water use studies in wheat and soybeans with the help of the weighing lysimeter technique.* It has contributed substantially to a better understanding of the process of water flow through the soil/plant/atmosphere system, the



Stubble mulching used for maize cultivation under mechanised irrigation: a possible method to prevent crust formation in soils.

Irrigation



Drip irrigation of vegetable crops.

onset of water stress in crops and the effects of water stress on crop growth, water use and yield. In the course of carrying out the research, a considerable number of valuable techniques were developed and evaluated, many of them relating to the early detection of the onset of crop water stress.

Completed projects

Research on a wheat irrigation scheduling service for the Free State region

This project, completed by the University of the Orange Free State, succeeded in demonstrating the feasibility of providing an effective irrigation scheduling service on an irrigation scheme such as Vaalharts. Meteorological data from an automatic weather station in the Vaalharts area were obtained daily in Bloemfontein and processed through the PUTU-9 irrigation scheduling model for wheat. Logistics of communicating information and advice to farmers were developed and tested. The ability of PUTU-9 to assess the degree of crop water stress on a continuous basis proved to be of considerable value for working out irrigation scheduling strategies for coping successfully with water restrictions which were in force at the time. The PUTU-9 model itself, developed under a previous research contract, underwent further testing and refinement during this project.

Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems

The final report on this project, produced by a firm of consulting engineers and entitled *The development of procedures for design and evaluation of irrigation systems*, describes the development of user-friendly software for the design of all pressurised irrigation systems excluding centre pivot and other mechanical move type systems. The design process has been comprehensively analysed, formally structured into modules and fully documented. This will facilitate ongoing improvement of the software as better algorithms are developed. Certain of the hydraulic design procedures provide for fully optimised designs, but optimisation has not been extended to the design process as a whole. A strong feature is nevertheless a built-in design evaluation capability which enables the designer to compare alternative designs with regard to specified objectives or criteria such as uniformity of distribution, crop yield per unit area, application efficiency and/or financial return on investment.

Development of the required apparatus and programmes for the monitoring and management of irrigation systems

The aim of this project, carried out by the University of Stellenbosch, was to develop an economical monitoring system which would allow daily crop water requirements to be estimated, performance of a commercial irrigation system to be assessed in relation to crop water requirements, and the management of the system to be adjusted for best performance. As described in the final report, this aim was achieved as follows: firstly, by developing, adapting or selecting suitable sensors for monitoring soil water content and water potential, quantity and flow rate of water supplied, pan evaporation and other relevant meteorological variables; and secondly, developing the necessary hardware and software for computer-controlled data capture and processing.

New research projects

Research on the development of criteria for sprinkler irrigation systems to combat surface sealing of soils

Soil surface sealing is a widespread phenomenon which greatly retards infiltration of rain and irrigation water into soil and hampers seedling emergence. It is exacerbated by mechanical dispersion of soil particles at the soil surface due to the impact energy of falling water drops. A 4-year project, jointly undertaken by the University of Potchefstroom and the University of Pretoria has been initiated to quantify the effects of the various factors which contribute to surface sealing, to design and construct an efficient sprinkler irrigation simulator and infiltrometer, to determine design infiltration capacities of soils destined to be sprinkler-irrigated and to recommend modifications to sprinkler systems in circumstances where surface sealing can become a problem.

Research on the development of an adjustable low pressure flow-rate control valve for flood irrigation

Flood irrigation is practised on more than half the area under irrigation in South Africa. Measures to increase the efficiency of flood irrigation are therefore of the utmost importance for the saving of water by the irrigation sector. One of the most important limitations on the accuracy of flood irrigation is the lack of an inexpensive practical means of measuring and maintaining the design flow rate, which governs the quantity of water applied to the land. This limitation will be overcome if this new 2-year project, undertaken by the University of Pretoria, is successful in developing a low cost, low-pressure flow-regulating valve which will maintain a constant outflow from a small farm reservoir under conditions of falling pressure head.

An investigation into methods of developing operational rules for individual irrigation systems

Operating rules for individual irrigation systems

(including irrigation scheduling procedures) are mostly based on meteorological measurements coupled with soil, crop and irrigation system parameters. Invariably they incorporate a large degree of generalisation. Because spatially variable local conditions are important, generalised operating rules may differ considerably from those which would give the highest irrigation efficiency under the given circumstances. In this 3-year project, the University of Stellenbosch will seek to develop a computerised method of *in situ* optimisation of operating rules for any particular irrigation system. This will be achieved through an iterative process of irrigation performance monitoring under reigning operating rules followed by systematic parameter adjustment and implementation of revised operating rules, this process being repeated until an acceptable level of performance is achieved.

Research on economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State

The economic advantages of more efficient irrigation practices, if adequately demonstrated, would be a strong incentive for adopting such practices. At present, the economic soundness of many recommended irrigation practices is uncertain on account of a past neglect of economic analysis. This 4-year project, which has been initiated at the University of the Orange Free State, aims to develop the methods needed for adequate economic evaluation of irrigation scheduling strategies. These methods will initially be used to investigate the economic efficiency of various irrigation scheduling strategies applied to wheat produced with a typical irrigation system under a range of growing conditions in the Orange Free State and adjacent areas.

List of research projects

Completed projects

- Research on a wheat irrigation scheduling for the Free State region (The University of the Orange Free State - Department of Agrometeorology).
- Development of the required apparatus and programmes for the monitoring and management of irrigation systems (The University of Stellenbosch - Department of Civil Engineering).
- Research on the development of procedures for the selection of appropriate irrigation methods and for the design of irrigation systems (A firm of consulting engineers; Murray, Biesenbach and Badenhorst).

Existing projects

- Research on the effect of different times and intensities of internal plant moisture stress on photosynthesis, respiration and water use efficiency of certain agronomic crops (The University of the Orange Free State - Department of Agronomy/Horticulture).
- A detailed regional soil moisture deficit analysis for irrigation planning in southern Africa (The University of Natal - Department of Agricultural Engineering).
- An investigation into the condition of soils irrigated over a protracted period and an evaluation of applicable selection criteria, and reclamation and control measures (The Potchefstroom University for CHE - Department of Pedology).
- Research on the use of the soil-root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil/plant/atmosphere systems (The University of the Orange Free State - Department of Soil Science).
- Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat (The University of the Orange Free State - Department of Agrometeorology).
- Research on the practical scheduling of irrigation in the northern Transvaal (The University of the North - Department of Crop Production).
- Research on 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).
- Investigation into water use and productivity of crops under conditions of water stress and the modelling thereof (The Department of Agriculture and Water Supply - Soil and Irrigation Research Institute).
- Research on improving irrigation management, based on soil water monitoring and detailed knowledge of profile available water capacities (The University of Fort Hare - Department of Soil Science).
- Development of a computer programme to simulate the flow of water in distribution canals (The Rand Afrikaans University - Department of Civil Engineering).
- Research on drip irrigation of tomatoes (The University of Pretoria - Department of Plant Production).

New projects

- Research on the development of an adjustable low pressure flow-rate control valve for flood

irrigation (The University of Pretoria - Department of Agricultural Engineering).

- Research on 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).
- An investigation into methods of developing operational rules for individual irrigation systems (The University of Stellenbosch - Department of Civil Engineering).
- Research on 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).

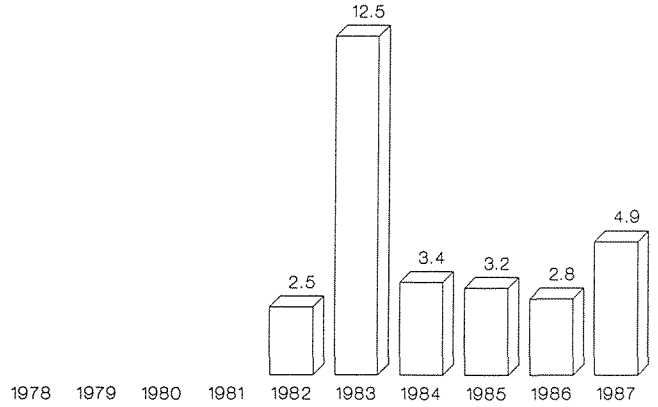
6 Research on salinisation

SURFACE waters increase in salinity directly as a result of the consumptive use thereof; the discharge of return flows into rivers and streams; the evaporation of impounded water; and the leaching of salts from the soil. The quality of return flows varies considerably depending on the source of salts, the potential amount of salt associated with every source, salt mobilisation processes, as well as the route along which return flows take place. Rising salt concentrations in our water resources have serious cost implications for most users and must therefore be actively combated. Measures to control increases in salinity should be based on a thorough understanding of the processes which result in increased salt concentrations and loads. Appropriate research needs to obtain this understanding have been identified as a result of the coordination role that the Commission has played amongst various organisations which have an interest in salinity research and control.

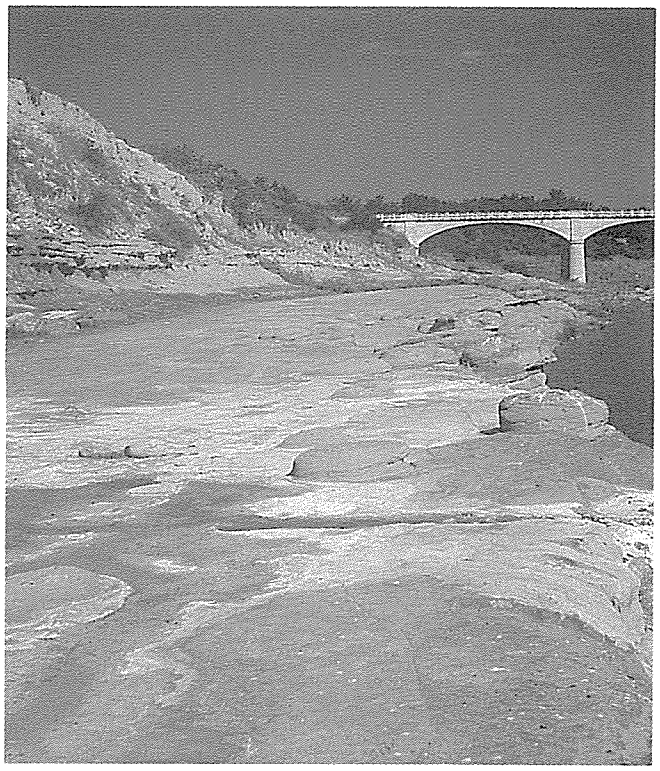
Salinisation as a result of irrigation return flows

The portion of irrigation water which is not used consumptively, seeps through the soil and underlying material and eventually returns, par ly to rivers and streams, and partly to recharge underground water. The volume and composition of this so-called irrigation return flow greatly affects the water quality of a number of rivers. For this reason it is imperative to be able to forecast what the volume and composition of the return flows will be. Notwithstanding the complexity and multiplicity of the processes concerned, good progress has been made in reaching this goal. Research on several aspects of this subject is being funded by the Commission through four research projects.

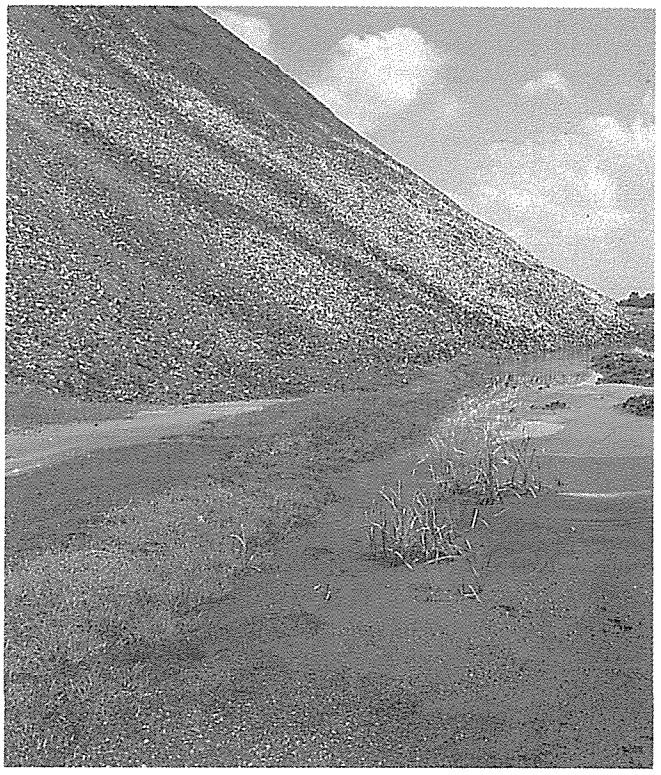
A pilot study to determine the practical and economic feasibility of conducting the necessary measurements for compiling the water and salt balances for an area under irrigation is being finalised. The study of the Breede River (Robertson)



Funding of research on Salinity expressed as a percentage of total WRC research expenditure (1978 to 1987).



Irrigation return flow originating from irrigated land seeping back over bedrock to the Sundays River.



Acid drainage area next to a colliery dump.

irrigation canal has been carried out by a firm of consulting engineers in collaboration with the Department of Water Affairs.

The University of Stellenbosch is currently testing the abilities of a number of salt and water transport models to predict the quantity and quality of water leaving the root zone. The problem of predicting the route along which drainage water seeps to the river, as well as the concomitant changes in composition, is being investigated by two more research projects. The first of these is a geohydrological investigation conducted by the University of Stellenbosch in the Poesjenels River catchment area of the Breede River. The aim of the research was to trace the flow routes of irrigation return flow to the river and to determine the relative contribution of processes in the root zone and underlying material to salinisation of the river. A final report on the results of this investigation is presently being compiled. The second geohydrological investigation is a new research project being conducted by Rhodes University over a 5-year period in the Coerney River area in the Sundays River valley.

Salinisation in undeveloped catchment areas

Over the past five years Rhodes University has conducted reseqrch on the influence of natural rainfall on the generation of runoff, salts and sediment in a number of subcatchments of the Ecca River, a tributary of the Great Fish River. Although it coincided with the period of abnormally low rainfall, an understanding of the salt-producing mechanisms and hydrology of semi-arid areas was nevertheless obtained. A final report on this research project has already been received. Flow events, however, will still be monitored over the next five years, as part of a new project with Rhodes University in the Sundays River, in order to verify the validity of current conclusions over a longer period and over a wider range of rainfall events.

Salinisation as a result of mining activities

Mining activities contribute to the salinisation of the water environment, but the precise magnitude of this contribution, especially from mine dumps, has not yet been quantified. Exposed pyrite (iron sulphide) is oxidised in the presence of water and forms acid mine water and sulphate which causes this salinisation. Bacterial activity accelerates the oxidation process considerably. Research currently funded by the Commission in this regard aims to establish the contribution of mine dumps to the salinisation of the Vaal Barrage on the one hand and to develop methods for the inhibition of bacterial oxidation on the other hand.

The research on the contribution of mine dumps to salt pollution of the Vaal Barrage is being undertaken by a firm of consulting engineers and the Department of Water Affairs. This project has now been completed and a final report is being prepared. The investigation entailed a monitoring network for surface and ground water and the subsequent analysis and interpretation of collected data on water flow and quality. Thereafter an inventory of mine dumps in the study area was drawn up and the results extrapolated to all mine dumps in order to estimate the total contribution of mine dumps to the salinisation of the Vaal Barrage.

The research on the inhibition of bacterial oxidation of pyrite is conducted in terms of a tripartite agreement with the Chamber of Mines and the University of Stellenbosch. Chemicals which inhibit bacteria have been selected and tests have been conducted for the controlled release of the inhibitors. Pilot-scale studies are currently being conducted over three seasons on ten experimental coal mine dumps at Wolwekrans Colliery near Witbank.

New research project

Hydrosalinity studies in the Eastern Cape

In spite of progress that has been made there is still a large measure of uncertainty about the routes which are followed and the time it takes for water to reach the river from the root zone through the so-called delivery zone. As part of this five-year project by Rhodes University, the geohydrology of the delivery zone will be investigated in detail with an eye on a better understanding and description of the hydrochemical processes which occur in this zone. The objective is to develop a model whereby the quantity and composition of irrigation return flows can be forecast. Although it is envisaged to develop and test this model for several spatial scales, the ultimate objective is to utilise it as a management option at macro-scale (entire irrigation scheme). Field-work for this purpose will be concentrated in the Coerney River, a tributary of the Sundays River.

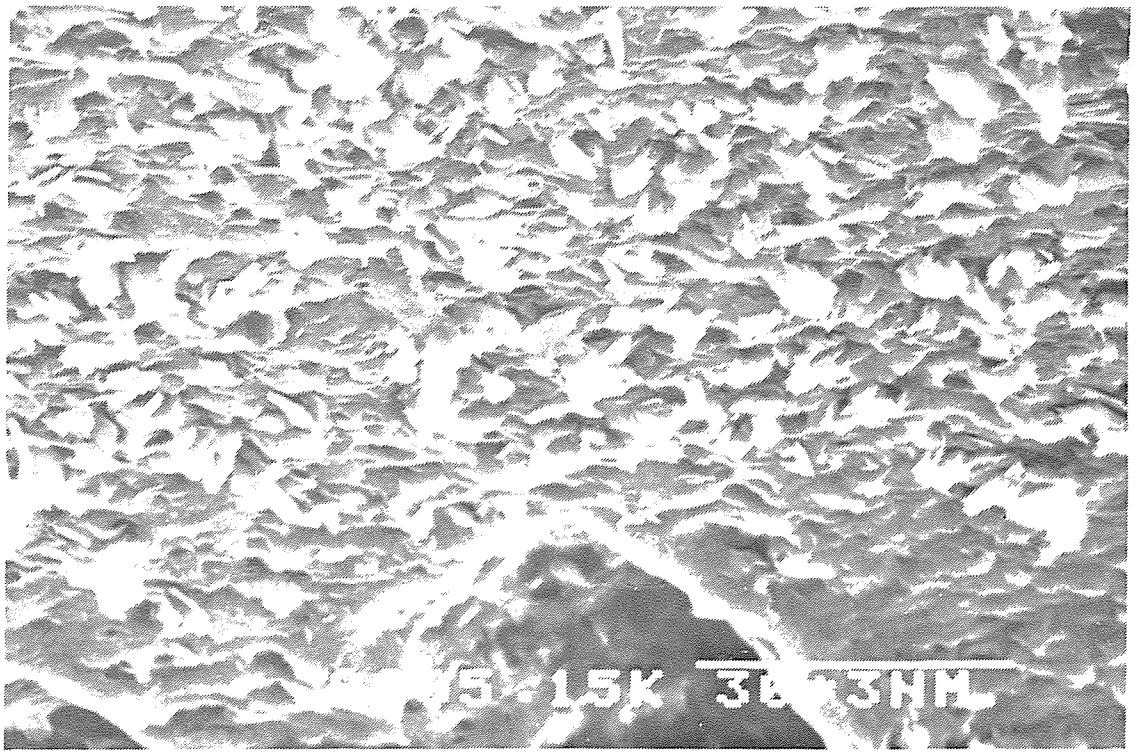
List of research projects

Completed project

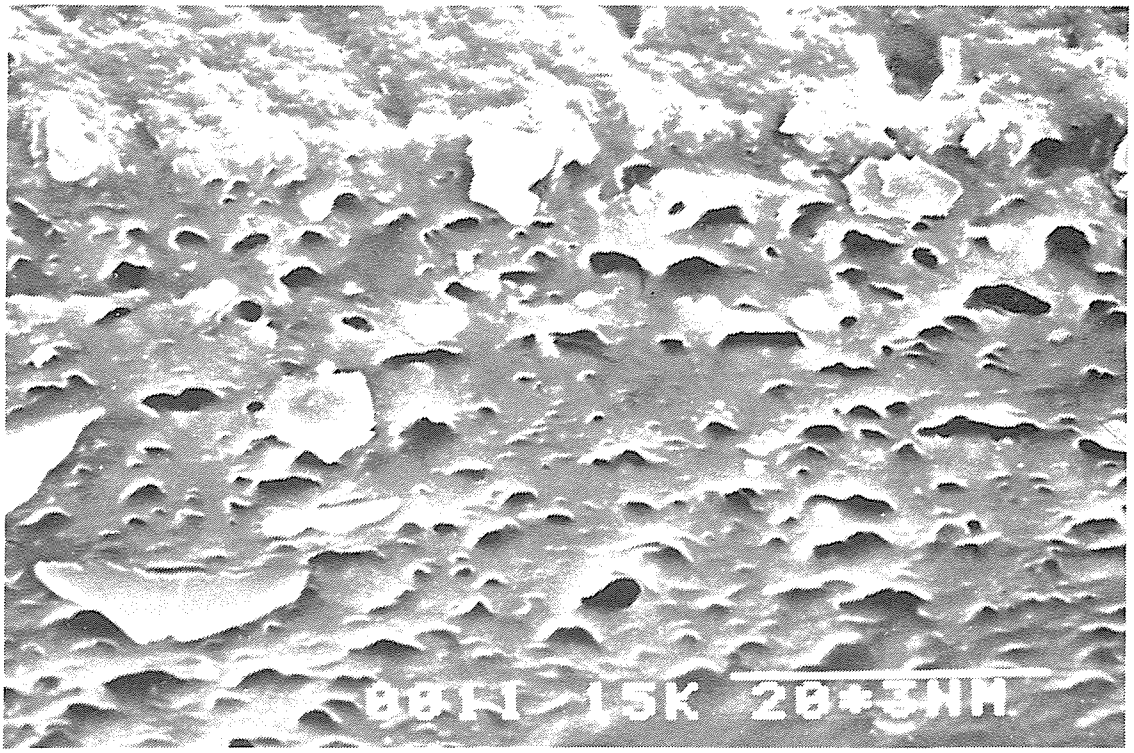
- Research on the contribution of mine dumps to pollution in the Vaal Barrage (The Department of Water Affairs, and a firm of consulting engineers; Steffen, Robertson and Kirsten).

Existing projects

- Research on the inhibition of bacterial oxidation of pyrite and concomitant acid mine water (The Chamber of Mines and the University of Stellenbosch - Department of Microbiology and Virology, and the Institute for Polymer Science).
- Research on integrated studies of the generation of runoff, solutes and sediment in the tributary catchments of the Great Fish River (Rhodes University - Department of Geography).



Scanning electron micrograph of a cross-section of a natural-rubber membrane which contained 35% sodium lauryl sulphate (SLS).



Scanning electron micrograph of a cross-section of a natural-rubber membrane which initially contained 35% SLS, showing the porosity which was formed in the membrane after the release of SLS.

Salinisation

- Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralisation (The Department of Water Affairs - Division of Geohydrology, and the University of Stellenbosch - Department of Geology).
- A pilot study of the irrigated areas served by the Breede River (Robertson) irrigation canal (A firm of consulting engineers; Murray, Biesenbach and Badenhorst).
- Research on 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).

New project

- Hydrosalinity studies in the Eastern Cape (Rhodes University - Department of Geography).

7 Research on eutrophication

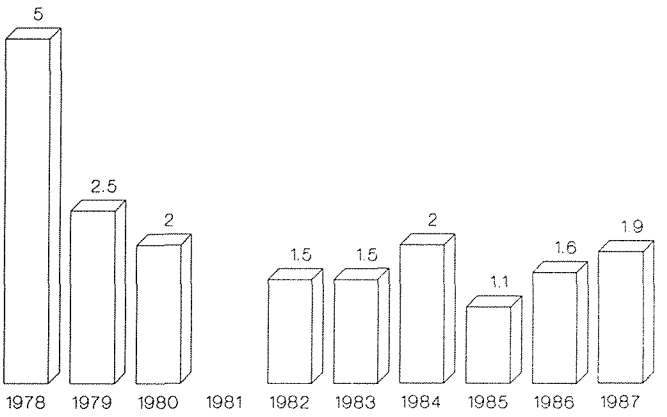
EUTROPHICATION is a process whereby the water environment, mainly impounded water, is enriched with plant nutrients, such as nitrogen compounds and phosphates. The most conspicuous consequence of this enrichment is the prolific growth of aquatic plants, especially algae. This luxuriant growth is not only aesthetically unattractive but also creates problems when this water is used as drinking water. The Commission has been supporting research in this field for many years now and several aspects have been investigated. Some of these results have shown that phosphate was the most important nutrient source and that control of this nutrient could make an important contribution to eutrophication management. The Department of Water Affairs has also intensified their effort to control the discharge of phosphates by implementing an effluent phosphate standard of 1 mg/*l* as P in certain sensitive areas. One such area is the Hartbeespoort Dam and its catchment.
At present the Commission supports four projects on different aspects of eutrophication. One project was completed during the year.

Existing projects

The following projects are being supported at present:

Evaluation of the impact of the phosphate standard on the water quality and trophic status of Hartbeespoort Dam

The purpose of this project, being carried out by the CSIR, is to measure the expected decrease in the supply of phosphate to the Hartbeespoort Dam and to determine the consequences thereof on the impoundment. Increased flow during 1986 caused a sharp increase in the volume of the impoundment, which in turn led to a decrease in the concentration of a number of chemical substances in the water.



Funding of research on Eutrophication expressed as a percentage of total WRC research expenditure (1978 to 1987).

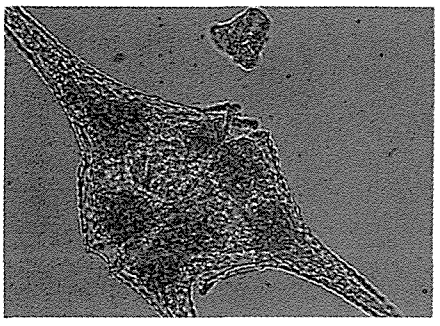
A decrease in the phosphate load to the impoundment was observed in 1986, and this trend continued during 1987, as shown in **Table 1**.

Table 1
Changes in the phosphate load to Hartbeespoort Dam for the period 1981-1987. Loads are given as PO_4-P in t/a

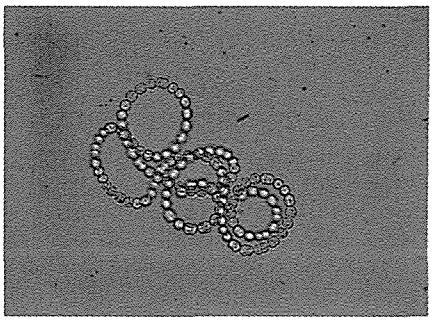
YEAR						
1981	1982	1983	1984	1985	1986	1987
539	566	594	624	655	460	325

It is too early to establish the effects of this decrease in the phosphate load. It is also doubtful whether the observed decrease will continue.

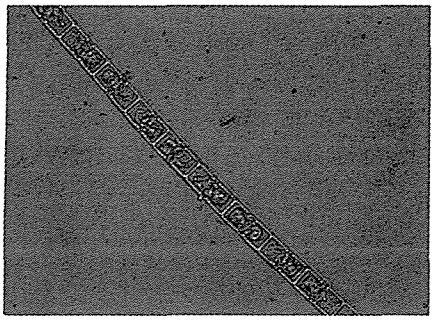
It was established, however, that the elevated nitrogen concentrations observed during 1986, continued during 1987. No obvious explanation for this phenomenon is apparent.



CERATIUM



ANABAENA



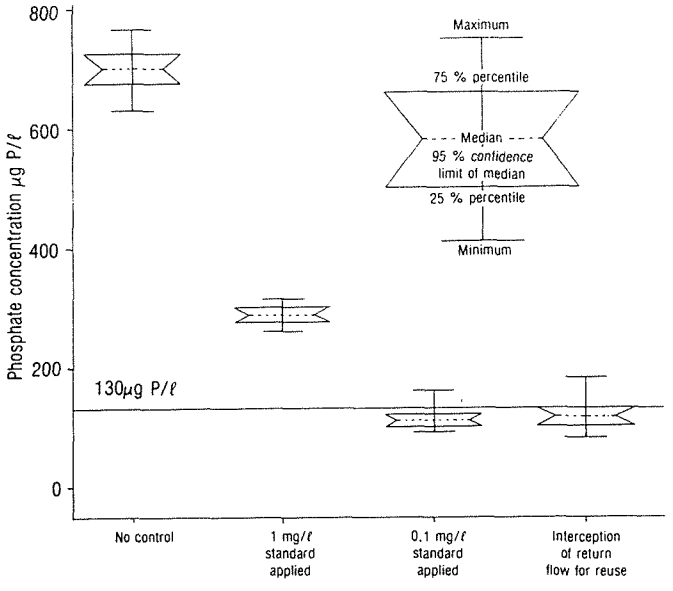
MELOSIRA

Three types of algae which are commonly found in impounded water.

Eutrophication

Management orientated models for eutrophication control

This study, conducted jointly by the National Institute for Water Research and the Department of Water Affairs, aims to develop mathematical models as an aid for decision-making, and to simulate the eutrophication process and its effects on water quality. These models are being incorporated into a user friendly decision support system (DSS) to facilitate the application thereof for decision-making. The DSS has progressed to the extent that the Department of Water Affairs is currently utilising it to revise decisions concerning the implementation of the phosphate standard in sensitive catchment areas. The output of the DSS will forecast the typical phosphate concentrations of an impoundment resulting from various catchment management options which are being considered for the catchment. It was also decided to extend the project in order to incorporate the Analytical Hierarchical Process (AHP) as part of the DSS to enable decision-makers to consider both quantitative and qualitative aspects of eutrophication in decision-making. During the remaining term of the project uncertainty analysis will receive attention and the DSS will be further refined.



Changes in the phosphate concentration in Hartbeespoort Dam as a result of various management strategies

Research on the effective use of water by means of an algal-aqua culture system

The Commission entered into a one-year agreement with the University of the OFS to investigate the possibility of producing protein from enriched water by means of an algal culture system. It is a small-scale investigation to establish the possibility of utilising an alga *(Spirulina)* to convert nutrients in water into protein. First results look promising and the project has been extended for another year to obtain more information on certain questions. Preliminary results indicate that a mixed culture of *Spirulina* and rotifers is capable of producing proteins under minimum supervision. Projections on the viability of the study are possible and form the basis of the continued study.

Inland water ecosystems

A block grant of R100 000 is made annually to the CSIR's Committee for Inland Water Ecosystems in order to conduct research in fields which are deemed important by the Commission. These studies are then financed jointly by the Commission and the Foundation for Research Development. Studies of importance are the Hartbeespoort Dam and the Mgeni catchment area.

List of research projects

Completed project

- Research on the inhibition of algal growth by water hyacinth (The University of Natal - Department of Botany).

Existing projects

- Development of phosphate export models for catchments (The CSIR - National Institute for Water Research).
- Research on the effective use of water by means of an algal-aqua culture system (The University of the Orange Free State - Limnology Unit).
- The development of management orientated models for eutrophication control (The CSIR - National Institute for Water Research and the Department of Water Affairs).
- Evaluation of the impact of the phosphate standard on the water quality and trophic status of Hartbeespoort Dam (The CSIR - National Institute for Water Research).

8 Research on the treatment of municipal waste water

IT is estimated that in 1990 approximately 15% of the expected total demand for water for direct use will be from the municipal and domestic sector. By the year 2000 this figure is expected to increase to approximately 17%. Apart from the demand for water for irrigation purposes (about 65% in the year 1990) water demand in the municipal and domestic sector is the single largest. Since an estimated 80% of this water is used non-consumptively, most is returned to the water environment in the form of treated sewage in keeping with the requirements of the Water Act.

The degree of treatment required before discharge of effluents to the water environment is necessarily high in order to maintain an acceptable quality of water in our rivers, lakes and impoundments. Degradation of the quality of these waters by improper management of effluent discharges cannot be permitted and therefore better and improved techniques for the removal of pollutants from effluents to levels which can be safely released to the water environment must be researched.

Research financed by the Commission in this particular field has been aimed at the prevention of pollution from the discharge of effluents. The approach adopted by the Commission has been to identify high priority research areas and to initiate research to address these in a number of different ways. The organisations that will ultimately use the results of research programmes have invariably been involved with the programmes right from the start. Laboratory-scale, pilot-scale and full-scale research has been undertaken for the Commission by municipalities themselves and by universities, research organisations and consultants. Chief amongst these has been research aimed at the removal of nutrients from effluents and the problems associated with waste-water treatment plants operated in the nutrient removal mode.

The Commission currently sponsors seven research projects in this field.

Phosphate removal in the activated sludge process

The Commission supports three research projects in this respect:

Research on biological excess phosphate removal

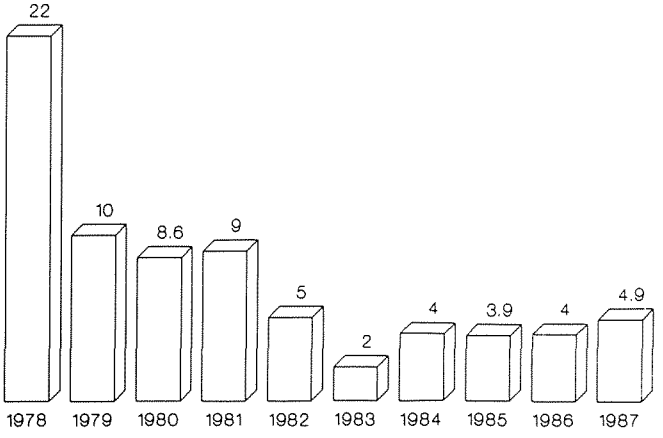
The original contract between the Commission and the University of Cape Town ran for a period of three years from January 1984 to December 1986. It was extended until the end of 1987. Four principle research objectives were identified in the programme, viz. short sludge age processes, measurement of readily biodegradable organic content, biological phosphate removal *per se* and acid fermentation for the generation of readily biodegradable organic material. Research conducted during the year addressed the latter two principle objectives, particularly the characteristics of the organisms that give rise to biological excess phosphate removal and a batch type mode of operation for the prevention of methane gas formation in the acid fermentation of primary sludge.

Research on enhancement of biological phosphate removal from sewage by altering process feed composition

The final report for this project was accepted by the Commission in 1986, after which an extension of the contract until the end of 1988 was negotiated with the City Council of Johannesburg. During the course of the contract a number of problem areas were identified which are being addressed in the contract extension. These include, *inter alia*, methods to improve elutriation of readily biodegradable compounds from primary sedimentation tanks, methods to minimise the mass of nitrate entering the anaerobic zone of the activated sludge plant and methods for efficient measurement of oxygen utilisation rates.

Evaluation and optimisation of full-scale chemical phosphate removal in biological filter sewage treatment processes

During the year this project was completed by the Town Council of Boksburg and consulting engineers. The final report was accepted by the project steering committee and will be considered by the Commission early in 1988. Findings of the research highlight that simplistic chemical dosing strategies for phosphate removal are unlikely to lead to optimised chemical usage efficiency on full-scale plants. Optimisation is important, not only from the chemical cost point of view, but also because the addition of ferric chloride increases the total dissolved solids and more specifically the chloride content of the effluent.



Funding of research on Municipal Waste Water expressed as a percentage of total WRC research expenditure (1978 to 1987).

Dosing strategies will have to be calculated on a daily basis and be based on historical data for that particular day of the week. The study found that addition of ferric chloride for phosphate removal has little effect on the overall sludge management and that although a significant increase in mass of humus sludge is generated, the increase in humus sludge mass has a negligible effect on the total sludge production of the plant.

Sludge bulking

The Commission supports two projects in this respect.

Research, development and full-scale evaluation of preventative and remedial methods for the control of activated sludge bulking

The main objective of this research, being undertaken by the University of Cape Town, is to undertake a study of remedial and preventative methods for sludge bulking in activated sludge plants with a view to developing appropriate design guidelines and operational procedures. Sludge bulking is a serious and common operational problem in activated sludge plants in South Africa and results in the carry-over of suspended solids into the final effluent discharges from the sewage works.

Current findings of the project have proved that selectors, which are short retention period reactors incorporated in an activated sludge plant, control bulking only for three specific types of bacteria. These bacteria do not occur very often in South African activated sludge plants with their relatively long sludge ages.

A new direction in the research project was initiated during 1987 and would appear to provide a new procedure for the amelioration of the bulking problems.

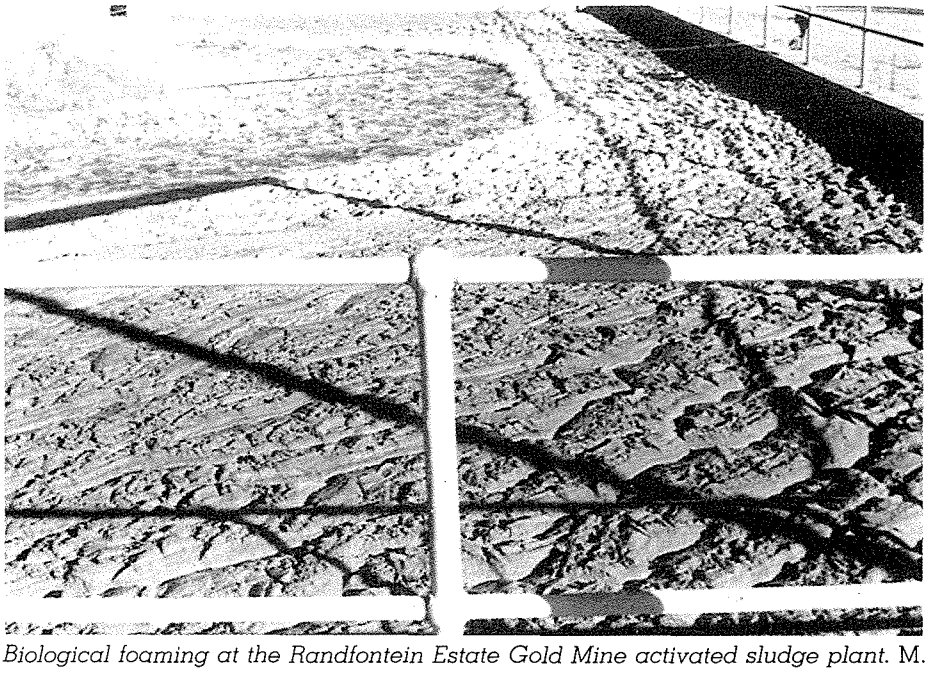
Research on biological foam in the activated sludge process

The research undertaken by the University of Pretoria in terms of a two-year contract with the Commission was completed in 1986. The final report for the project was completed during the year and will be published by the Commission in 1988. The report deals with the extent of occurrence of biological foam; physical, chemical and microbiological characterisation; dynamics of foam formation; and the development of a technique for the selective removal of foam by flotation.

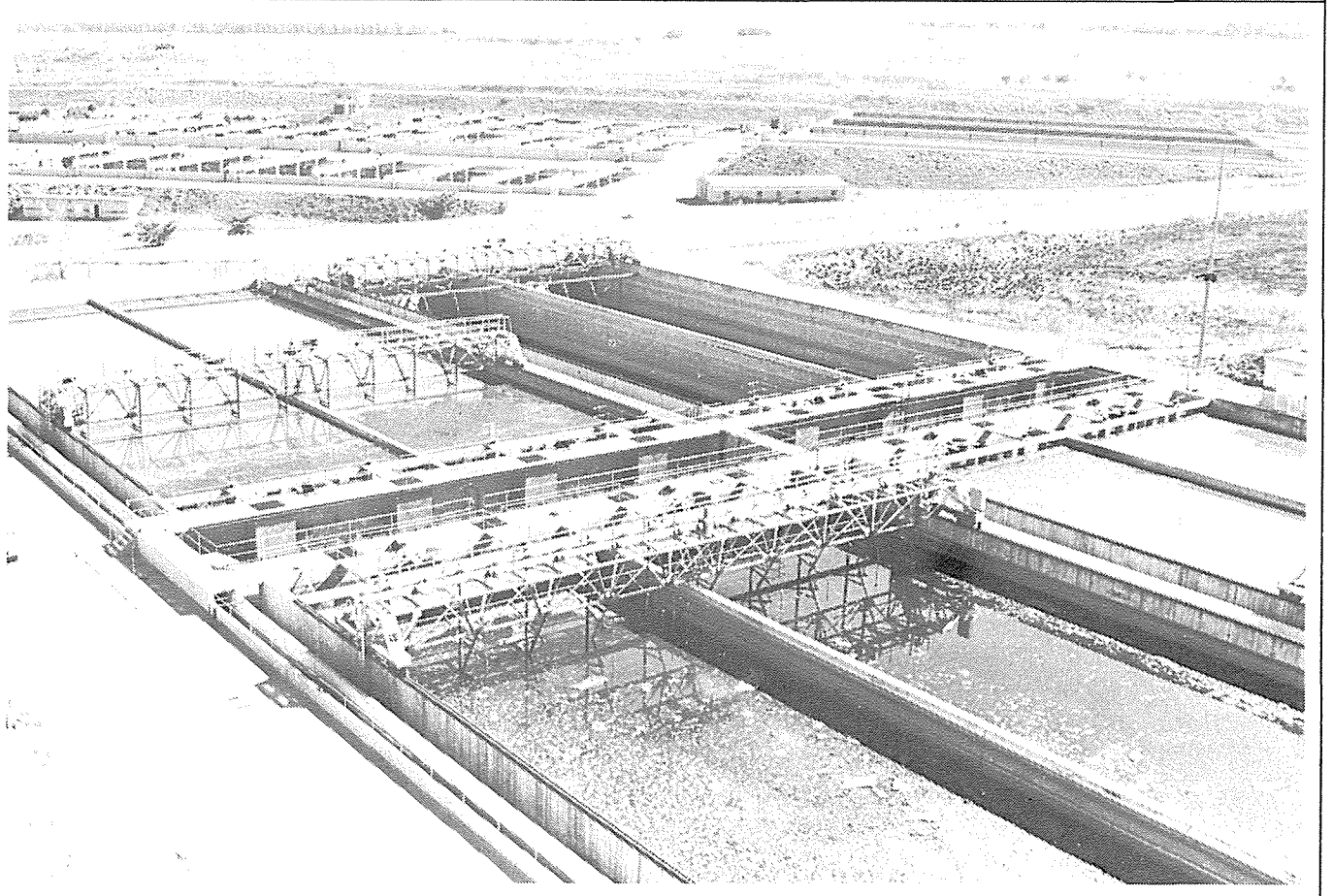
New projects

Research on phosphate crystallisation in activated sludge systems

This new research project commenced in January 1987 and is being undertaken by the NIWR of the CSIR. Laboratory and pilot-scale studies are planned during the three-year duration of the project with pilot-scale studies envisaged only after successful completion of the laboratory-scale work. The objectives of the study are to investigate the precipitation of calcium phosphate in the anaerobic basins of nutrient-removing activated sludge plants. Phosphate removed in this way in the form of calcium phosphate which has crystallised out on small grains of sand is then permanently removed



Biological foaming at the Randfontein Estate Gold Mine activated sludge plant. M. parvicella *are the dominant foam bacteria.*



A view of the Northern Sewage Purification Works, Johannesburg.

from the system, unlike bacterial uptake of phosphate which can be rapidly re-released into the system.

Electro-chemically produced metal coagulants for the purification of polluted water

This is being undertaken by the University of Pretoria. The study is a one-year pilot study aimed at evaluating the most important physical and chemical factors that affect the kinetics of electro-chemical production of coagulants; development of a practical electrode system and application of the principle in practice.

List of research projects

Completed projects

- Evaluation and optimisation of full-scale chemical phosphate removal in biological filter sewage treatment processes (The Town Council of Boksburg and a firm of consulting engineers: Scott and De Waal Inc.).
- Research on biological foam in the activated sludge process (The University of Pretoria - Division of Water Utilisation Engineering, Department of Chemical Engineering).

Existing projects

- Research on enhancement of biological phosphate removal from sewage by altering process feed composition (The City Council of Johannesburg).
- Research on biological excess phosphate removal (The University of Cape Town - Department of Civil Engineering).
- Research, development and full-scale evaluation of preventative and remedial methods for the control of activated sludge bulking (The University of Cape Town - Department of Civil Engineering).

New projects

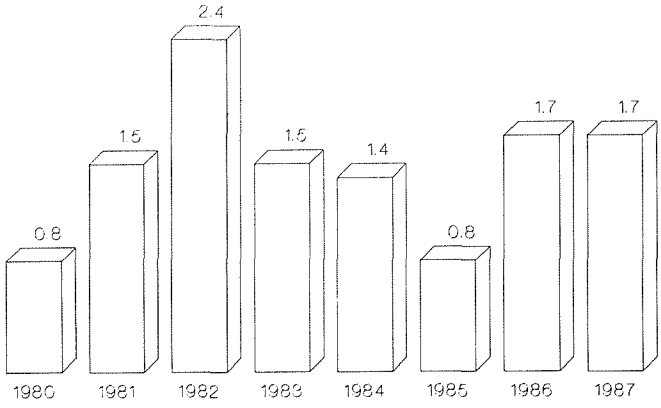
- Research on phosphate crystallisation in activated sludge systems (The CSIR - National Institute for Water Research).
- Research on eletrochemically produced metal coagulants for the treatment of polluted water (The University of Pretoria - Department of Chemical Engineering).

9 Research on sewage sludge treatment and disposal

SEWAGE sludge management throughout the world has tended to receive less attention than the management of the liquid phase of sewage. South Africa is no exception in this regard, but because of particular climatic conditions and severe health restrictions on the disposal of sludge, has tended to be more cautious in the management of this residue than countries elsewhere in the world. Generally sludge digestion is regarded as the minimum treatment before the sludge is permitted to leave the site of a sewage works. In some parts of the country sophisticated treatment processes are used to render the sludge completely inoffensive and safe for utilisation as a soil conditioner and fertiliser, while in others the sludge is discharged to the marine environment in a safe and responsible manner. In many locations, however, inexpensive yet effective treatment methods are required whereby sludge may be effectively treated to enable its universal use in agriculture and horticulture.

The fertiliser and soil conditioning properties of sludge are well-known and the amount and availability of nutrients in the sludge depend upon the type and degree of treatment it has undergone.

A further dimension to the problem of sludge management in South Africa is the increasing number of nutrient-removing sewage treatment plants being commissioned. These plants produce sludges which contain more phosphate than conventional plant sludges, in some cases chemically bound and in others biologically bound. In the case of biologically bound phosphate in sludges from biological nutrient removal activated sludge plants, these sludges need to be treated aerobically if the phosphate is to remain bound and not released to the supernatant liquid which could then not be returned to the head of works.



Funding of research on Sewage Sludge expressed as a percentage of total WRC research expenditure (1980 to 1987).

Ongoing research projects

Research on chemical characterisation of South African municipal sludges

The aims of this three-year project being undertaken by the NIWR of the CSIR are to conduct a survey of the occurrence of inorganic chemical contaminants and nutrients in South African sewage sludges; establish the most suitable methods for analysis of these contaminants; and contribute, in conjunction with other NIWR studies and information available from overseas, towards the preparation of guidelines for the application of sewage sludge to agricultural land.

Methods have now been established for the analysis of most of the inorganic contaminants and nutrients found in sewage sludges and the preparation and analysis of 300 samples collected from 75 sewage works throughout the country is almost complete.

Research on the evaluation and optimisation of the process of dual digestion of sewage sludge

This project is being undertaken jointly by the NIWR and the Milnerton Municipality. The dual digestion process comprises autothermal aerobic treatment at thermophilic temperatures followed by conventional anaerobic digestion at mesophilic temperatures. This combination produces a stabilised disinfected sludge which is suitable for agricultural applications. A 45 m^3/d facility has been established at Milnerton's Potsdam Waste Water Treatment Works and tests were started on the operation of the aerobic reactor.

The degree of disinfection attained has been high; all viable *Ascaris lumbriciodes* ova being inactivated and 99% plus of other pathogenic organisms being destroyed.

New project

Performance evaluation of forced aeration composting of sewage sludge

This project, being undertaken jointly by the Municipality of Stellenbosch and the NIWR of the CSIR, commenced late in 1987. Following on the completion of the research undertaken by the NIWR in Bellville into the process of forced aeration composting of sewage sludge, the Municipality of Stellenbosch opted to build a forced aeration composting plant for the treatment of sludge from their sewage works. In terms of an agreement with the Municipality, the Commission is to make available to it the research expertise at the NIWR to assist with the design and operation of the process and to monitor the performance of the plant scientifically once it becomes operational. Since this will be the first full-scale forced aeration

Sewage sludge



Forced aeration composting of sludge: An effective sludge disinfection and stabilisation process incorporating the use of wood chips which are screened out on completion of the process.

composting facility in the country, the NIWR will be on hand to assist in decisions regarding any plant modifications, should this prove necessary.

The full-scale plant at Stellenbosch will serve as an extension of the Bellville experimental facility in that it has been designed using criteria developed by the NIWR and will be subjected to rigorous scientific evaluation to ensure optimal performance. Once operational, the facility will become available as a demonstration plant to other local authorities and interested parties.

List of research projects

Existing projects

- Research on the chemical characterisation of South African municipal sludges (The CSIR - National Institute for Water Research).
- Research on the evaluation and optimisation of the process of dual digestion of sewage sludge (The Town Council of Milnerton and the CSIR - National Institute for Water Research).

New project

- Performance evaluation of forced aeration composting of sewage sludge (The Municipality of Stellenbosch and the CSIR - National Institute for Water Research).

10 Research on marine disposal of effluents

THE advantageous geographical location of the country and the favourable ocean currents around the South African coastline have enabled significant use of the marine environment for the disposal of a number of different effluents. Some 60 discharges take place at different places around the coastline, but only 10 of these make use of deep, well-designed sea outfall sewers.

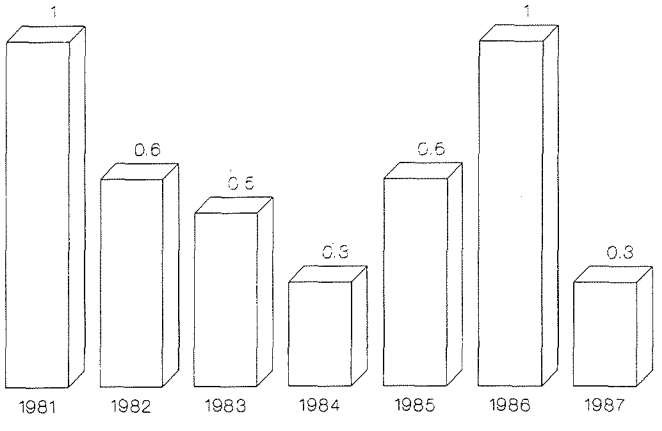
As a result of the increasing pressure on the use of this particular option and because of a need to protect the ecologically sensitive coastal zone, water quality criteria were developed and published in 1984 by the Marine Pollution Committee of the South African National Committee for Oceanographic Research (SANCOR). These criteria have provided useful design objectives for such systems and a further publication, still being compiled by the Commission, will assist the designer in the design of sea outfall systems.

New projects

Research on marine disposal practice in South Africa

The aim of this project, being undertaken by the National Research Institute for Oceanology (NRIO) of the CSIR, is to compile a comprehensive publication which will document descriptive and technical details of known marine discharges in South Africa. Details will be documented in such a way that prospective dischargers can review the successes and failures of present practice to ensure safe and circumspect design and operation procedures in the future.

The work has entailed site visits and the processing of questionnaires to gather all the relevant information for incorporation in the publication.



Funding of research on Marine Disposal expressed as a percentage of total WRC research expenditure (1981 to 1987).

Items to be covered in the document will include the degree of pretreatment of the effluent discharged; physical design aspects such as port design; problems experienced with operation of the pipeline such as pipe movement and fracture; water hammer problems and clogging or cleaning of the diffuser.

Photograph taken from an aeroplane during one of the exercises in Camps Bay, showing the sampling vessel positioned for sampling the dye concentrations.

Research on culturability of faecal coli following exposure to sea water – a pilot study

The NRIO of the CSIR commenced this pilot study during the year with the aim of determining the culturability rates of *Escherichia coli I* after various exposure times to sea water, by daylight, by night, in summer and in winter.

E. coli I is a major indicator in assessing the quality of the sea into which sewers discharge. Their number are reduced on coming into contact with the sea, usually attributed to dilution and dispersal, ultraviolet light, osmotic shock, bactericidal components in sea water, competition and/or predation from marine

organisms, and adsorbtion of the bacteria onto particulate matter.

Since the quality criteria for selected portions of the sea have been developed and limits for faecal coliforms have been specified in terms of these criteria, it is important to establish the fate of these indicator organisms in discharges to the sea. For the designer of a sea outfall sewer in particular, this information is of great importance since this one criterium will substantially influence the length of the outfall to ensure compliance.

List of research projects

New projects

- Research on marine disposal practice in South Africa (The CSIR - National Research Institute for Oceanology).
- Research on the culturability of faecal coli following exposure to sea water - a pilot study (The CSIR - National Research Institute for Oceanology).

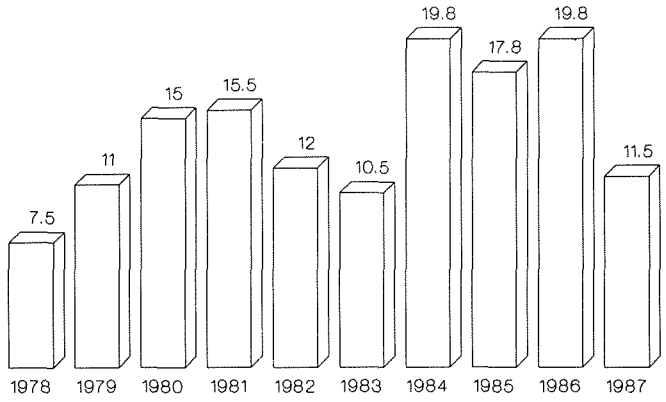
11 Research on the treatment of industrial effluents

INDUSTRIAL growth goes hand in hand with an increase in water consumption, and this in turn leads to increased industrial effluent discharges. However, the total volume of available water remains the same and unless precautionary measures are employed timeously, the quality of water will gradually deteriorate, especially in fairly closed catchment areas with a high percentage return flows, such as the PWV area. For this reason and especially in view of South Africa's limited water resources, research on the treatment of industrial effluents will always be a top priority, and consequently the WRC supports a number of research projects in this regard.

Improved management and internal reuse can result in a marked reduction in water consumption, although this will inevitably lead to elevated concentrations of pollutants. The accent of WRC research therefore falls on the treatment of industrial effluents and, if possible, the reclamation of energy, raw materials or by-products. Goal-orientated research will very often yield benefits in terms of the development of new processes, such as the patented tubular filter press sludge dewatering process, as well as the patented process for the reclamation of sodium hydroxide from process waters, both of which originated from WRC research projects.

The first full-scale application of the tubular filter press is the waterworks slurry dewatering plant at the H D Hill Waterworks of the Umgeni Water Board in Pietermaritzburg. This plant was officially opened on 27 November 1987 by the Minister of Environment Affairs and of Water Affairs, Mr G J Kotzé. An agreement has also been negotiated with an overseas organisation for the international marketing of the tubular filter press.

The Commission sponsored seven research projects in 1987, of which three were completed during the year, three are ongoing and one commenced.



Funding of research on Industrial Effluents expressed as a percentage of total WRC research expenditure (1978 to 1987).

Existing projects

A national industrial water and waste-water survey (NATSURV)

This project has been extended for a further period of three years and will terminate at the end of 1989. Initially the aim was to conduct surveys of the water intake and effluents of all factories, which would yield valuable information, such as the determination of research priorities and the creation of norms for water intake and effluent discharge for distinctive factory processes.

Subsequently, however, the survey was confirmed mainly to the PWV area, since the highest concentration of factories is to be found in this area. The survey was also adapted to give preference to priority industries, insofar as water usage is concerned. Up to now three guides have been published, viz. *Water and waste-water management in the malt brewing industry*, *Water and waste-water management in the metal finishing industry*, and *Water and waste-water management in the soft drink industry*. Approximately fourteen more NATSURV guides for various industries are envisaged.

The survey has undergone a further change of direction: area surveys of specific drainage areas are to be conducted. All water-using industries which discharge an effluent are included, in order to determine the pollution load of a drainage area. The first drainage area to be surveyed is the Vaal Barrage area.

A guide on water management in the metal finishing industry has been published.

Industrial effluents

Research on the development of polymers for the formation of dynamic membranes

Conventional membrane technology is applied mainly for the desalination of sea and brackish waters. These membranes are not suitable for the separation of contaminants in industrial effluents resulting from high temperature, low and high pH values and sometimes free chlorine. To solve the problem, this project is aimed at developing polymers which will form removable dynamic membranes within permeable stainless steel tubes. The advantages of this type of membrane are, *inter alia, that it can withstand high temperatures and* pressure; that it can be used in the presence of suspended material; that the dynamic membrane can be replaced with ease; that membrane types can be adapted to specific applications; and that a variety of membrane types can be laid down in one tube.

The Institute for Polymer Science at the University of Stellenbosch has already developed a number of promising polymers which are being tested currently.

Research into the treatment of wool scouring effluents

An integrated process for the treatment of wool scouring effluents, concomitant with water reclamation, has been developed over a number of years and has been tested at a wool scouring mill at pilot scale. During 1987 a modular full scale plant, which will treat the total effluent of one wash range, was constructed at the same wool scouring mill. This unit will now be operated for a year by the wool scouring mill itself under variable practical wool scouring conditions, with a view to an economic evaluation of the process, as well as to enhance technology transfer.

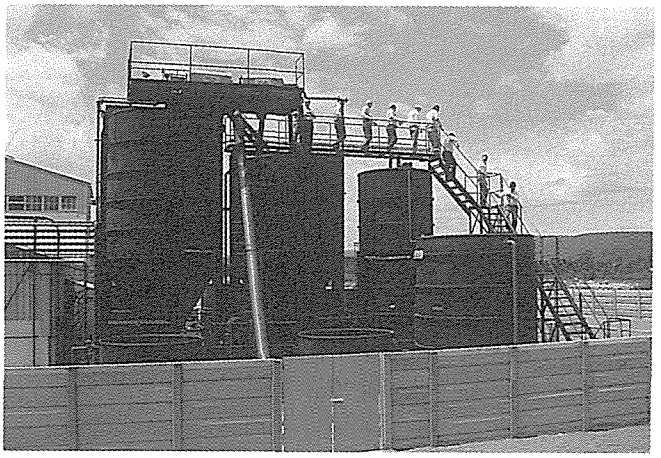
Completed projects

The development of support systems for cross-flow microfiltration

A process which is based on the use of a woven hose has been developed for the treatment of a wide range of industrial effluents. The cross-flow microfiltration technique has been developed into a simple and economic process for the thickening and dewatering of mainly waterworks sludge. The tubular filter press has been patented both locally and overseas.

The treatment of textile dyehouse effluent by hyperfiltration and evaporation

The project was aimed at evaluating a plant for the treatment of textile dyehouse effluents. The plant was provided by an overseas firm but as a result of technical problems the plant does not comply with



The Gubbs and Inggs wool scouring plant.

design specifications and subsequently it was decided to terminate the project.

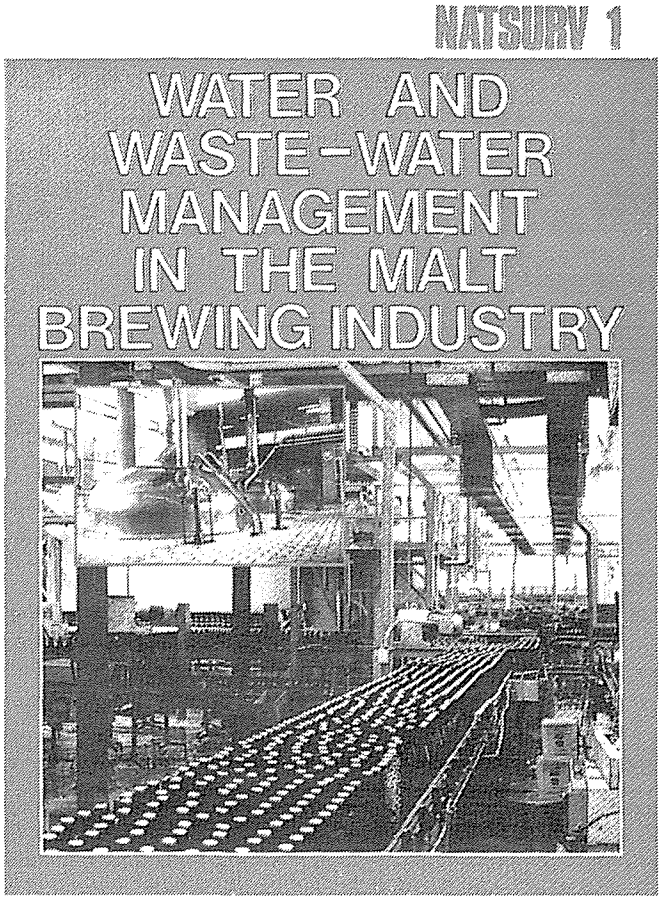
The treatment of scouring and bleaching effluents

A process has been developed by the university of Natal in which sodium hydroxide can be reclaimed and reused in the factory. This process can also be employed for the reclamation of sodium hydroxide from other industrial effluents viz. bottle-washing or fruit and vegetable effluents. The process comprises neutralisation, partial oxidation, cross-flow microfiltration, nanofiltration and electrolysis. A pilot-scale study proved that the process works well and is economically viable. A full-scale unit for the factory is being developed at present and will be financed by the company. The process has been patented locally as well as overseas.

New projects

Research on the chemical removal of sulphates

Waste waters containing high sulphate concentrations are becoming a serious problem in the PWV area. Mine waters make an important contribution to the sulphate component, and if this polution could be combated, the water quality of the Vaal River system could be improved significantly. A biological technique has been developed by the CSIR for the removal of sulphates, but other and possibly more economical methods should be investigated. In this project a possible alternative method of precipitating the sulphates with barium will be investigated. However, on account of the high cost of barium this process cannot be justified, unless the barium can be reclaimed. This aspect will also be investigated. It is a simple process which does not require any sophisticated equipment and during which the



The first guide to be published as part of the NATSURV range.

barium can be recycled. Furthermore sulphur, of which there is a shortage in the country, can be reclaimed as a by-product. Another advantage of the process is that heavy and alkali earth metals are removed together with the sulphates.

List of research projects

Completed projects

- Water management and effluent treatment in the textile industry; Scouring and bleaching effluents (The University of Natal - Pollution Research Group, Department of Chemical Engineering).
- The technical performance evaluation of a full-scale industrial waste-water treatment plant: *Textile dyehouse effluent treatment* by hyperfiltration and evaporation (Kluk Textile Industries (Pty) Ltd. T/A MYM Textiles (Pty) Ltd. and the University of Natal).
- The development of support systems for cross-flow microfiltration and technical performance evaluation on industrial waters and waste waters (The University of Natal - Pollution Research Group, Department of Chemical Engineering).

Existing projects

- A national industrial water and waste-water survey (The Department of Water Affairs and a firm of consulting engineers; Binnie and Partners).
- Research into the treatment of wool scouring effluents (The University of Natal - Pollution Research Group, Department of Chemical Engineering; a firm of consulting engineers, Binnie and partners; and Gubb and Inggs (Pty) Ltd).
- Research on the development of polymers for the formation of dynamic membranes and the evaluation thereof for the treatment of industrial effluents (The University of Natal, University of Stellenbosch and the CSIR).

New project

- Research on chemical removal of sulphates (The University of Natal).

12 Research on water treatment and reuse

TWO main problem areas have to be taken into account when providing water for urban and industrial usage. The first problem is to find adequate quantities of freshwater to satisfy escalating demands and the second problem is to produce water of the required quality, allowing for the deteriorating quality of many freshwater sources.

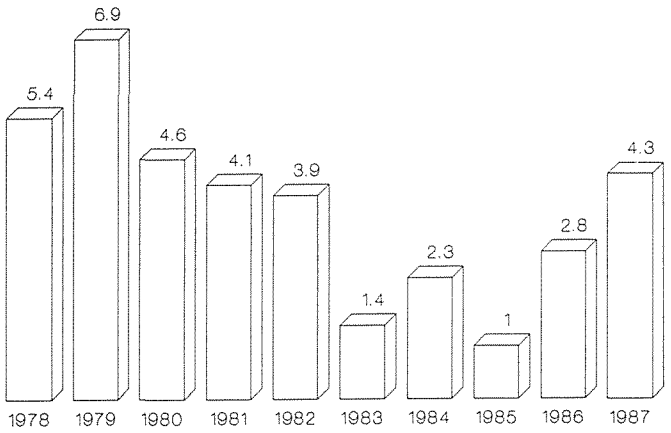
Pertaining to the problem of adequate quantities, the Commission supports several projects on hydrology, geohydrology, rainfall stimulation, water reclamation and desalination, in order to find additional supplies and to enhance existing resources. The deterioration of the quality of water resources is being approached from two sides. On the one hand research is supported to develop new processes and to improve existing waste-water treatment processes, thereby decreasing the pollution load of the return flow to the water environment. On the other hand research on advanced treatment processes is supported in order to provide water of the required quality.

The WRC presently supports five projects on water treatment of which two new projects commenced during the year.

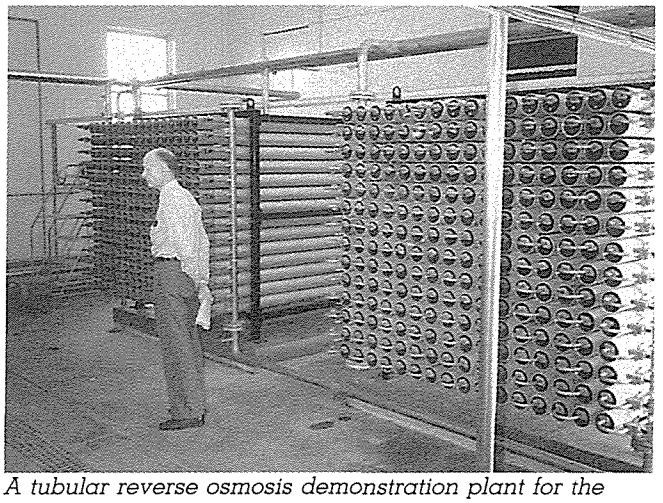
New research projects

Research on dissolved air flotation for the treatment of eutrophied surface water for potable use

The main aim of this study is to optimise the flotation process for the removal of algae, as well as compounds which react with chlorine in the water to form chlorinated compounds which are undesirable in drinking water. The study is being undertaken by the National Institute for Water Research of the CSIR and pilot-scale studies will be undertaken at Schoemansville on Hartbeespoort Dam water.



Funding of research on Water Treatment and Reuse expressed as a percentage of total WRC research expenditure (1978 to 1987).



A tubular reverse osmosis demonstration plant for the reclamation of water from secondary sewage effluent.

An exploratory study into the efficiency of drinking-water treatment in South Africa

The study is being undertaken by the Department of Civil Engineering of the University of Cape Town. The aims of the project are to collect information on the efficiency of existing processes, to identify problem areas in the design and operation of plants where more research is required, and to establish guidelines for the design and management of plants for the treatment of different types of water. (The drafting of guidelines will be managed as a separate project.) As part of this programme information is also collected on corrosion and aggression problems being experienced in distribution systems.

List of research projects

Existing projects

- Technological development of water reclamation on the basis of the Windhoek plant (The Municipality of Windhoek and the CSIR – National Institute for Water Research).
- The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality (The City Council of Cape Town).

New projects

- Research on dissolved air flotation for the treatment of eutrophied surface water for potable use (The CSIR – National Institute for Water Research).
- An exploratory study into efficiency of drinking-water treatment in South Africa (Department of Civil Engineering, University of Cape Town).

13 Research on drinking-water quality and health aspects

WATER quality is of primary importance for the utilisation thereof. The quality of water should therefore be monitored carefully, not only because decisions in this connection can have far-reaching effects, for example in respect of water resource development and management, but also because drinking-water quality has a direct influence on man's health.

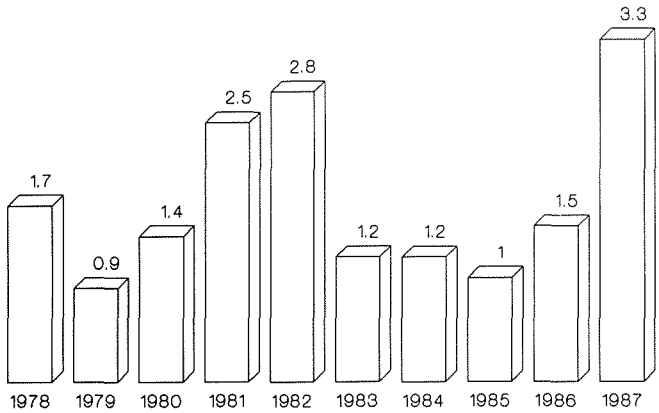
Although microbial contamination is still the most important health hazard, inorganic and especially organic compounds have been receiving more and more attention lately. Up to and including the 1960's the emphasis was on organic compounds contaminating water sources, but this emphasis has shifted over the past few years, and by-products which result during disinfection processes are now receiving more attention. The reason why attention is focussed on micro-organic compounds as a whole, is mainly because the precise effect on man's health due to the intake of these compounds over an extended period is still an unknown factor.

Approach in respect of drinking-water quality

The overall aim of the WRC supported research on drinking water is to gain knowledge on drinking-water quality and to assist in developing a water treatment technology, so that water which meets all the quality requirements, and does not pose a health hazard, can be supplied at a reasonable price.

WRC supported research emphasises the following:

- the development of the required water treatment technology (see *Chapter 12*);
- investigating the incidence and concentration of contaminants (microbiological and chemical);
- the effect of water quality on man (for instance epidemiological studies); and
- obtaining data which will make a contribution towards establishing quality criteria.



Funding of research on Drinking-water Quality and Health Aspects expressed as a percentage of total WRC research expenditure (1978 to 1987).

The WRC supported seven research projects in connection with the above. One project was completed during the year and two projects commenced.

Completed project

The project on the surveillance of the virological quality of reclaimed water from the Cape Flats water reclamation plant was completed during the year. Plant operation ceased at the end of 1986. The virological quality of the reclaimed water complied with prescribed norms at all times, confirming the results of Windhoek, which still utilises reclaimed water as a drinking water. The results of this project are further proof that reclaimed water can comply with all the microbiological requirements.

Existing projects

All ongoing projects reported good progress during the year.

The investigation on the incidence and concentration of trihalomethanes in drinking water will be continued for a further six months in 1988. Trihalomethanes are halogenated organic compounds which develop as a result of the disinfection of water with chlorine. Continued interest is shown in these compounds because of the potential health hazard to the consumer.

The research on the development of a portable toxicity detector was completed during the year and the final report is being prepared. The detector is based on the principle of inhibiting specific enzyme systems by toxic chemical substances.

Headway was made in the surveillance of potential changes in drinking-water quality, especially in developing a technique for tracing birth defects and entering them in a data bank. It is thought that such information could perhaps be a more reliable indicator of changes than existing methods. The compilation of statistics in the Cape Peninsula and the PWV area has been proceeding so well that this study could easily be extended country-wide. These statistics will be used to compare the disease patterns of these two areas. This type of information could possibly indicate areas in the country which are at variance with existing or expected patterns, and which could then be further investigated.

The research on the possible chronic health effects of reclaimed water on consumers in Windhoek has also been continued in order to establish a data base with sufficient information over a period of at least 10 years. Only a small number of people consume reclaimed water and therefore the observation period has had to be extended. The results to date still indicate that no obvious

deleterious effects due to the long-term intake of reclaimed water have been observed.

New research projects

Research on the isolation and identification of mutagens in drinking water

The use of chlorine for the disinfection of drinking water results in the formation of low concentrations of organic compounds which could constitute a potential health hazard and special concern is voiced over those which are mutagenic. Mutagens are agents which increase the frequency of mutation in the DNA molecule, and can result in carcinogenesis. It is doubtful whether mutagenity in drinking water will have any deleterious effect on the consumer, but the consequences of long-term consumption of these compounds at low concentrations are still not known. The aim of this three-year project, which will form part of the research programme of the NIWR, is to develop a process for the isolation of mutagens in drinking water and to develop methods for the identification of the isolated mutagens. Provided that the precise incidence of the mutagens can be established, methods for the removal of these compounds during water treatment processes can then be investigated.

The development of water quality monitoring strategies and procedures for water quality data interpretation

Mention has been made already of the importance of water quality, but the existence of reliable water quality data is equally important. Furthermore, these data should be carefully collected, interpreted and utilised. A number of related components, of which some are better developed than others, play a part in the assessment of water quality. All these components will receive attention in this project, but the development of monitoring strategies and procedures for water quality data interpretation and analysis will receive priority. This will be done so that reliable information can be made available for use in decision making systems in respect of, for instance, water resource development, water quality control, etc. These results will be used mainly by the Department of Water Affairs, one of the partners in this 5-year tripartite agreement, between the WRC, the CSIR and the Department.

List of research projects

Completed project

- Surveillance of the virological quality of reclaimed water from the Cape Flats prototype water reclamation plant (The University of Cape Town - Department of Bacteriology).

Existing projects

- An investigation into the occurrence and concentration of trihalomethanes and their precursors in South African drinking water (The CSIR - National Institute for Water Research).
- The development of a portable toxicity detector for water (The CSIR - National Institute for Water Research).
- Research on epidemiological surveillance of potential changes in drinking-water quality (The University of Cape Town - Department of Community Health).
- Research on the possible chronic health effects of consumption of reclaimed water by consumers in Windhoek (The South African Institute for Medical Research).

New projects

- Research on the isolation and identification of mutagens in drinking water (The CSIR - National Institute for Water Research).
- Development of water quality monitoring strategies and procedures for water quality data interpretation (The CSIR - National Institute for Water Research and the Department of Water Affairs).

14 Research on desalination

A number of processes can be employed to remove dissolved salts from sea or brackish water, viz. distillation, reverse osmosis, electrodialysis and ion exchange. Distillation is the oldest one of these processes and is used on a large scale *inter alia* in the Middle East for the desalination of sea water. Large installations of up to 225 000 m³/d are in operation. Compared to reverse osmosis, the energy *eonsumption of distilation is high, resulting in the* trend of using reverse osmosis more and more often for the desalination of sea water and especially brackish water. The WRC does not support any projects on distillation at present, but keeps abreast of developments in this area.

Reverse osmosis

Reverse osmosis is a pressure driven process which employs synthetic membranes to remove impurities, *including dissolved salts, from water. Reverse* osmosis can be utilised to produce freshwater from sea or brackish waters and also to reclaim water from domestic and industrial effluents.

The Commission has been supporting research on reverse osmosis over the past twelve years. An *important aspect which is being supported is the* development of locally manufactured membranes. The research has resulted in the establishment of a South African industry for the manufacture of reverse osmosis equipment. A local company recently achieved the honour of building the largest tubular reverse osmosis plant in the world at the Lethabo Power Station, where it is utilised to reclaim water for reuse in the system.

Electrodialysis

Electrodialysis is an electrically driven membrane *process which is capable of removing ionised* substances from solutions. Electrodialysis reversal (EDR) differs from conventional electrodialysis in that the polarity is reversed periodically which results in a reversal of the flow of ions. This action minimises problems of membrane fouling and scaling so that high water recoveries are possible. The Commission supports research on different applications of EDR, viz. on the desalination of cooling tower blow-down, in collaboration with Eskom, and on the desalination of underground mine water in collaboration with the *Chamber of Mines.*

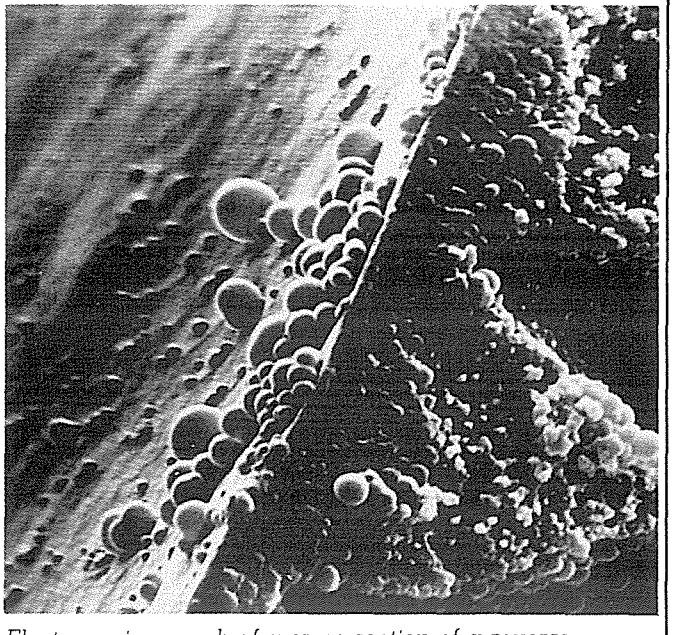
Research on cooling water blow-down was initiated on small pilot-plant scale (5 m³/d) and later extended to a 120 m³/d plant. This work has resulted in the construction of a large-scale EDR plant of 4 000 m³/d for desalination and reclamation of cooling tower blow-down at the Tutuka Power Station.

Research on the desalination of underground mine water moved to the Orange Free State gold mines after initial research on the East Rand. The research is being continued on the 120 m³/d pilot plant used earlier on the cooling water project.

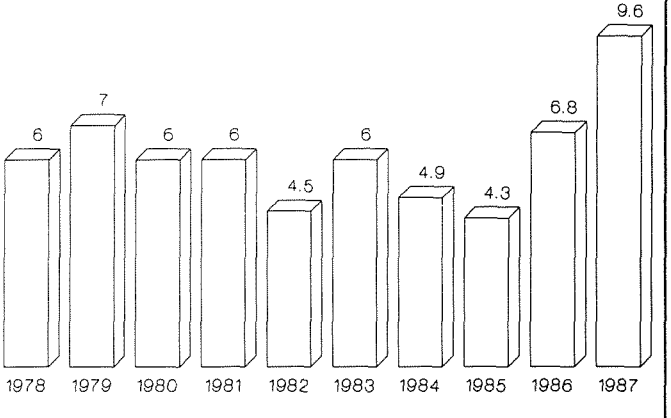
List of research projects

Existing projects

- Research on membrane development and fabrication for reverse osmosis and ultrafiltration (The University of Stellenbosch – Institute for Polymer Science).
- Pilot plant studies on the desalination of underground mine water with EDR (The Chamber of Mines).
- *Research on the feasibility of reverse osmosis for* water reclamation on large scale (The Municipality of Port Elizabeth, the CSIR and Bintech (Pty) Ltd).



Electron micrograph of a cross-section of a reverse osmosis membrane.



Funding of research on Desalination expressed as a percentage of total WRC research expenditure (1978 to 1987).

15 Research on water economy in urban areas

DESPITE the economic decline which prevailed during the year, unabated urban growth continued. Associated with urban expansion is an increase in the water requirements for domestic, commercial and industrial consumers. The costs for storing, treating, transporting and distributing urban water supplies are considerable, involving high technology, and capital-intensive treatment plants requiring highly skilled operators.

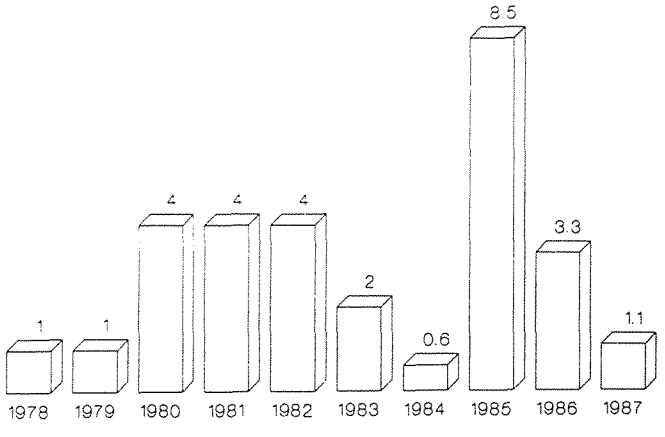
With competition for limited water resources becoming more and more intensive every endeavour must be made to promote the frugal use of water by eliminating water wastage wherever it occurs. As the demands on the water resources increase, the severity of drought events will intensify. A minor drought occurrance of ten years ago will be of major concern ten years hence.

For these reasons research into water economy in the urban sector is continuing, irrespective of the rainfall patterns in the interim. The Water Research Commission supported four research projects during the year, of which one has been completed and three commenced.

Joint Acceptance Scheme for Water Installation Components (JASWIC)

The commission also serves as a member on the "Acceptance Committee for the Joint Acceptance Scheme for Water Installation Components" (JASWIC). This municipal body came into being largely as the result of recommendations contained in an aerlier project with the National Building Research Institute entitled "Research on water economy measures for water distribution systems in urban areas".

The Acceptance Committee currently comprises representatives from Cape Town, Port Elizabeth, Durban, Pretoria, the SABS and the WRC. In 1987 there were 65 participating local authorities. Through membership of JASWIC a major coordinating function is achieved between local authority water research requirements in the one direction and technology transfer from the Commission in the other direction.



Funding of research on Water Economy in Urban Areas expressed as a percentage of total WRC research expenditure (1978 to 1987).

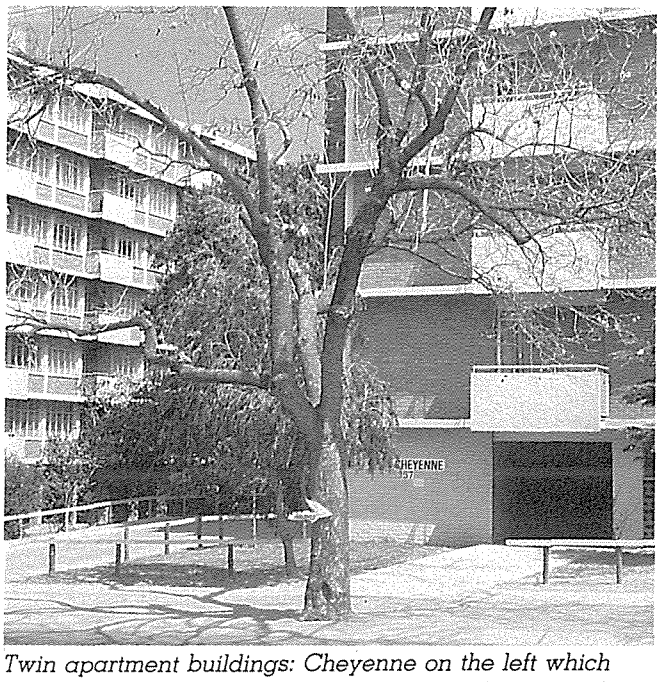
During the year, JASWIC continued to function on a high level by providing local authorities with a list of accepted components for use on plumbing systems. Through the membership of the SABS on the JASWIC Acceptance Committee, fittings can be tested quickly and easily and the results reported back with a minimum delay. "Fit for purpose" fittings can therefore appear promptly on the JASWIC list of accepted fittings. JASWIC also attends all the relevant SABS technical committee meetings which gives local authorities a very powerful voice when it comes to the preparation of SABS specifications which eventually will be applicable in their areas of jurisdiction.

Existing project

Individual water meters for apartment buildings

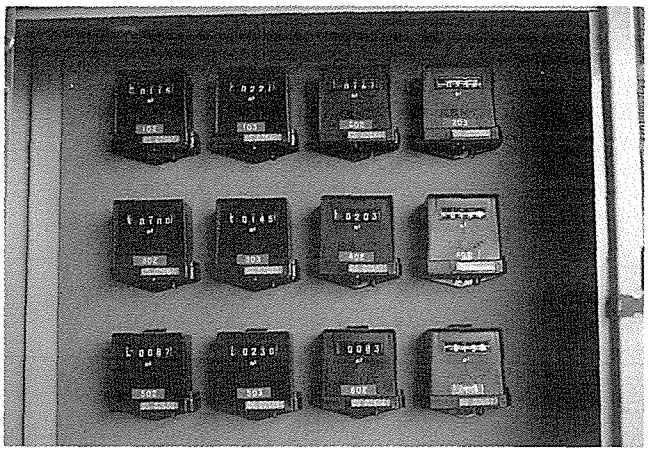
During the year a project investigating the practicalities of individually metering dwelling units in apartment buildings came to an end. This project was carried out in Pretoria by the National Building Research Institute of the CSIR, using twin blocks of flats. While one block was retrofitted with water meters the other was monitored as a control.

Results indicated that the mere expedient of metering individual consumers in apartment buildings could save around 30 per cent of the total consumption.



Twin apartment buildings: Cheyenne on the left which serves as the control and Kiowa which has been retrofitted with remote registering water meters.

Urban areas



Remote registers of water meters installed at the individual units of Kiowa flats.

It was found that individual metering is useful for identifying the culprits who exceed the average quota for the building. In the first month of measurement 14 occupants in the building, fitted with meters, exceeded the quota while in subsequent months this number varied from two to four.

New projects

During the year three new projects commenced.

The effects of reduced water consumption on domestic sewer systems

This project looks at the effects of drastically reduced water consumption on the performance of domestic sewers.

Waterborne sewerage requires a certain amount of wash water to keep the sewers flowing freely. In the event of severe restrictions or rationing being imposed, water normally wasted direct to the drainage system is utilised elsewhere within the household and eventually wasted onto the garden.

Under such critical circumstances often the only water entering the drainage system is that flushed from toilets to clear solid wastes. It is anticipated that under these circumstances the number of blockages occurring increase to unacceptable levels.

Emanating from a request from JASWIC in this direction, a 4-year agreement has been negotiated with the National Building Research Institute (NBRI) of the CSIR to research all aspects of sewer performance under severe drought situations.

Ground-water abstraction in residential areas

A new 3-year project with the NBRI commenced during 1987. This involves determining the effects of private boreholes on the municipal water supply system, both during good rainfall periods as well as during times of water restrictions. The long-term effects on ground-water levels, recovery rates and civil defence planning are all aspects which will be investigated. A cross-section of residential areas within the Pretoria municipal area has been selected for monitoring.

The City Council of Pretoria is also cooperating extensively, especially with regard to historical and background data.

The flow rate and pattern of water consumption and unaccounted-for water in urban areas

In this 2-year project, the University of Pretoria, the City Council of Pretoria and the Commission are cooperating in a tripartite agreement, investigating the performance of water meters and the practice of metering. A significant volume of water can reach the consumer without being registered when the water meter is faulty or when the rate of flow is very low. The magnitude of this unaccounted-for water will be determined and the long-term performance of various types of meters at low, medium and high flow rates will be investigated.

List of research projects

Existing projects

- Research on water consumption and possible water saving in apartment buildings (The CSIR - National Building Research Institute).
- Research into water loss analysis on municipal water distribution systems (Castle Brass Holdings (Pty) Ltd and the Johannesburg City Council).

New projects

- Research on the effects of reduced water consumption on domestic sewer systems (The CSIR - National Building Research Institute).
- Research on ground-water abstraction in residential areas (The CSIR - National Building Research Institute).
- Research on the flow rate and pattern of water consumption and unaccounted-for water in urban areas (The University of Pretoria and the City Council of Pretoria).

16 Research on water economy at power generating stations

POWER generation is a strategic industry which requires an assured water supply as a top priority. It is also true that power stations are large consumptive water users – mainly as a result of evaporation during cooling. The water use situation is put into perspective by the following data: Evaporation losses for a 3 600 MW wet-cooled power station amount to approximately 120 000 m^3/d. Eskom's total water usage in 1985 amounted to 275 × 10^6 m^3 in the Vaal River supply area which is approximately 21% of that used by urban, industrial and mining sectors in that area, and about 11% of the total use in that area, including irrigation. Expressed as a percentage of South Africa's total water usage power generation required about 1,7% of the total water in 1980 and it is projected that this figure will rise to 3,5% of the total in the year 2000.

Evaporation losses can be almost completely eliminated by implementing dry cooling. Although these systems effect considerable water savings, certain disadvantages are associated with the process. Firstly, the capital investment for dry cooling greatly exceeds that of wet cooling and secondly, dry cooling is less efficient, necessitating the use of more coal for the same amount of energy generation than with wet cooling. It is therefore necessary that dry cooling systems should be made to operate as efficiently as possible.

During the 1970's it became apparent that the provision of adequate water for additional planned power stations on the Transvaal coal fields would become difficult. Eskom was therefore confronted with the fact that some of its power stations will have to be dry cooled and, furthermore, that it will have to be done on a scale which has not been done elsewhere and for which only limited experience is available. In discussions with Eskom and the Department of Water Affairs, the Commission undertook to support research in collaboration with Eskom on the optimisation of dry and dry-wet cooling under local conditions.

The Commission has been supporting research on the following aspects since 1979:

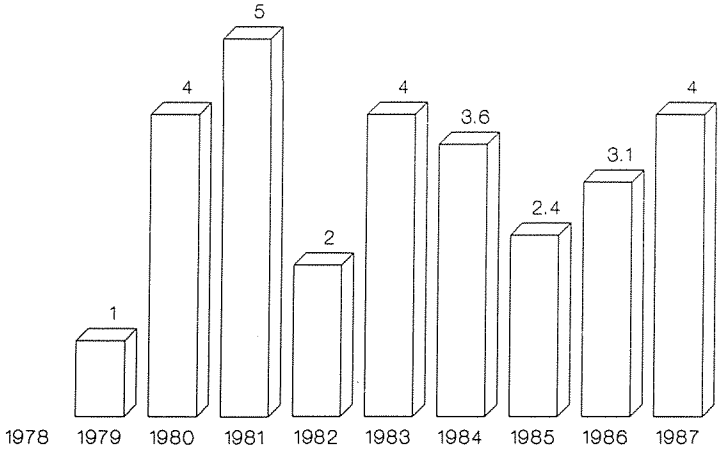
- the effect of atmospheric conditions on the performance of dry cooling towers;
- the development of computer techniques for the evaluation and optimisation of dry-wet cooling systems;
- research on the possible recirculation of hot air in dry cooling systems; and
- research on corrosion in dry and dry-wet cooling tubes.

Three of the new generation air cooled power stations are presently under construction. Matimba, near Ellisras in the Transvaal, which employs a direct air condensing system, is the most advanced, and two of its 6 × 630 MW systems were commissioned during 1987. The Commission is still involved in the project by supporting the studies of the CSIR and the University of Stellenbosch. The Matimba Power Station, as well as the Kendal Power Station (indirect dry cooling; 6 × 640 MW) near Kendal in the eastern Transvaal were the focus of a special international conference on power generation during November 1987 in Johannesburg. The third station, Majuba, near Volksrust is still in an early stage of construction.

List of research projects

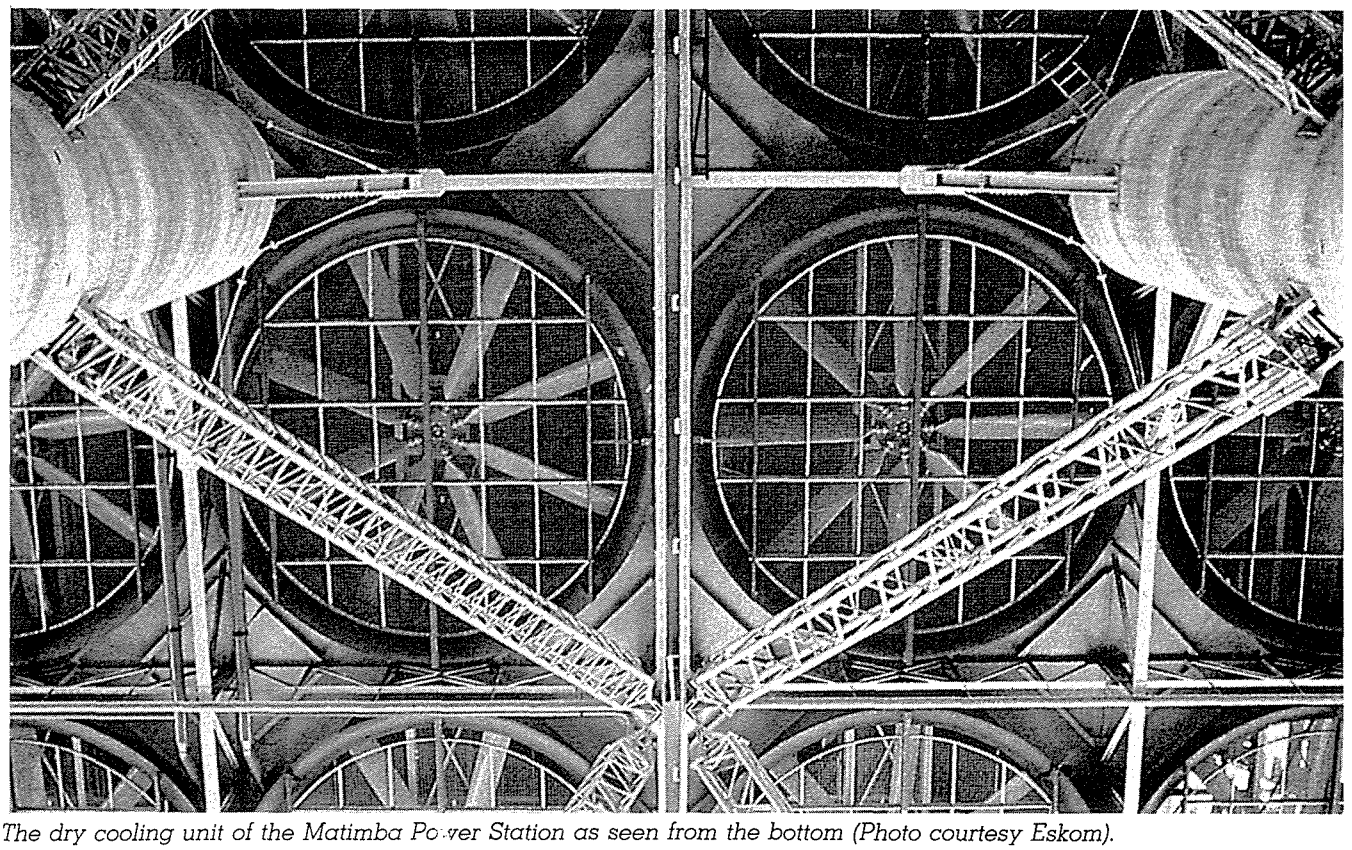
Existing projects

- Research on thermal feedback caused by dry cooling at power generating stations (Eskom and the CSIR – National Physical Research Laboratory).
- Model studies on air flow patterns in mechanical draught air cooling systems at power stations (Eskom and the CSIR).
- Computer and laboratory optimisation studies on dry and dry-wet cooling (University of Stellenbosch and Eskom).



Funding of research on Water Economy at Power Stations expressed as a percentage of total WRC research expenditure (1978 to 1987).

Power stations



The dry cooling unit of the Matimba Power Station as seen from the bottom (Photo courtesy Eskom).

An individual fan blade.

17 Research on the socio-economic effects of water restrictions

FOR the greater part of the eighties the climate in South Africa was characterised by the drought which prevailed over a large part of the summer rainfall area. This state of affairs gradually deteriorated to such an extent that large geographical areas were affected. At the beginning of 1983 the authorities were compelled to impose a series of water restriction measures in the Vaal River supply area, in the Umgeni Water Board supply area and other cases in the OFS and Natal, in order to counter the situation. As was to be expected these measures had far-reaching consequences.

However, little information on the precise socio-economic consequences of water restrictions was available before the imposition of the restrictions which were in force between 1983 to 1987. The Commission therefore saw an ideal opportunity during the period of water restrictions to supplement the existing state of knowledge. Not only would such an investigation indicate the magnitude of the consequences, but it would also provide information on the efficacy of different measures as well as on the implementation thereof to prevent unacceptable economic losses and a decrease in the standard of living.

Consequently three organisations were approached by the Commission to conduct the investigation, viz. the Institute for Social and Economic Research (ISER) of the University of the Orange Free State, the Bureau for Market Research of the University of South Africa and the Centre for Applied Social Sciences of the University of Natal. After consulting these institutions, it was decided to divide the investigation sectorally and not geographically between the institutions.

The overall aim of the research was to determine the nature and extent of the tangible and intangible socio-economic consequences of water restrictions for the period 1983 and for 1984 on these respective sectors for each of the following water supply systems:

- Ngagane Government Water Scheme, Natal;
- Umgeni catchment area, Natal;
- Vaal River system, but excluding tributaries of the Vaal River;
- Riet River Government Water Scheme, OFS; and
- Vaalharts Government Water Scheme, Cape Province.

Reports on the socio-economic consequences of water restrictions on the domestic sector, and on irrigation farming, mining, electricity supply and the central government have respectively already been submitted to the Commission by the Bureau for Market Research and the Institute for Social and Economic Research.

The total nett tangible effect of the water restrictions on the domestic sector, which is served by the three first-mentioned water supply systems, amounted to R262,0 million for the period March 1983 to March 1985. However, a large portion of this amount (78%) is the result of expenses which are in actual fact permanent improvements to the relevant properties, *inter alia* own water supply by means of boreholes; paving; and the installation of more effective irrigation systems. It has to be accepted, though, that these expenses were a direct result of water restrictions, and that the running costs of water supply were also increased as a result of these permanent improvements.

The total nett tangible effect, also over the period March 1983 to March 1985, amounted to R205,8 million for government institutions, agriculture, mining and electricity supply. The relative proportions, expressed as a percentage of the total, amounted to 10,3%; 32,1%; 22,2% and 35,4%. The Vaal River system was affected most severely, as was to be expected, followed by the Vaalharts Government Water Scheme.

The investigation found that the restrictions could also be constructive in some respects. The most notable positive effects are ways of saving water, a realisation of the fact that water is life and that water is a means of production.

After considering these reports, the Commission decided to withhold publication thereof, pending the report of the Centre for Applied Social Studies, as well as the summary report. The reason for this decision was that the Commission considered it important to obtain a total picture of the economic consequences of water restrictions so that the relative importance of the different sectors can then be evaluated more effectively.

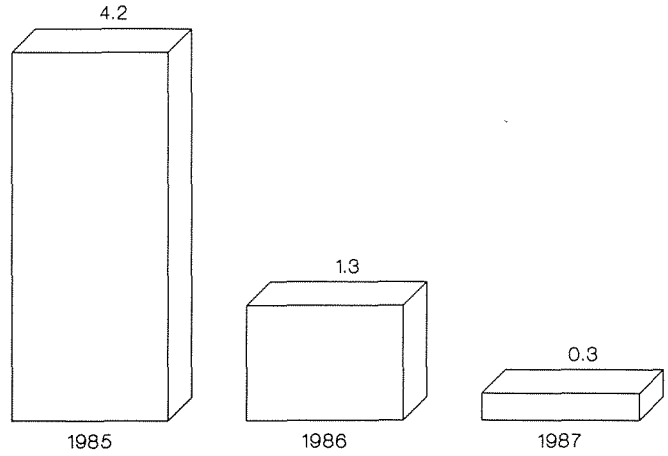
List of research projects

Completed project

- Research on socio-economic domestic losses as a result of restrictions on water consumption (The University of South Africa - Bureau of Market Research).

Existing projects

- Research on the socio-economic effects of water restrictions on irrigation farming, mining, electricity supply and central government (The University of the Orange Free State - Institute for Social and Economic Research).
- Research on the socio-economic effects of water restrictions on industries and local governments (The University of Natal - Centre for Applied Social Sciences).



Funding of research on Socio-economic Effects of Water Restrictions expressed as a percentage of total WRC research expenditure (1985 to 1987).

18 Research support services

THE mission of the Water Research Commission is to promote water research in South Africa. This entails the coordination, stimulation and encouragement of research on all aspects of water. To fulfill this mission, it is essential to provide information systems to aid the planning and execution of research.

The WRC has developed a number of such information systems as research support services. These operate on two levels, firstly on a primary level, which serves all of water research and secondly on a secondary level which serves only one or other aspect of water research.

Primary information systems

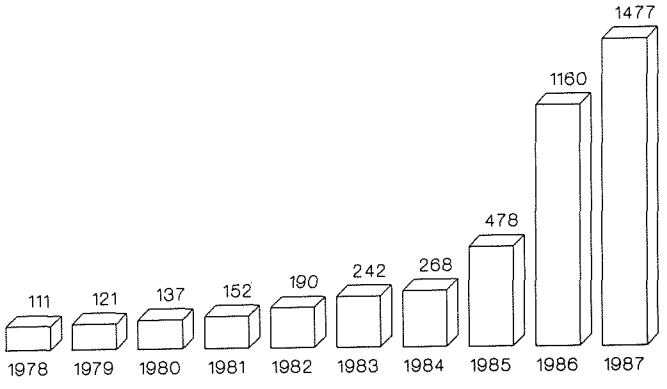
The first and probably the most well-known service is the South African Water Information Centre (SAWIC) which provides bibliographic information. Recently the WRC has developed a numeric information system, the Computing Centre for Water Research (CCWR). Additionally, the WRC is also involved with the development of the national Hydrological Information System (HIS).

The South African Water Information Centre (SAWIC)

The SAWIC is funded by the WRC and is operated as an independent unit by the CSIR on behalf of the WRC. The SAWIC provides services to scientists and engineers in the water field on a national basis.

The SAWIC operates a computerised bibliographic data base, WATERLIT, which has been developed by themselves. WATERLIT already contains more than 132 000 references, which are added at a rate of 11 500 items per year from approximately 420 scientific and technical journals, as well as reports, theses, books, patents and conference proceedings.

In the course of the year approximately 110 retrospective searches per month were done on WATERLIT, while roughly 364 SDI (selective dissemination of information) profile holders are informed monthly of publications in their specific field of interest. Some of the retrospective searches were done by the Department of Water Affairs, university libraries, other CSIR institutes and regional offices of the NII (National Institute for Informatics).



Funding of Research Support Services by the WRC for 1978 to 1987 (in 10^3 Rand)

During the year the Centre provided assistance to the JLB Smith Institute for Ichthyology in Grahamstown to establish a data base similar to WATERLIT namely FISHLIT. Information which had been entered previously on WATERLIT is now being indexed on FISHLIT by the JLB Smith Institute. FISHLIT is also available to the SAWIC and already 90 SDI profiles are being conducted by the SAWIC on FISHLIT.

Table 1 contains information on how the services of WATERLIT were used locally during the year. Table 2 contains information on the fields of interest for which information was requested most frequently.

The SAWIC has created a *Register of South African Hydrological Data Sources* which is available as a data base as well as in hard copy.

A *Bibliography on African Limnology South of the Sahara* was compiled by the SAWIC for the Limnological Society of Southern Africa, while a *Bibliography of Large Dams in Southern Africa* was compiled for the South African branch of the International Commission for Large Dams.

The Computing Centre for Water Research (CCWR)

In 1986, the WRC in collaboration with the then IBM (SA) (Pty) Ltd (now ISM (Pty) Ltd) and the University of Natal, established the Computing Centre for Water Research (CCWR) which is a numeric information system. The mission of the CCWR is:

"To support water research in South Africa by providing a national, computer-based information system which will:

- enhance the transfer of data and results;
- provide a facility for multidisciplinary research; and
- provide alternative computer facilities."

The objectives of the CCWR are:

1. The provision of a national facility for:

- the enhanced transfer of data and other information between supply organisations and researchers;
- the development of appropriate data products and the provision of these to researchers;
- the provision of appropriate applications software for water research purposes; and
- the enhanced transfer of research results between researchers and end-user organisations.

The Market Concept

Table 1
Use of the centre's services by the various sectors

WATERLIT Users	Retrospective searches			SDI profiles		
	1985	1986	1987	1985	1986	1987
Total	820	981	1 202	250	314	364
	%	%	%	%	%	%
Universities	25,5	21,0	27,0	36,0	42,0	42,0
Department of Water Affairs and other government organisations	20,2	17,7	13,0	20,4	16,6	20,0
CSIR	16,0	20,1	13,0	16,8	17,2	14,0
Industry and private companies	13,7	14,4	18,0	8,4	9,9	8,0
Consultants	6,7	8,9	10,0	4,0	2,9	2,0
Municipalities and water boards	5,2	5,9	6,0	6,4	5,4	5,0
Other	12,7	12,0	13,0	8,0	6,0	9,0

Table 2
Fields of interest for which information was requested most frequently

Field of Interest	Retrospective searches			SDI profiles		
	1985	1986	1987	1985	1986	1987
Total	820	981	1 202	250	314	364
	%	%	%	%	%	%
Industrial effluents	14,1	13,5	14,0	8,0	6,1	4,0
Water control, quality and distribution	13,0	12,5	15,0	8,4	8,3	9,0
Limnology and biology	12,7	13,9	23,0	21,6	30,9	41,0
Analysis and quality control	9,1	16,2	11,0	3,6	9,2	7,0
Hydrology	8,1	5,6	5,0	12,0	11,8	7,0
Waste-water treatment	6,4	8,8	6,0	10,4	7,5	9,0
Pollution	4,9	6,5	5,0	4,4	4,8	3,0
Marine aspects	4,4	0,7	1,0	4,4	4,1	4,0
Aquaculture	3,6	5,0	3,0	8,4	5,1	5,0
Ground water	2,8	2,6	2,0	4,4	3,1	3,0
Agriculture and irrigation	2,5	4,2	2,0	4,0	3,5	4,0
Solid waste	1,5	1,5	4,0	1,6	1,3	1,0
Desalination	1,2	0,8	2,0	3,2	1,3	2,0
Other	15,7	8,0	7,0	6,4	2,9	1,0

2. The provision of a facility whereby multidisciplinary, multi-organisational research can be undertaken by people in different organisations throughout the country.
The Invisible College Concept
3. The provision of enhanced and/or alternative computing and computer graphics capabilities for researchers throughout South Africa.

During 1987 the CCWR expanded its services by providing full graphics capability to remote centres using SAPONET. Users at Rhodes, Natal and Orange Free State Universities now have synchronous access to the CCWR.

The Hydrological Information System (HIS)

A serious limitation to water research has been the fact that data of suitable quality in computerised form were not readily available. The Department of Water Affairs has a vast amount of data collected over many years which are not, however, as accessible to water research as is deemed necessary. The WRC therefore entered into a contract with the department in terms of which these data would be stored in an efficient, computerised, national

information system called the Hydrological Information System (HIS). The WRC is aiding the department with the development of the data banks and the digitisation of historical data. These aspects are of course only a small, although very important, part of the whole data capture, storage and dissemination system of the Department of Water Affairs.

The project is in its third year now and it is anticipated that the HIS will be completed by the end of 1990. Already, the benefits of the project in terms of river flow and other data are being realised. It is planned that the information system will include *inter alia* river flow, reservoir, sediment, water quality, evaporation and ground-water data by the time it is completed.

National Data Bank for Ground-water Data

The National Data Bank for Ground-water Data is being established by the Institute for Groundwater Studies at the University of the Orange Free State, in collaboration with the Department of Water Affairs.

The objective is to design and implement the ground-water data bank for the Department of Water Affairs, in order to improve ground-water detection, ground-water research and the utilisation and management of ground-water sources, by means of storage, processing and evaluation of ground-water data. The data bank will be point-orientated and will contain raw data with respect to site, evalution and water use efficiency. A variety of other data will also be included, such as information on boreholes, the aquifer, formations, the contractor, drilling costs, physical measurements, etc.

Although the data bank will be hosted by the Department of Water Affairs, negotiations are under way to secure access by other parties to the data bank.

Secondary information systems

In addition to the aforementioned primary computerised information systems, the WRC has now also embarked on the establishment of secondary systems to support one or other aspect of water research. Initially, secondary systems are being established for surface hydrology (see ***Chapter 3***) and will include:

- A data base containing information on all sources of hydrological data.
- A data base containing information on current and past research projects in surface hydrology and their results, where applicable.
- A data base containing information on research needs and priorities for surface hydrology.

These are being established and will be maintained by the SAWIC in collaboration with WRC personnel. They will be used for the planning, coordination and control of the national hydrological research effort.

List of support services

- The establishment of a National Hydrological Information System (HIS) (The Department of Water Affairs).
- South African Water Information Centre (SAWIC) (The CSIR - National Institute for Informatics).
- Computing Centre for Water Research (CCWR) (The University of Natal and ISM (Pty) Ltd).
- The development of a National Data Bank for Ground-water Data (The University of the Orange Free State - Institute for Groundwater Studies in collaboration with the Department of Water Affairs).

19 The 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. 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. Frequently references are made in various chapters of the annual report to specific actions taken in the interest of technology transfer. These actions are not described in any detail in this chapter, but reference is made to the methods used for the promotion of technology transfer.

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 Water Research Commission 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.

During the year under review, the *Bulletin* changed from a quarterly periodical being published four times annually to a bi-monthly periodical with six annual editions. This enables the Commission to bring information and news from the water field to the notice of the various target groups more rapidly and more frequently. At the moment the number of recipients amounts to about 3 000.

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 in Annexure 1.

List of Commission publications

Annexure 1 to this annual report contains a list of publications (articles, papers and published reports) which appeared during 1987 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.

Technology transfer

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.

20 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 1987 to 31 December 1987.

The Commission derives its income from rates and charges on water usage and on scheduled irrigation land. The tariffs for the 1987 financial year were 0,70 c/m^3 for water supplied for urban, industrial or domestic use, and 90 c/ha of land scheduled for irrigation.

WATER RESEARCH COMMISSION

STATEMENT 1

BALANCE SHEET AS AT 31 DECEMBER 1987

1986	Liabilities	1987	
R		R	R
	Accumulated Funds -		
	Balance at 31/12/86	12 436 378,63	
12 436 379	*Plus*: Income over expenditure, 1987	5 304 580,43	17 740 959.06
	Current liabilities -		
	Sundry creditors -		
	Revenue paid in advance	4 435,31	
31 551	*Bank overdraft*	996,87	5 432,18
R12 467 930			R17 746 391,24

1986	Assets	1987		
R		R	R	R
	*Capital assets -			
5 000	Land (Cost)		5 000,00	
	Motor vehicles	28 703,30		
27 830	*Less:* Depreciation	4 753,46	23 949,84	
	Office equipment	249 224,23		
219 002	*Less:* Depreciation	11 489,54	237 734,69	
	Office furniture	32 875,20		
30 920	*Less:* Depreciation	1 587,22	31 287,98	297 972,51
7 233 222	Loan			9 226 921,52
	Investments		4 928 441,82	
2 285 719	*Plus:* Accrued interest		108 315,80	5 036 757,62
	Current assets -			
	Sundry debtors -			
975 337	Outstanding revenue		875 895,70	
214 107	In transit		-	
1 286 315	Project advances (Statement 3)	2 220 776,35		
919	Subsistence and transport advances	-		
122 120	Motor financing	87 617,54		
300	Deposits	300,00	2 308 693,89	
150	Cash on hand		150,00	
66 989	Cash in bank		-	3 184 739,59
R12 467 930				R17 746 391,24

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

Pretoria, 7 April 1988

(Signed) P.E. Odendaal
Executive Director

The above Balance Sheet has been audited in accordance with the provisions of section 42(4) of the Exchequer and Audit Act, No. 66 of 1975, read with section 14(1) of the Water Research Act, No. 34 of 1971, and in my opinion reflects a true and fair view of the financial affairs of the Water Research Commission.

Cape Town, 21 April 1988

(Signed) J.H. de Loor
Auditor-General

WATER RESEARCH COMMISSION

STATEMENT 2

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31 DECEMBER 1987

1986	Expenditure	1987
R		R
1 710 435	Salaries and allowances	1 848 060,02
6 946	Motor transport	10 403,52
46 716	Subsistence	48 231,77
161 700	General transport	195 949,04
1 800	Commission members' allowances	1 700,00
9 083	Postal and telegraph services	11 412,72
40 448	Telephone services	43 750,55
34 759	Printing and stationery	39 139,87
3 160	Advertisements	17 114,34
226 419	Publications and Information	258 482,43
8 393	Technology and information transfer	14 105,24
25 878	Lease and maintenance of office equipment	37 824,15
8 675	Entertainment	10 213,48
58 262	Office rental	71 064,80
1 114	Maintenace of and alterations to offices	1 089,35
6 573	Electricity	9 412,52
208	Maintenance and lease of furniture	33,15
3 807	Typing and translation services	1 154,13
7 618	Insurance and licenses	18 536,27
119 197	Collection fees	159 042,84
1 847	Audit fees	3 845,53
6 448	Legal costs	128 640,26
27 348	Registrations and subscriptions	24 330,08
9 443	Miscellaneous petty expenses	15 276,60
16 488	Depreciation	17 830,22
8 877 902	Research projects and Research Support Services (Statement 3)	7 246 076,86
187 938	Contracting of researchers and expertise	221 502,69
	Weather modification at Bethlehem	152 825,56
	Investigation into water use and productivity of crops under conditions of water stress and the modelling thereof	68 677,13
110 000	Research and other grants	105 000,00
68 054	Specialist and consultation services	110 336,49
311 812	Income over expenditure	5 304 580,43
R12 098471		R15 974 139,35

1986	Income		1987
R		R	R
	Rates		
	Government irrigation schemes with canal systems:		
	Received	163 715,18	
157 429	*Plus*: Outstanding	35 103,35	198 818,53
	Irrigation Board Schemes:		
	Received	183 222,87	
150 987	*Plus*: Outstanding	106 980,89	290 203,76
	Charges		
	Metered water from Government schemes:		
	Received	11 530 865,57	
9 483 021	*Plus*: Outstanding	585 664,50	12 116 530,07
	Municipalities:		
	Received	2 854 372,99	
2 023 088	*Plus*: Outstanding	146 081,63	3 000 454,62
	Interest on rates and charges in arrear		
	Received	7 464,90	
4 373	*Plus*: Outstanding	2 065,33	9 530,23
	Interest on Investments:		
	Received	162 325,15	
240 326	Accrued	108 315,80	270 640,95
39 247	Sundry Income		87 961,19
R12 098 471			R15 974 139,35

WATER RESEARCH COMMISSION

STATEMENT 3

Statement of expenditure and advances outstanding in respect of research projects and research support services as at 31 December 1987

Project	Expenditure		Total advances outstanding as at 31/12/87
	1987	Total to 31/12/87	
1. RESEARCH PROJECTS	R	R	R
Technological development of water reclamation on the basis of the Windhoek plant	4 148,46	810 965,55	*(516,94)
The construction and operation of the Cape Flats prototype water reclamation plant and the surveillance of reclaimed water quality	23 809,00	931 395,62	81 613,52
Research on the influence of different times and intensities of internal plant moisture stress on photosynthesis, respiration and water use efficiency of certain agronomic crops	45 100,00	377 431,80	-
Development of the required apparatus and programmes for the monitoring and management of irrigation systems	294,98	522 063,42	-
Research on the revision of the temporal and spatial distribution of precipitation statistics in Southern Africa	39 374,18	278 151,41	-
Research on urban hydrology and drainage	56 250,00	361 850,70	-
A detailed regional soil moisture deficit analysis for irrigation planning in Southern Africa	10 350,00	65 327,51	-
Research on detailed geohydrological investigations in the Poesjenels River catchment in the Breede River valley, with special reference to mineralization	21 301,57	223 515,13	*(9 301,57)
Water management and effluent treatment in the textile industry: Treatment of scouring and bleaching effluent	40 230,69	733 850,25	7 769,31
Research on an investigation into the use of physical/chemical techniques for water and wastewater management in the meat processing industry	-	500 600,00	60 100,00
Research on the inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage	16 957,51	152 170,98	1 914,02
An investigation into the condition of soils irrigated over a protracted period and an evaluation of applicable selection criteria, and reclamation and control measures	6 391,48	55 711,32	6 117,68
Research on the contribution of mine dumps to mineral pollution in the Vaal Barrage	84 376,84	233 900,00	-
Research on enhancement of biological phosphate removal from sewage by altering process feed composition	17 156,87	221 635,17	8 507,11
Hydrological research in catchments of the Eastern and Southern Cape	153 514,38	468 427,79	*(3 647,79)
Research on an evaluation of hydrological flood estimation techniques for small ungauged catchments	15 000,00	210 056,32	-
Research on the use of soil/root conductance index and stress ratio as inputs for the determination of irrigation requirements of selected soil/plant/atmosphere systems	60 612,23	270 416,60	6 896,64
A national industrial water and wastewater survey	-	1 871 188,12	547 800,00
Research on biological foam in the activated sludge process	15 831,84	67 051,74	-
Research on biological excess phosphate removal	-	426 243,41	139 828,95
An investigation into rainfall recharge to groundwater	-	456 598,80	121 268,71
Research on the development of a national data bank for groundwater data	204 150,42	706 999,95	-
Research on correction factors for the evaporimeter coëfficients used in the irrigation scheduling of wheat	49 027,82	202 512,95	7 172,18
Research on the practical scheduling of irrigation in the Northern Transvaal	121 192,38	227 156,41	*(22 796,29)
Research on the quantification and limitation of water losses associated with centre pivot irrigation systems	63 165,61	169 720,49	*(2 165,61)
Applied hydrological process and modelling studies for the determination of water and sediment yield	210 347,89	735 199,59	40 800,41
Research on design stormflow and peak discharge rates for small catchments in Southern Africa	46 102,50	208 221,45	-
Research into water loss analysis on municipal water distribution systems	142 285,00	450 900,00	-
Research on thermal feedback caused by dry cooling at power generating stations	38 000,00	155 928,00	*(5 796,00)
Research on the evaluation and optimisation of full-scale chemical phophate removal in biological sewage treatment processes	56 275,87	143 033,86	*(572,91)
Research into the treatment of wool scouring effluents	69 495,59	757 973,22	211 246,78
The technical performance evaluation of a full-scale industrial wastewater treatment plant: Textile dyehouse effluent treatment by hyperfiltration and evaporation	-	44 162,72	2 412,28
The development of support systems for cross-flow microfiltration and technical performance evaluation on industrial waters and wastewaters	132 300,00	422 110,26	*(200,26)
Research on and development and full-scale evaluation of preventative and remedial methods for the control of activated sludge bulking	20 985,46	113 202,39	57 653,76
Research on improving irrigation management based on soil water monitoring and detailed knowledge of profile available water capacities	102 977,22	148 700,17	75 999,83
Research on the sosio-economic effects of water restrictions on industries and local governments	70 152,24	98 234,63	*(12 776,97)

STATEMENT 3 (continued)

Project	Expenditure		Total advances outstanding as at 31/12/87
	1987	Total to 31/12/87	
	R	R	R
Research on the exploitation potential of Karoo aquifers	195 127,08	548 754,40	24 175,64
Research on membrane development and fabrication for reverse osmosis and ultrafiltration	549 845,09	1 222 410,30	35 154,91
Research on the health implications of the intake of chemical contaminants by man	4 857,12	14 457,89	-
The development of management-orientated models for eutrophication control	53 872,00	182 458,00	20 401,00
Modelling of the ground-water quality in the Atlantis aquifer	244 139,37	408 176,79	71 860,21
The development of a computer program to simulate water flow in distribution canals	63 485,83	88 583,07	17 708,91
Research into water consumption and possible water saving in apartment buildings	7 307,09	39 600,00	*(1 100,00)
Research on the possible chronic health effects of consumption of reclaimed water on the consumer at Windhoek	22 278,00	38 229,67	*(1 978,00)
Pilot plant studies on the desalination of underground mine water with EDR	1 906,58	15 000,00	-
Research on chemical characterisation of South African municipal sludge	22 927,00	36 554,00	1 073,00
Research on the evaluation of the impact of the phosphate standard on the water quality and trophic status of Hartbeespoort Dam	85 219,00	150 293,00	*(3 593,00)
Research on the effective use of water by means of an algal-aqua culture system	14 355,88	22 444,11	*(355,88)
Research on the effects of urbanisation on catchment water balance	162 348,74	162 348,74	230 001,26
A pilot study of the irrigated areas served by the Breede River (Robertson) irrigation canal	89 407,20	194 953,27	-
Research on drip irrigation of tomatoes	202 062,13	202 062,13	100 037,87
Research on epidemiological surveillance of potential changes in drinking water quality	-	97 491,68	113 234,40
Research on the development of polymers for the formation of dynamic membranes and the evaluation thereof for the treatment of industrial effluents	202 231;60	386 503,41	4 916,59
Research on the evaluation and optimisation of the process of dual digestion of sewage sludge	113 402,04	160 256,04	11 943,96
Model studies on air flow patterns in mechanical draugth air cooling systems at power stations	40 000,00	75 000,00	-
Computer and laboratory optimization studies on dry and dry-wet cooling	332 733,31	516 796,69	*(29 733,31)
Research on the feasibility of reverse osmosis for water reclamation on large scale	266 606,00	516 606,00	19 394,00
The development of a portable toxicity detector for water	17 872,00	17 872,00	22 128,00
An investigation into the occurrence and concentration of trihalomethanes and their precursors in South African drinking water	32 438,00	33 832,00	6 268,00
Hydrosalinity studies in the Eastern Cape	362 394,19	362 394,19	48 965,81
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	67 740,78	108 912,65	16 387,35
Development of phosphate export models for catchments	3 574,00	8 376,00	1 424,00
The development of methods to assess the impact of agricultural practices on water resources in Southern Africa	122 748,72	122 748,72	18 751,28
Research on the effects of reduced water consumption on domestic sewer systems	21 764,96	21 764,96	*(1 764,96)
Research on the development of a stochastic daily climate model for South African conditions	-	-	40 890,15
Research on the treatment of inorganic brines and concentrates	107 524,83	107 524,83	*(424,83)
Research on dissolved air flotation for the treatment of eutrophied surface water for potable use	51 871,00	51 871,00	*(2 991,00)
Research on chemical removal of sulphates	32 931,06	32 931,06	*(2 231,06)
Development of water quality monitoring strategies and procedures for water quality data interpretation	49 537,00	49 537,00	*(11 537,00)
Research on the isolation and identification of mutagens in drinking water	37 008,00	37 008,00	*(17 508,00)
Research into water consumption rates and patterns and unaccounted-for water in urban areas	-	-	18 000,00
Research on the development of an adjustable low pressure flow-rate control valve for flood irrigation	-	-	25 000,00
Research on the development of criteria for sprinkler irrigation systems to combat surface sealing of soils	20 998,96	20 998,96	2 501,04
An investigation into methods of developing operational rules for individual irrigation systems	131 183,09	131 183,09	29 466,91
Research on electro-chemical produced metal coagulants for the treatment of polluted water	-	-	6 500,00
Research on groundwater abstraction in residential areas	26 901,10	26 901,10	3 098,90

Statement 3 (continued)

Project	Expenditure		Total advances outstanding as at 31/12/87
	1987	Total to 31/12/87	
	R	R	R
Research on the use of electromagnetic exploration techniques for the development of ground-water resources	-	-	50 000,00
Research of marine disposal practice in South Africa	17 247,60	17 247,60	2 752,40
Research on the culturability of faecal coli following exposure to seawater - a pilot study	-	-	5 000,00
Research on phosphate crystallization in activated sludge systems	15 563,00	15 563,00	34 437,00
Research on the evaluation and development of techniques for the determination of geohydrological parameters by use of geo-electrical methods	11 144,00	11 144,00	1 356,00
Research on economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State	27 144,60	27 144,60	5 025,40
TOTAL	5 768 855,98	20 106 541,68	2 233 963,79
2. RESEARCH SUPPORT SERVICES			
South African Water Information Centre	338 428,06	920 987,37	*(80 794,76)
The establishment of a national hydrological information system	956 400,14	1 738 637,84	-
Establishment of a computing centre for water research	182 392,68	290 743,58	67 607,32
TOTAL	1 477 220,88	2 950 368,79	*(13 187,44)
GRAND TOTAL	7 246 076,86	23 056 910,47	2 220 776,35

*Excess expenditure over advances for projects

WATER RESEARCH COMMISSION

STATEMENT 4
BUDGET 1988

	R	R
ESTIMATED INCOME		
Rates and charges in terms of Section II of the Water Research Act		17 886 000
Interest on investment		150 000
		18 036 000
ESTIMATED EXPENDITURE		
Administrative expenses:		
Salaries and allowances	2 221 000	
Subsistence and travelling expenses	304 000	
Postal, telegraph and telephone	60 000	
Printing, stationery, advertisements and publications	432 000	
General expenditure	502 600	3 519 600
RESEARCH PROJECTS		
Approved projects		
Technological development of water reclamation on the basis of the Windhoek plant	6 000	
Research on the inhibition of bacterial oxidation of pyrite and the concomitant acid mine drainage	35 000	
Hydrological research in catchments of the Eastern and Southern Cape	200 200	
A national industrial water and wastewater survey	518 500	
Research on correction factors for the evaporimeter coefficients used in the irrigation scheduling of wheat	37 100	
Research on the practical scheduling of irrigation in the Northern Transvaal	76 400	
Research on the quantification and limitation of water losses associated with centre pivot irrigation systems	68 000	
Applied hydrological process and modelling studies for the determination of water and sediment yield	334 000	
Research on thermal feedback caused by dry cooling at power generating stations	48 200	
Research into the treatment of wool scouring effluents	68 300	
Research on and development and full-scale evaluation of preventative and remedial methods for the control of activated sludge bulking	36 000	
Research on improving irrigation management based on soil water monitoring and detailed knowledge of profile available water capacities	117 000	
Research on the exploitation potential of Karoo acquifers	212 172	
The development of management-orientated models for eutrophication control	41 000	
Modelling of the ground-water quality in the Atlantis acquifer	255 962	
The development of a computer program to simulate water flow in distribution canals	6 500	
Research on the possible chronic health effects of consumption of reclaimed water on the consumer at Windhoek	21 100	
Research on chemical characterisation of South African municipal sludge	27 000	
Research on the evaluation of the impact of the phosphate standard on the water quality and trophic status of Hartbeespoort Dam	87 200	
Research on the effects of urbanisation of catchment water balance	220 000	
Research on drip irrigation of tomatoes	117 000	
Research on epidemiological surveillance of potential changes in drinking water quality	136 000	
Research on the development of polymers for the formation of dynamic membranes and the evaluation thereof for the treatment of industrial effluents	148 692	
Research on the evaluation and optimisation of the process of dual digestion of sewage sludge	118 000	
Computer and laboratory optimization studies on dry and dry-wet cooling	278 000	
Research on the feasability of reverse osmosis for water reclamation on large scale	71 000	
An investigation into the occurrence and concentration of trihalomethanes and their precursors in South African drinking water	8 600	
Hydrosalinity studies in the Eastern Cape	343 500	
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	69 000	
Development of phosphate export models for catchments	120 000	
The development of methods to assess the impact of agricultural practices on water resources in Southern Africa	279 400	
Research on the effects of reduced water consumption on domestic sewer systems	44 400	
Research on the development of a stochastic daily climate model for South African conditions	74 500	
Research on the treatment of inorganic brines and concentrates	264 000	
Research on dissolved air flotation for the treatment of eutrophied surface water for potable use	49 500	
Research on chemical removal of sulphates	44 000	
Development of water quality monitoring strategies and procedures for water quality data interpretation	99 000	
Research on the isolation and identification of mutagens in drinking water	47 150	
Research into flowrates and patterns of water consumption as well as unaccounted for water in urban areas	36 000	
Research on the development of an adjustable low pressure flow-rate control valve for flood irrigation	23 000	
Research on the development of criteria for sprinkler irrigation systems to combat surface sealing of soils	113 300	
An investigation into methods of developing operational rules for individual irrigation systems	148 000	
Research on groundwater abstraction in residential areas	60 000	
Research on the use of electromagnetic exploration techniques for the development of ground-water resources	72 000	
Research on marine disposal practice in South Africa	10 900	
Research on the culturability of faecal coli following exposure to seawater - a pilot study	1 000	
Research on phosphate crystallization in activated sludge systems	55 000	
Research on the evaluation and development of techniques for the determination of geohydrological parameters by use of electrical methods	27 500	
An exploratory study into the efficiency of drinking water treatment in South Africa	10 000	
Research on economic evaluation of alternative irrigation scheduling strategies for wheat in the irrigated area of the Orange Free State region	60 800	

WATER RESEARCH COMMISSION

STATEMENT 4
BUDGET 1988

(Continued)

	R	R
RESEARCH PROJECTS		
The development of fixed and dynamic membrane systems for the treatment of brackish water and effluents	539 000	
Forced aeration composting performance evaluation	13 000	
	5 896 876	
Possible projects	3 915 000	9 811 876
Contracting of researchers and expertise		70 000
Research and other grants		170 000
Specialist and Consultation Services		160 000
Loan		2 270 700
Research Support Services		2 027 370
TOTAL ESTIMATED EXPENDITURE		18 029 546
Expected investment balance		6 454
		R18 036 000

Annexure 1

PUBLICATIONS EMANATING FROM RESEARCH FINANCED WHOLLY OR PARTIALLY BY THE COMMISSION

This appendix contains a list of publications released in 1987. Requests for publications should be directed, as far as possible, to the authors.

PUBLICATIONS FOR 1987

ARTICLES AND PAPERS

Alexander, W.J.R. (1987) The use of microcomputers in water resource modelling. *Proc. Symp. on Modelling of Aquatic Systems.* CSIR Foundation for Research Development. Pretoria.

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Benade, N. en Annandale, G.W. (1987) Die ontwikkeling van 'n rekenaarprogram om watervloei in besproeiingskanale te simuleer. *Water SA* **13** (2) 103-108.

Bennie, A.T.P., Taylor, H.M. and Georgen, P.G. (1987) An assessment of the core-break method for estimating the rooting destiny of different crops in the field. *Soil and Tillage Research* **9** 347-353.

Berliner, P.R. and Oosterhuis, D.M. (1987) Effect of root and water distribution in lysimeters and in the field on the onset of crop water stress. *Irrig. Sci.* **8** 245-255.

Bindoff, A.L., Davies, C.J., Kerr, C.A. and Buckley, C.A. (1987) The nanofiltration and reuse of effluent from the caustic extraction stage of wood pulping. *Desalination* **67** 455-465.

Blackbeard, J.R., Gabb, D.M.D., Ekama, G.A. and Marais, G.v.R. (1987) A survey of filamentous organisms in nutrient removal activated sludge processes. Paper presented at IWPC (SA Branch) Conference, Port Elizabeth, May.

Bosch, D.J., Eidman, V.R. and Oosthuizen, L.K. (1987) A review of methods for evaluating the economic efficiency of irrigation. *Agricultural Water Management* **12** 231-245.

Buckley, C.A., Bindoff, A.L., Kerr, C.A., Kerr, A., Simpson, A.E. and Cohen, D.W. (1987) The use of speciation and X-ray techniques for determining pretreatment steps for desalination. *Desalination* **66** 327-337.

Buckley, C.A., Simpson, A.E., Kerr, C.A. and Schutte, C.F. (1987) The treatment and disposal of waste brine solutions. *Desalination* **67** 431-438.

Cogho, V.E. and Kirchner, J. (1987) A national ground-water data base for southern Africa. *Proceedings of the Hydrological Sciences Symposium,* Rhodes University, Grahamstown, September. **2** 598-607.

Cousens, D.W.H. (1987) Computing Centre for Water Research (CCWR) - A national information system for water research. *Proc. Symposium on Modelling of Aquatic Systems,* CSIR, Pretoria. Occasional Report Series No 24, FRD Ecosystems Programmes 14-25.

De Jager, J.M. (1987) Maximization of whole farm profit from flood irrigation of winter wheat when water supply is limited. Paper presented at 17th Congress of the South African Society of Crop Production, Stellenbosch.

De Jager, J.M. and Singels, A. (1987) An iterative technique for estimating leaf water potential and transpiration rate. Paper presented at Soil-Plant-Air Continuum Workshop on Study Techniques, CSIR Foundation for Research Development, Cedara, 15-18 September.

Dent, M.C., Lynch, S.D. and Tarboton, H. (1987) Detailed delimitation of rainfall regions in southern Africa. *Proceedings of the Hydrological Sciences Symposium,* Rhodes University, Grahamstown, September. **1** 62-69.

Dent, M.C. and Schulze, R.E. (1987) The hydrological data manager and digitisation in 1986: Points to ponder in the development of a new digitising system. *Water SA* **13** (1) 49-52.

Dent, M.C., Schulze, R.E. and Angus, G.R. (1987) Sensitivity of the output of the ACRU model to daily and mean monthly temperature based evaporation estimates. *Proceedings of the Hydrological Sciences Symposium,* Rhodes University, Grahamstown, September. **2** 509-520.

Dent, M.C., Schulze, R.E., Wills, H.M.M. and Lynch, S.D. (1987) Spatial and temporal analysis of the recent drought in the summer rainfall region of southern Africa. *Water SA* **13** (1) 37-42.

Dold, P.L. and Marais, G.v.R. (1987) D.O. control: Extent of problem in South Africa. Paper presented at Symposium on Instrumentation, Control and Automation in Water and Wastewater Management, CSIR, Pretoria, November.

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Du Plessis, H.M. (1987) Soil Water: Porous cup lysimeters/soil water extractors. Paper presented at Soil-Plant-Air Continuum Workshop on Study Techniques, CSIR Foundation for Research Development, Cedara, 15-18 September.

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Fischer, H.H. en Nel, P.C. (1987) Die invloed van grondvogtoestande gedurende die wintergroeiseisoen op sekere planteienskappe van kopkool (*Brassica oleracea* cv Capitata). *Toegepaste Plantwetenskap* **1** 28-33.

Flemmer, R.L.C., Buckley, C.A. and Groves, G.R. (1987) The arrangement of spiral wound ultrafiltration modules. *Desalination* **61** 159-168.

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Geldenhuys, J.C. (1987) Evaluation of the use of granular activated carbon in the production of potable water. Paper presented at IWPC (SA Branch) Conference, Port Elizabeth, May.

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Green, G.C. (1987) Transpiration measurement: the heat pulse technique. Paper presented at Soil-Plant-Air Continuum Workshop on Study Techniques, CSIR Foundation for Research Development, Cedara, 15-18 September.

Green, G.C. (1987) Transpiration measurement: weighing lysimetry. Paper presented at Soil-Plant-Air Continuum Workshop on Study Techniques, CSIR Foundation for Research Development, Cedara, 15-18 September.

Grobler, D.C. and Rossouw, J.N. (1987) Decision support system

Annexure 1

for selecting pollution control strategies. Poster presentation as part of the exhibition of the Department of Trade and Commerce at the Trade Fairs in Hannover and München, April.

Grobler, D.C. and Rossouw, J.N. (1987) The implications of effluent phosphate management on the trophic status of Hartbeespoort Dam. In: *Symposium on Hartbeespoort Dam: 'Quo Vadis?'.* Occasional Report Series No. 25, Ecosystems Programmes, CSIR Foundation for Research Development.

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Grobler, D.C., Rossouw, J.N., Van Eeden, P. and Oliveira, M. (1987) Decision support system for selecting eutrophication control strategies. In: Thornton, J.A. (Compiler) (1987) *Proceedings of a Symposium on Modelling of Aquatic Systems.* Occasional Report Series No. 24, Ecosystems Programmes, CSIR Foundation for Research Development.

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Hunt, J.W., Treffry-Goatley, K., Flemmer, R.L.C., Raal, J.D. and Buckley, C.A. (1987) A mathematical model of steady-state cross-flow microfiltration in a woven hose support. *Desalination* **61** 187-200.

Immelman, E. (1987) Controlled release of sodium lauryl sulphate from monolithic elastomeric matrices and through elastomeric membranes. M.Sc. Thesis, University of Stellenbosch.

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Louw, A.S. (1987) Chemical phosphate removal at Boksburg Water Pollution and Control Works: automation and control. Paper presented at Symposium on Instrumentation, Control and Automation in Water and Wastewater Management, CSIR, Pretoria, 19 November.

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Lynch, S.D. and Dent, M.C. (1987) Appropriate record lengths for the estimation of mean annual and mean monthly precipitation in South Africa. *Proceedings of the Hydrological Sciences Symposium,* Rhodes University, Grahamstown, September. **1** 50-61.

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Annexure 1

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