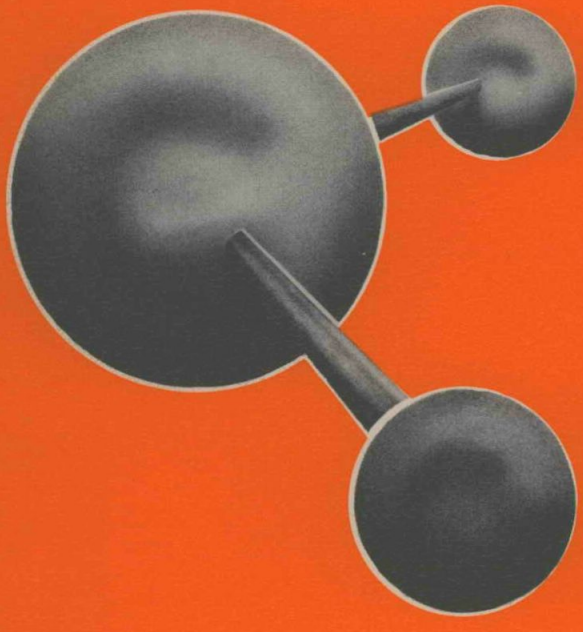

water research commission

ANNUAL REPORT

1 January 1977 to 31 December 1977

WATER RESEARCH COMMISSION

Annual Report

1 January 1977 to 31 December 1977

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Water Research Commission
P O Box 824
PRETORIA
0001
1 March 1978

Dear Sir

We take pleasure in submitting to you, herewith, the report of the Water Research Commission. This report covers the period 1 January 1977 to 31 December 1977.

Balance sheets and statements of revenue and expenditure for the financial year 1 January 1977 to 31 December 1977, as certified by the Auditor-General, are furnished in chapter 15 of this report.

Yours respectfully

G J Stander
CHAIRMAN

J P Kriel
VICE CHAIRMAN

The Honourable A J Raubenheimer, MP
Minister of Water Affairs
P O Box 23
CAPE TOWN
8000

Members of the Water Research Commission for the period ending 31 July 1977

DR G J STANDER
Pr. Eng., M.Sc., Ph.D., D.Sc.h.c.
Chairman: Chief Executive Officer
Honorary Professor:
University of Pretoria
Member of the Executive Committee of the International Association on Water Pollution Research and immediate past President

PROF D C MIDGLEY
Pr. Eng., B.Sc. (Eng.)., Ph.D.
Director: Hydrological Research Unit
University of the Witwatersrand

DR J P KRIEL
Pr. Eng., B.Sc. (Civ. Eng.)., D. Eng.h.c.
Vice Chairman
Honorary Professor: University of Pretoria
Vice President: International Commission on Large Dams
Secretary for Water Affairs

PROF S MEIRING NAUDé
M.Sc., Ph.D., D.Sc.h.c., LL.D.h.c., F.R.S. (SA)
Honorary Professor: Rand Afrikaans University
Former Scientific Adviser to the Prime Minister

MR V N BOLITHO†
Pr. Eng., B.Sc. (Eng.)
Dip. (T.Pg.) (Rand)
Assistant City Engineer
Johannesburg Municipality

DR N STUTTERHEIM
Pr. Eng., D.Sc. (Eng.)
Chairman: Noristan Ltd
Chairman: Telephone Manufacturers of South Africa
(co-opted member)

PROF B J V BOTHA
B.Sc., M.Sc., D.Sc.
Head: Department of Geology
University of the Orange Free State

DR P W VORSTER
B.Sc. (Agric.), M.Sc. (Agric.), D.Sc. (Agric.)
Former Secretary of the Department of Agricultural Technical Services

DR C v d M BRINK
M.Sc., D.Sc., F.R.S. (SA), D.Sc.h.c.
President of the Council fo:
Scientific and Industrial Research

Members of the Water Research Commission with effect from 1 August 1977

Reappointed members

DR G J STANDER
Chairman: Chief Executive Officer

DR J P KRIEL
Vice Chairman

DR C v d M BRINK

PROF D C MIDGLEY

DR N STUTTERHEIM
(co-opted member)

New members

PROF G D B DE VILLIERS
B.Sc., M.Sc., D.Sc., S.E.D.
Vice Rector: University of the Orange Free State

MR E J HALL
Pr. Eng., M.Sc. (Eng.)
City Engineer
Johannesburg

PROF D J SCHOEMAN
Pr. Eng., M.Sc. (Eng.), Ph.D.
Dean: Faculty of Engineering
Head: Departement of Chemical Engineering
University of Pretoria

DR W A VERBEEK
B.Sc. (Agric.), M.Sc. (Agric.), D.Sc. (Agric.)
Secretary of Agricultural Technical Services

Chapter 1

Review and preview of the Commission's activities

The Commission and the Executive Committee each held three meetings during the year under review.

Four new Commission members, *viz* Prof G D B de Villiers, Mr E J Hall, Prof D J Schoeman and Dr W A Verbeek, have been appointed by the State President for a term of three years, effective from 1 August 1977. These new members replace Mr V N Bolitho, Prof B J V Botha, Dr S Meiring Naudé and Dr P W Vorster. The members who have been reappointed are Dr G J Stander (Chairman), Dr J P Kriel (Vice Chairman), Prof D C Midgley, and Dr C v d M Brink, whilst Dr N Stutterheim remains a co-opted member.

It was with a deep sense of loss that the Commission learnt of the death of Mr Val Bolitho on 10 February 1977. The late Mr Bolitho had been the Assistant City Engineer (Health Services) of Johannesburg and an honoured member of the Water Research Commission since its inception. He controlled the City Engineer's Department's environmental engineering aspects such as waste water collection and purification, storage and distribution of potable water and the collection and disposal of solid wastes. In this capacity he played a leading role in the development of urban waste water schemes, including the latest process development in the field of nutrient removal. Mr Bolitho rendered invaluable services to the Commission and his experience and knowledge were of great value since the establishment of the Commission.

Prof Botha, Dr Meiring Naudé en Dr Vorster each retired after two terms totalling six years. Through this medium appreciation is expressed for their valuable advice and services since the establishment of the Commission. They have contributed greatly to the expansion of the Commission's activities.

The Commission's strategy reviewed and in perspective with its future activities

The activities of the Commission have now reached an important phase in that a large number of research projects which are financially supported by the Commission terminate during the year under review or during the next financial year.

In looking at the Commission's original research programme, it is now clear that a sound basis was laid for the subsequent development of research guidelines. Currently each project, before initiation, is viewed in terms of a master plan and in perspective with other projects. The stage has now been reached where experience gained can be effectively used for further refinement of research goals.

At the completion of each contract, thorough consideration is now given to effective application of research results, utilization of the expertise developed in the process, profitable use of the capital equipment purchased and possible extension or expansion of the relevant research.

It has become especially clear that the Commission should focus its attention on the correct packaging of research results to promote their application. In this regard the publication of technical manuals has commenced as well as the writing of final project reports in such a form that they may easily be used and applied by the consumer.

In view of the many agreements which will soon be terminated, a critical evaluation of each situation with regard to future financing of research has become much more necessary. The Commission, therefore, has consolidated its strategy in respect of support for water research and has decided to reinforce especially the principle of partnership research as previously established and as already reflected in a number of projects.

Coordination

In the execution of its terms of reference the Commission has always realised that it carries a direct responsibility to ensure that the projects it finances, are directed at national priorities, and meet the current and future water needs of the country. Furthermore it must exercise care, not only that these projects are fully coordinated with the research of government departments and statutory organizations, but also that they promote, as far as possible, coordination between the research activities of the organizations mentioned.

The strategies pursued by the Commission to meet these criteria are the following:

(1) In order to execute its coordinating functions, the Commission has effected the establishment of Coordinating Research and Development Committees (CRD committees) and Study Groups for specific problem areas with representation from all interested organizations. These Study Groups and CRD committees advise the Commission on the evaluation of research proposals, keep the Commission informed of research being done elsewhere, and expose shortcomings in the relevant fields of research which should receive attention. In this way the Commission is enabled to progressively refine its initial master research plan and coordination strategy and to actively develop and operate a national research programme which is based on the master plan.

(2) For the management of research projects financed by the Commission, steering committees are established consisting of representatives of interested organizations. Not only does a specific project benefit through the knowledge and expertise of the participating bodies, but the organizations can also ensure that the project is suited to their own research and operational requirements. In this way a two-way flow of information between the project and the participating organizations is obtained.

(3) Before initiating research projects, the Commission consults with government departments who have an interest in the research, in order to ensure that projects suit the needs of the departments and that unhealthy duplication is avoided as far as possible without discouraging productive duplication.

The creation and utilization of expertise

The research agreements entered into by the Commission, of which some are now terminating, can basically be divided into three groups, namely, agreements with (1) organizations having the required expertise but who are not responsible for applying research results, (2) organizations where, to a certain extent, expertise still has to be developed, and (3) operational organizations who possess operational expertise and can apply the research results.

(1) Research organizations with the required expertise.

The Commission has entered into agreements with various organizations who had already developed expertise in the field of water, e.g. the National Institute for Water Research and some of the universities. These organizations have through the years obtained an expertise and this can be further expanded and utilised during the execution of the projects. Some of these organizations direct their efforts at the development of a basic expertise and are often, unlike some government departments, not involved in operational functions.

(2) Organizations where an expertise has been reinforced.

The Commission has financed a number of projects at universities in order to reinforce a specific expertise in the process. (Some universities had already possessed a large measure of expertise). Apart from the development of expertise these projects were also aimed at developing useful research results.

(3) Organizations who apply research results themselves.

The Commission has also entered into agreements with organizations who possessed a specific operational expertise and responsibility and wished to apply the research results themselves. In cases where organizations were interested in the application of results but did not always possess the relevant research expertise, a component of scientific expertise was built in by using a third party. The development of this third type of agreement has led to the concept of partnership research.

Partnership research

The Commission is effecting a gradual change of emphasis in its financing of research in order to promote the practical application of research results, i.e. technology transfer. This strategy is to involve potential users of research results in the planning and execution of research projects by contracting such organizations as partners in the research. This approach is known as partnership research.

In addition to the obvious advantages afforded by partnership research with regard to technology transfer, the input of the research partners in the form of facilities and manpower also represents a considerable saving on direct research expenditure by the Commission. It has to be realised that the development phase is usually much more expensive than the preceding research and that this is often the obstacle in the way of the eventual application of research results.

It is increasingly becoming clear that the Commission's key role in the financing of water research in South Africa lies in the support of development projects for which the required order of financing could hardly have been achieved before the establishment of the Commission. The Commission can most effectively and inexpensively perform this key role by expanding the principle of partnership research as far as possible.

A common feature of the projects to which the partnership principle is already being applied is that in addition to the potential user, who is more involved with operational tasks, a research organization responsible for the scientific input to the research is also involved. In this way the communication gap which often exists between the research worker and the possible user is bridged.

Examples of typical projects to which the partnership principle has already been applied are the following (further details of the projects appear in the relevant chapters): Modernisation of the water reclamation plant at Windhoek (a tripartite contract with the National Institute for Water Research (NIWR) and Windhoek Municipality); reclamation of water at the Athlone sewage works in Cape Town (contract with NIWR and Cape Town Municipality); reclamation, storage and abstraction of purified sewage water in the Cape Peninsula (contract with NIWR and Cape Town Municipality); treatment of effluents from fellmongers and tanners (agreement with the Leather Industries Research Institute in collaboration with the relevant industrial associations); treatment of spent wine effluent (contract with the NIWR in collaboration with Stellenbosch Municipality); treatment of textile effluents (contract with the University of Natal in collaboration with the relevant manufacturers); and desalination of water at Swakopmund (agreement with the Department of Water Affairs and the NIWR).

It will not always be possible, however, to incorporate the partnership principle when renewing or extending existing contracts. It must be borne in mind that by financing a research project at an organization a specific expertise is built up and facilities created which present an important investment for future research. This is especially true of university research projects. Should it not be possible to apply the partnership principle in further support of research, it must be realised that some means of ensuring continuity in such organisations must be found if the investment already made is not to be largely wasted.

A rational approach would therefore be that the Commission in its future research programmes, should as far as possible involve the centres of expertise it has developed. At the same time the Commission can hardly undertake to support research at a specific organization for an unlimited period of time.

The appropriate approach in such cases would be to encourage the relevant organizations to propose projects which can be undertaken with existing facilities and expertise whilst bearing the declared research priorities of the Commission in mind.

In view of its programme of technology transfer, the Commission also has to identify deficiencies in the utilization of knowledge at an early stage and initiate research by existing organizations.

Involvement of Government Departments in respect of the coordination of water research

The Commission already has an established policy with regard to the creation and operation of study groups and coordinating research and development committees (CRD committees), and various government departments are represented on these. Officials of departments involved also serve on many steering committees responsible for the operation of the Commission's research projects. The Commission's policy is not to encroach upon the activities of other committees managed by other organizations for the coordination of research in the water field. However, it is important that such committees cooperate with the Commission's own overall programme of coordination.

For example, in its collaboration with government departments, the Commission has entered into an agreement with the Department of Transport for the execution of a project on weather modification at Bethlehem.

The Commission also regularly consults with the Department of Health on mutual interests with regard to health aspects. Thus, for example, the Department is represented on a recently established CRD Committee for Health Aspects of Water Use and also serves on five other CRD committees and six steering committees.

The Departments of Water Affairs, Agricultural Technical Services, Bantu Administration and Development, Forestry, Mines and Planning and the Environment, and the Provincial Administrations are also represented on various CRD and steering committees of the Commission.

During the year under review an agreement was entered into with the Department of Water Affairs with regard to the desalination of sea water at Swakopmund by means of reverse osmosis. The Commission also financially assists the Department of Agricultural Technical Services in an investigation of evapotranspiration, and in water use studies by means of weighing lysimeters.

During the past year important progress has been made with the coordination of research in connection with the hydrological cycle, and with irrigation, in collaboration with the Departments of Water Affairs and Agricultural Technical Services, in that the establishment of a Coordinating Research Committee for the Hydrological Cycle and a Coordinating Committee for Irrigation Research has been accepted in principle. The Programmes for these committees were compiled by the Departments concerned in conjunction with the Commission. These programmes were expanded around existing coordination mechanisms within the relevant Departments.

The Coordinating Research Committee for the Hydrological Cycle

During the year under review a new Coordinating Research Committee for the Hydrological Cycle (CRCHC) was formed which replaced the existing Coordinating Committee for Hydrological Research. The latter Committee was formed some years ago to promote liaison between the relevant departments in the field of hydrological research. As time passed the number of organizations serving on the Coordinating Committee for Hydrological Research increased, as did the field covered by the Committee — and consequently it became more difficult to coordinate research in depth.

As a result of this the Department of Water Affairs and the Commission jointly considered the matter can came to the conclusion that a new dispensation was required. It was decided that the appropriate solution to the problem would be to apply the basic management principle of delegation of responsibility and to arrive at a better definition of the specific problem area. For this reason the proposal was put forward that the Coordinating Committee for Hydrological Research should be responsible for the overall coordination of research regarding the hydrological cycle in South Africa, and therefore the in-depth coordination could be transfered to CRD committees established by the Water Research Commission. To facilitate operations, to avoid misunderstanding of any kind, and to suit the circumstances it was decided to rename the Committee the Coordinating Research Committee for the Hydrological Cycle (CRCHC). Since the CRCHC will be operated by the Department of Water Affairs (chairmanship and secretariat) and since the Water Research Commission will be involved to a large extent in this CRCHC, the formulation of this Committee's functions was done jointly by the Department and the Commission.

The Coordinating Committee for Irrigation Research

In view of the fact that irrigation is currently responsible for approximately 75 per cent of the total water consumption in South Africa, it is essential that water in this consumer sector be efficiently utilized and in 1973 the Commission established a Study Group for Irrigation Research.

The investigations of this Study Group indicated that the formation at a high level of an overall co-ordinating committee would be of considerable importance for the coordination of irrigation research. To achieve this, the Department of Agricultural Technical Services and the Commission, in conjunction with the Department of Water Affairs, collaborated closely in establishing and defining such a committee. This led to the establishment of the Coordinating Committee for Irrigation Research (CCIR) by the Department of Agricultural Technical Services.

The CCIR, which will function under the management and chairmanship of the Department of Agricultural Technical Services, will provide overall coordination of irrigation research at a high level. In this way overlapping of irrigation research will be eliminated and this will ensure that the best application of scarce manpower and funds for this purpose will be realised.

Specific functions have been envisaged for the CCIR in order to advise the relevant government departments and other organizations and to make recommendations with regard to projects in the field of irrigation research, which will promote the efficient execution of the research.

The CCIR will not be assigned executive powers and will act only in an advisory capacity to the relevant organizations. Not only organizations involved in irrigation research will be represented on the CCIR, but also those organizations which, through their planning of irrigation schemes, will be able to identify constraints requiring research.

Research on behalf of specific sectors

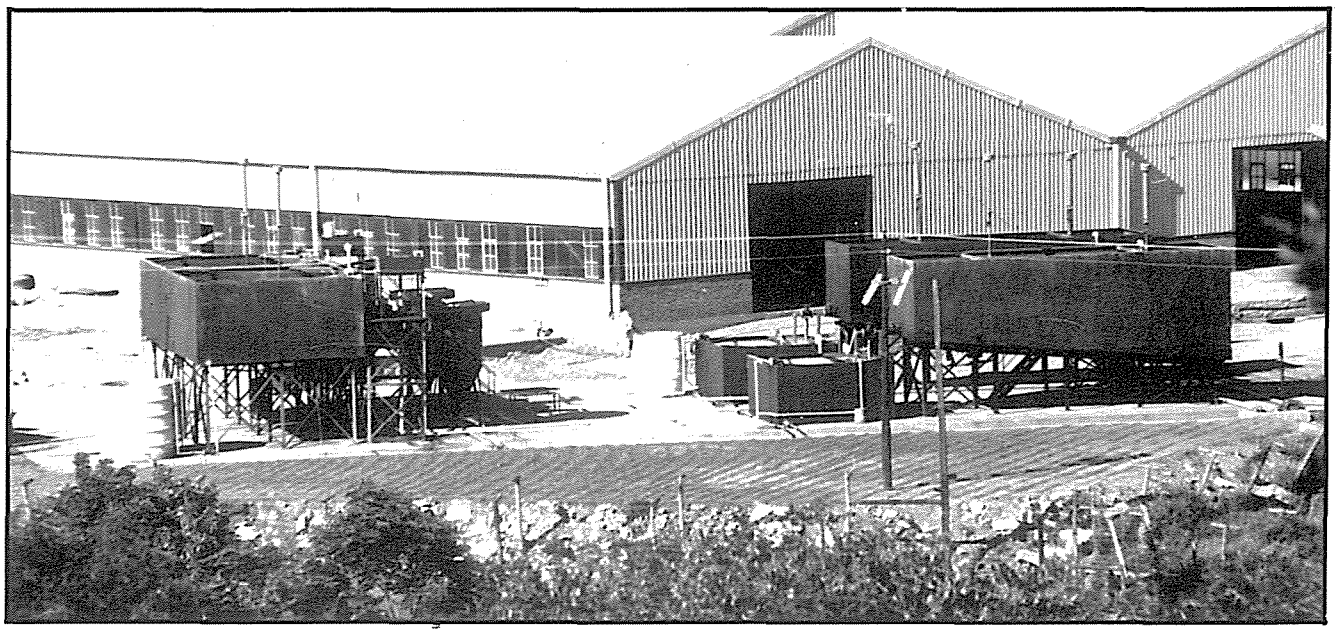
These sectors are especially of importance to the water economy of the Republic *viz* the agricultural, industrial and local authority sectors. In previous annual reports meticulous attention was paid to the role of the agricultural sector and of water research undertaken on behalf of this sector. Although in this report further information is naturally provided on the latest developments in this field, the other two sectors, namely those of industry and local authority, will be discussed in more detail. In addition, Chapters 2 and 3 are devoted exclusively to research on behalf of these two sectors.

Local authorities and industry can make an important contribution to the optimisation of water utilization in the country and many of the activities of the Commission are of direct importance to these sectors. Extensive investigations and research are required to ensure adequate water supplies for the future and to protect the quality of our water sources. In this regard these sectors have an important role to play.

In the case of local authorities essential research on common problems will be financed by the Commission while the expertise and facilities of the larger cities may be of great value in the process. The Commission has already obtained good cooperation from several municipalities which are prepared to make an important input to the execution of specific research. Furthermore, under the guidance of the Commission a Study Group has been established on which senior officials of six of the Republic's largest cities serve. This Study Group will consider problems of water supply, and the treatment of effluent and of wastes which have water pollution potential, by local authorities and will make recommendations for research to be undertaken.

The Pretoria-Witwatersrand-Vereeniging-Sasolburg (PWVS)-complex with its problems with regard to water supply and waste water treatment, water reuse and pollution, and which includes a large number of municipalities, has for a number of years enjoyed the highest priority of the Commission. Apart from establishing a CRD committee for the PWVS-complex, the Commission recently appointed a consulting firm as project manager with regard to the research being done by various organizations in this problem area. Some of this research is also financed by the Commission.

During the year several developments occurred in respect of waste water treatment and water utilization in the industrial sector. Industries such as the textile industry, the tanning and related industries, and others entered into partnership with the Commission to do research suited to their operational programmes. A Study Group was also appointed to study effluent problems of the fishing industry and to make recommendations for research.



A pilot plant for the treatment of tannery effluent with, in the background, the buildings of a large tannery in King William's Town of which the effluent is being studied. This project constitutes one of the cases where the Commission has initiated a research project in partnership with an operational organization.

Overseas consultants

From time to time, in the execution of its tasks, the Commission uses local as well as overseas consultants. In certain areas in the field of water, especially in specialised industrial sectors, local expertise often is unavailable and overseas assistance has to be sought.

When a request in connection with water research is received from, for example, an industrial sector, the matter is investigated carefully and all relevant parties meet to consider the problem and to compile a situation statement to serve as a basis.

Suggestions for the employment of a consultant are also considered. One of the most important functions of such a meeting is to determine available local technology and expertise. Should it appear that local specialist consultants and expertise are lacking, then only will the use of overseas consultants be considered. The overseas expert is expected to compile a report on the South African situation and current state of the art in the light of the situation abroad. Furthermore he has to indicate the research and development work which, in his opinion, is required, including the necessary transfer of available technology to South Africa and the possibility of its application and utilization to the best advantage within the South African ambit.

The consultant has to be an expert in the relevant field to be investigated and all efforts are also made to involve a South African firm of consulting engineers in the process, since this affords South Africans the opportunity of more readily absorbing overseas expertise. Furthermore it is the Commission's policy to involve local young scientists and engineers in such an investigation and the resultant project or projects so that the overseas expertise may be to their direct advantage.

It has to be borne in mind that the Commission itself does not undertake research and development work but contracts organizations in the country for such work. In cases where an overseas consultant is used, local organizations are still depended upon to execute the programme. The aim with this approach remains the expansion of local expertise.

During the year under review the Commission used several overseas consultants and more details appear in the relevant chapters.

Coordinating Research and Development Committee for Health Aspects of Water Use

In a country like South Africa, with its rapid development, limited water resources and sensitivity to pollution of the available water, research on the quality of water for human use deserves high priority in water research programmes.

The Commission already finances a number of projects in which health aspects form a significant part of the programme. At the Stander Reclamation Plant, for example, at Daspoort, technological development of water reclamation and pollution control is being studied. Apart from the development of design and operational criteria for the full-scale application of water reclamation, however, microbiological, virological and bacteriological investigations of water samples of different purification stages are also undertaken. Similar tests are done on water samples from the Windhoek Water Reclamation Plant, as well as epidemiological studies on consumers of reclaimed water. The original plant had been indispensable during a period of acute water shortage in the city and has since then been modernised.

The microbiological monitoring is being done by both the NIWR and the South African Institute for Medical Research and the latter is responsible for the epidemiological studies as well as for an extensive toxicological study of selected synthetic compounds found in water.

In 1974 the Commission acknowledged the importance of health aspects by establishing a Study Group for Health Aspects. This Study Group came to the conclusion that effective coordination in the field of health aspects of water was essential and that close liaison had to be established between the Commission and all organizations that undertake relevant water research programmes. As a result and on the recommendation of the Study Group, the Commission has established a CRD committee for Health Aspects of Water Use. Various government departments and other organizations will be represented on the Committee.

New projects

During 1977 the Commission entered into new agreements with organizations for the execution of the following projects:

- The application of reverse osmosis at a pilot plant

for the desalination of sea water at Swakopmund — agreement with the Department of Water Affairs and the CSIR (National Institute for Water Research.)

- Research and development work in the field of water desalination including industrial and municipal effluents — agreement with the CSIR (National Institute for Water Research).
- Water management and effluent treatment in the textile industry — agreement with the University of Natal (Department of Chemical Engineering).
- Development of effective irrigation methods for application to steep lands with special reference to micromethods — agreement with the University of Stellenbosch (Department of Civil Engineering).
- Research on flood occurrences — agreement with the Hydrological Research Unit of the University of the Witwatersrand.
- Pollution control and reclamation of effluents in the PWVS-complex — agreements with relevant organizations in the area.
- Research on water resources — agreement with the Hydrological Research Unit of the University of the Witwatersrand.
- Evapotranspiration and water use studies by means of weighing lysimeters: evapotranspiration as a function of soil, plant and atmospheric factors — agreement with the Department of Agricultural Technical Services.
- Research programme for studying conditions in Hartbeespoort Dam before and after full-scale spraying of the water hyacinths — agreement with the CSIR (National Institute for Water Research).

Briefly

Contribution to the International Conference on the Advanced Treatment and Reclamation of Waste Water, held by the International Association on Water Pollution Research (IAWPR)

The Commission still maintains close ties with the IAWPR and makes positive contributions to the activities of this organization.

The Chairman, who retired as President of IAWPR in October 1976 after a continuous term of eight years, delivered the keynote address at the international conference in Johannesburg in June 1977. Dr M R Henzen, Chief Adviser of the Commission, who also serves on the Governing Board of IAWPR, acted as one of the session chairmen. One of the Senior Advisers of the Commission, Mr P E Odendaal, was chairman of the organizing committee for the Conference.

Technical manuals

As part of its programme of technology transfer, the Commission has decided to publish technical manuals. These manuals can be based on results of completed projects or on results being obtained during the execution of a project. The first such publication appeared in 1977 entitled "Tussentydse riglyne vir die beheer van eutrofikasie" (English: Interim guidelines for the control of eutrophication). A second manual, on water reclamation, is being prepared and should appear in 1978.

Water SA

Water SA, which was launched by the Commission in 1975 is published quarterly and contains original research articles and review articles on all aspects of water science. The number of articles being submitted is increasing and the journal is well received both locally and abroad. Subscribers currently number about 1 200 and this figure is still increasing. Of these approximately 300 are from abroad. A significant breakthrough with regard to *Water SA*'s coverage was attained during the year in that 10 overseas abstracting services agreed to cover *Water SA* in their services. This means that the journal will now enjoy world-wide coverage by means of these services.

Collaboration with the CSIR's National Programme for Environmental Sciences

In order to rationalise the coordination of research on water ecosystems in South Africa, the Commission negotiated with the CSIR on the basis for collaboration between the Commission and the Committee for Inland Waters. This Committee was responsible to the CSIR's Inland Waters Division of the National Programme for Environmental Sciences.

The negotiations have led to an arrangement whereby the Committee, renamed as the Committee for Inland Water Ecosystems, would act on behalf of the Commission as a Coordinating Research and Development Committee (CRD committee) for research on environmental problems related to water — similar to CRD committees already established by the Commission for other problem areas. This means that the Committee will act as an advisory body to the Commission in determining research priorities, and will also initiate certain research projects on the Commission's behalf.

To avoid duplication it was also agreed that the Committee would concentrate on problems related to the water environment as such, whilst the Commission, as far as the water environment is concerned, would direct its attention to water utilization and the prevention of pollution. A strict demarcation of study areas is obviously impossible, and taking into account the fact that there are several areas in which research is coordinated directly by the Commission and in which the Committee has some measure of interest, care will be taken that the required liaison and exchange of information are maintained.

Spraying of hyacinths in the Hartbeespoort Dam

The growth of water hyacinths on the Hartbeespoort Dam gradually increased during the past few years until, in mid-1977, the plant covered approximately 55 per cent of the water surface. There was a distinct danger that the whole surface would be covered by March 1978, which would have been detrimental to the quality of the water. In the light of previous tests the Department of Water Affairs decided to undertake the spraying of hyacinths with a herbicide.

It was considered important that complete information on the effect of the spraying operation should be obtained. On the recommendation of the Commission the Minister of Water Affairs approved the allocation of funds by the Commission to a research programme to study conditions in the dam before and after full-scale spraying of the hyacinths. This investigation is being done in collaboration with the Department of Water Affairs, the CSIR's National Institute for Water Research and several other organizations.

More details of this programme appear in Chapter 7.

Chapter 2

Research on behalf of local authorities

There is no doubt that, in the aggregate, local authorities are responsible for the distribution of the largest quantity of potable water for consumption, both in the domestic and in the industrial fields in South Africa. The total quantity consumed by this sector is increasing at a rapid rate, and it is estimated that at the turn of the century, the amount distributed, mainly through local authorities, will account for more than 55 per cent of the total water consumption of the Republic. It is clear, therefore, that the local authority must play a key role in this sphere, and that it is in a most advantageous position to promote the optimum use of this vital commodity. In addition, local authorities also have a primary interest in and responsibility for the prevention of pollution by domestic and industrial effluents as well as by solid and toxic wastes.

In order to assist the local authorities in this important responsibility, the Water Research Commission has set out to establish the exact background position as regards water supply in relation to urban consumption, and to that end, has carried out a comprehensive survey of water and wastewater facilities, and the related problems. This information has been supplemented by staff visits to the various cities and towns and the stage had been reached by May 1977 when it was opportune to convene a meeting of representatives of all the major cities and towns of the Republic, to discuss ways and means whereby the Water Research Commission could institute and direct research into the various problems in these fields with which the local authorities are confronted. As mentioned in Chapter 1 a Study Group consisting of representatives of six of the major cities in the Republic was accordingly established. This Study Group will attend to various problems concerning water supply, effluents and waste, in so far as these may influence water quality.

In the meantime, however, the Commission, aware of some of the most pressing needs in this realm, has proceeded apace with several major projects which are directed to assist the local authorities in their task of ensuring that potable water is used in the best and most economical manner and to tackle problems in respect of pollution of the water environment.

Water supply and economy

In this field of prime water supply, research projects which are financially supported by the Commission are water consumption patterns in urban areas, prevention of water losses in pipe networks, and the optimisation of water utilization in the Pretoria-Witwatersrand-Vereeniging-Sasolburg complex. These projects, and other research projects on behalf of local authorities and still to be referred to, are reported on in later chapters.

As the major distributors of potable water throughout the country, the local authorities must have a close interest in water economy to ensure that wastage is cut to a minimum. The extensive survey

which the Water Research Commission carried out into the existing water supply systems revealed that there is an excessively high water consumption per capita in many instances, while the amount of 'unaccounted-for' losses in many municipal distribution systems reaches such dimensions that it calls for urgent attention.

The concern about the wastage of water which can take place due to defective or inefficient fittings, as well as these water losses in urban distribution systems, led some years ago to the appointment of a Water Economy Committee, under the aegis of the Department of Water Affairs, to investigate the matter. This Committee decided that it was a subject which called for considerable research, and that any such investigation should correctly be undertaken by the Water Research Commission. As the Commission had already instituted certain other research projects in the field of water economy referred to earlier, this led to a widening of the scope of the research, to establish ways and means to ensure that water is used in the most economical way throughout the entire range of usage.

One of the countries which has led the way in this matter of economy in water usage is Israel, spurred on by the difficult water situation within that country. The Water Research Commission considered that, initially, consultation in this matter with Israel would be advantageous and accordingly, arrangements were made for Mr M Kantor, the Water Commissioner for Israel and a moving spirit in that country's well-known water economy measures, to visit South Africa, and to advise on the practices adopted by Israel, and to what extent these could be beneficially adopted here. Any research in these fields which follows the visit of Mr Kantor will be carried out in close conjunction with the local authorities, who will obviously be required to adopt and implement any recommendations for water economy arising therefrom.

Water reuse and pollution control

Another fertile source in water savings lies in the fields of waste water reuse and pollution control — realms which are of immediate concern to local authorities. The research work financially supported by the Commission in regard to the reuse of purified wastewater at Windhoek and Pretoria is well-known, and this work is being carried further in the large scale research project on the reclamation and reuse of purified sewage effluent now being undertaken in the Cape Peninsula. Much research remains to be done in the field of reuse however, and the Commission is pressing ahead in this direction.

In conserving water supplies the prevention of pollution is a very important factor. While the Department of Water Affairs is empowered in terms of the Water Act, to exercise control over effluents before discharge to the environment, it is the duty of the local authority in most cases to control such discharges within its municipal area. Obviously, the sources of pollution within such limits are innumerable and these can give rise to problems which require research to find the preventive answers. One such source, for example, is the disposal of solid and toxic wastes and sludges — a field in which answers are still being sought throughout the world.

Dr E H Kuntze, President of the West German 'Abwassertechnische Vereinigung', who acted as a specialist consultant to the Commission on the disposal of solid and toxic wastes.

The Commission took advantage of a recent visit to South Africa of Dr E H Kuntze, President of the German *Abwasser Technische Vereinigung* and Head of the relevant Department of the City of Hamburg in West Germany, to engage him to report on the position as he sees it in South Africa, and to advise on any techniques of the German practice which can be adopted in this country. This report has been received, and is now being closely studied in collaboration with the local authorities.

Waste water purification

In the field of waste water purification — a field which is almost exclusively that of the local authority — there are many aspects in which applied research can effect improvements leading to better treatment processes and to economies in treatment costs, apart

from producing a better quality of effluents. In this field the Water Research Commission has been actively engaged for some time (e.g. financial support for projects on the activated sludge process and on denitrification and phosphate removal), but so much importance is attached to these activities, that it is now planned to further step up the research in this field. For example, the technology of nitrogen and phosphorus removal has been taken a long way where the modern activated sludge process is concerned and can be incorporated at new works, but most of the large municipal plants in this country follow the older methods of biological filtration, and there is too much capital involved to expect local authorities to scrap these existing plants in favour of more modern and accepted methods. Hence research is urgently necessary for treating these effluents for the removal of nitrogen and phosphorus, particularly in view of the danger of eutrophication of any waters receiving these effluents. This research in conjunction with the local authorities will be given a high rating of priority by the Commission.

Another aspect of wastewater purification which has been much in the limelight recently is the important one of possible health hazards in the treatment of wastewaters. It is already known that the Commission finances a number of projects in which health aspects form a significant part of the programme and a Coordinating Research and Development Committee for Health Aspects of Water Use has already been established. The Commission will also play an active role with regard to health aspects which relate to purified effluents. The process of waste water treatment also produces sludge which, in itself, may constitute a health hazard. Some organizations have already done preliminary investigations into the sterilization of this sludge by means of gamma radiation and this whole matter is seriously being attended to by the Commission. The treatment and disposal of waterworks sludge and washwaters originating from water purification works are further problems of local authorities and the Commission has been financing relevant research for some time. Possible health hazards in this connection will now also receive attention.

Chapter 3

Research on behalf of industries

In the previous chapter it was indicated that the local authority is by far the major distributor of potable water to consumers within the Republic and in this tally is included the industrial demand. Since this approximates in the larger cities and towns to almost half of the total consumption of potable water, it will be appreciated that Industry has an important part to play in this matter. There is, however, even more to it than just a question of quantity, since the water management and waste water problems of Industry are much more complex than those of the domestic sector. A good illustration of this is in the City of East London, where the total population which contributes a pollution load to the waste water which has to be treated at the municipal works is 100 000, whereas the effluent received from only the fruit and vegetable canneries in the city is equivalent to the pollution load contribution of some 400 000 persons! This type of situation applies in many local authority areas. Hence it is clear that the industrial sector deserves much research attention. Since the tariffs which industry pay to the local authority for the purification of its effluent is based generally on treatment costs, any solution to the problems of industrial effluents will be to the advantage of both the local authorities and the industry.

Furthermore, it is apparent from the surveys which the Water Research Commission and other authorities have carried out on the water management and effluent problems of industries, that there is a fertile field of research on water economy in the various industrial processes and techniques that are followed today. This was clearly shown in the comprehensive industrial survey which the Commission carried out, and is continuing to carry out into the water consumption patterns and usages of all water-intensive industries within the Republic. This survey covered no less than 4 000 individual industrial undertakings, and gave the Commission a good insight into the many problems that exist in this field. It is through this survey that the Commission has been enabled to pin-point the more urgent problems, and to determine some of the avenues that the research should follow.

The principle adopted in dealing with these problems is to maintain close liaison with the various industrial organisations. With the intended appointment of an adviser who will establish such liaison and who will apply himself to water management and effluent problems of industry, it is expected that many of the problems can be solved.

Liaison with National Industrial Associations

It is obvious, of course, that industry covers many diverse activities and contacts have been established between the Commission and the various National Associations which exist in connection with each particular type of industry. This aspect is one of considerable importance, since any research work which is sponsored by the Commission in the industrial field must be for the benefit of the whole industry, and not for any particular member of that industry. This is a basic principle of the operation of the Commission, since individual problems can be, and should be, dealt with by consulting engineers or specialists, but when

problems are of national importance and can be applied to all members of a particular group of industries then there is justification for Commission assistance.

A further advantage of dealing with National Associations of industrial groups is that when research results lead to techniques which can be usefully and advantageously applied, the National Association, through its constitutional standing, can influence its members to adopt these improved techniques, since a willing adoption will show better results than that forced by legal requirements. This is a basic example of the partnership principle on which it is endeavoured to place all such research work — and this is peculiarly applicable to the realm of industry — where the individual organisations have much to gain from improved techniques of water management.

Coordinating Research and Development Committees

It has been indicated that industrial research in water and wastewater management is a very diverse field, and each particular group has to be treated as an entity of its own. In each sector, the guiding control is through a Coordinating Research and Development (CRD) Committee, on which are representatives of the various National Associations belonging to that group. As an example, the CRD Committee for the Textile Industry has the following Associations represented:

S.A. Wool Combers
National Association of Woolwashers and Carbonisers of S.A.
S.A. Cotton Textile Manufacturers
S.A. Worsted Manufacturers
National Textile Manufacturers
S.A. Dyers and Finishers

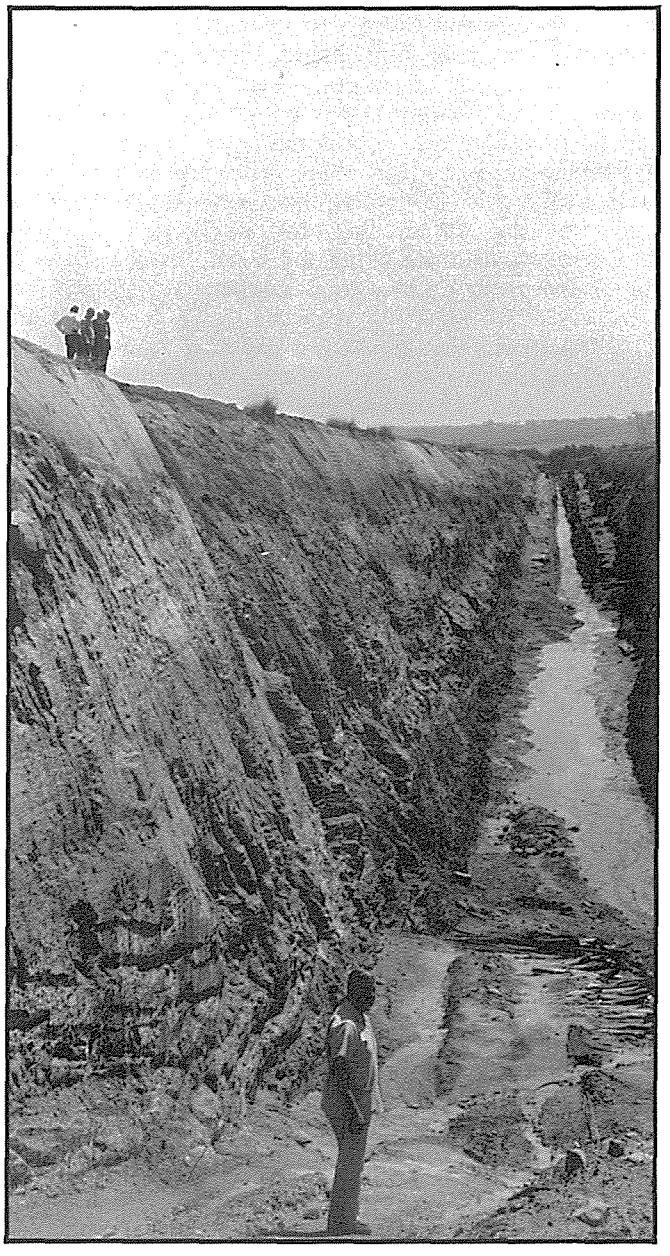
with the following technical organisations:—

The Water Research Commission
University of Natal Research Group
S.A. Wool Textile Research Institute
S.A. Wool Board

In this way, every facet of the Textile Inudstry has a special representative to look after the particular interests of that group. This principle is similarly applied to all other industrial groups and there are CRD Committees dealing with the water and effluent problems of the following:

Mining Industry
Fruit and Vegetable Canning Industry
Meat, Hides and Skins, Leather and Allied Industries
Economy Measures to be incorporated in Water Distribution Systems in Urban Areas
Discharge of Industrial Effluents into Sewerage Systems and the Environment
Water Management and Effluent Reclamation in the Pretoria-Witwatersrand-Vereeniging-Sasolburg Complex

Special reference should be made to one of the Republic's major industries — namely mining. For some time the question of the mineral pollution which arises from the stormwater run-off from slimes dams



The mineral pollution associated with many mining activities is one of the aspects which enjoy the attention of the Commission's Coordinating Research and Development Committee for Water and Effluent Problems in the Mining Industry. During the year the Committee arranged an inspection tour in this regard and one of the sites visited is this canal which was excavated by the Department of Water Affairs in order to drain acid water from a worked out mine.

and waste rock dumps has been a cause for concern, particularly on the Witwatersrand. A Coordinating Research and Development Committee for the Mining Industry was set up two years ago and, while no actual research work has yet been instituted directly through the Commission, the Commission has taken full cognisance of the admirable work of the Department of Water Affairs and the Chamber of Mines in this connection, and is engaged in drawing up a Master Plan for research which will incorporate all the work done to date.

There are as yet many other major industries which have to be assisted. Prominent amongst these are such industries as pulp and paper, fermentation, dairy products, food products, distilleries, laundries, petrochemicals, sugar, and many others. The work of the Commission will undoubtedly be of appreciable assistance to these industries, many of which have serious difficulties in meeting the standards laid down in terms of the Water Act for discharge into the environment, or those stipulated by the local authority for discharge to its sewerage system.

The programme of research which lies ahead in the field of industrial water and wastewater management is, therefore, one of considerable magnitude.

Utilization of overseas expertise

When the need for research in any particular group has been established — usually by means of a situation statement and motivation by a Study Group elected *ad hoc* from within that particular section of the Industry — it is of advantage to accurately find out the 'state of the art' of applicable technology as it exists overseas, so that unnecessary duplication of research work may be avoided, and relevant overseas techniques suitable for local application may be identified. It has been found from experience that the most advantageous procedure is to arrange, in conjunction with the relevant industry, a visit to South Africa, and an inspection of local plants, by a top level overseas expert in that particular field to evaluate the local situation and make recommendations in the light of overseas experience. This was the procedure followed in the case of the fruit and vegetable canning industry. Arrangements were made with the National Canners Association of the United States of America to second a top man to undertake the visit, and they agreed to make Mr W W Rose, Head of their Water and Waste Engineering Department available. Mr Rose came to South Africa early in 1977 and inspected most of the canning plants in this country. His report, recently received, is now being studied, and will then be referred to the Coordinating Research and Development Committee for the fruit and vegetable canning industry.

Similarly, it was considered that an expert in the Textile Industry should be brought over from England to study local practices and advise on available technology. Accordingly, arrangements were made for Mr A H Little, former Head of the Water Use and Pollution Control Division of the Shirley Textile Institute, Manchester (the leading textile research organisation in England), to visit various textile factories in the Republic. These visits have been well appreciated by the local manufacturers, who have also had an opportunity to exchange views with an overseas expert and to obtain useful information.

One of the features that has come out from the visits of overseas experts in various industries has been the fact that there is much room for improvement within the factories by 'good housekeeping'. This can lead to appreciable economies in the use of potable

Mr W W Rose, of the National Canners Association of the USA, who visited South Africa as a specialist consultant in respect of water and effluent problems of the fruit and vegetable canning industry.

Mr A H Little, formerly of the Shirley Textile Institute in England, who visited the Republic in 1977 as a specialist consultant with regard to water and effluent problems of the textile industry.

water, while reducing the ultimate pollution load on any treatment works by eliminating the wastage of raw material and reclaiming chemical substances. There is no doubt that the utilization of overseas expertise in the first instance has been advantageous, and it enables our own scientists and technical experts to follow up their work on a soundly prepared basis and to refine their expertise.

Codes of Practice

One of the main objects of the Commission in respect of much of the research work in the industrial sector is the establishment of Codes of Practice, which will provide guidelines for 'good housekeeping' and for the optimum use and reuse of water within the factory. Such codes will be invaluable to the industrialist in his own control over the factory processes which are water-intensive, and in reduced water and wastewater costs in the manufacturing operations.

The partnership principle has been mentioned above in regard to the various national associations, but it has been particularly applicable to the various individual industrial undertakings in whose factories the pilot research plants have been set up. In most of the units, the industrialist has made ample space available, while supplying at no cost all water, light, power and material. Labour for construction and operation is also freely given, and in a few cases, the factory laboratory facilities, and the services of the chemist, have been provided free. It may be mentioned that in one case a firm had been so impressed with the work of the University of Natal's research team — financed by the Commission — that they have spent R10 000 towards a large-scale unit. Several other industries have made substantial contributions to research projects undertaken in their fields.

Finally, it should be recorded that the cooperation of the industrial sector up to date in the research work carried out under the aegis of the Commission has been most gratifying and this has undoubtedly helped to make the research work more successful and rewarding.

Specific projects supported by the Commission and of interest to Industry are covered in further chapters.

Chapter 4

Water reclamation

Water reclamation is undoubtedly an important measure to establish a healthy balance between water demand and water supply. The contribution of water reclamation will ensure a water credit instead of a predicted debit by the turn of the century. Furthermore, it provides the key to the prevention of water pollution and the protection of the utilization value of water. Since its inception, the Commission has awarded high priority to research on water reclamation.

In order to produce a consistent quality of reclaimed purified sewage effluent for unrestricted reuse, it is desirable to reclaim sewage effluents of predominantly domestic origin. To achieve this it is necessary to segregate heavily mineralized and toxic industrial effluents from those of predominantly domestic origin and to establish separate treatment facilities for the two types of effluents. This can often be effected by segregation of the toxic and mineralised fractions of an industrial effluent at the factory itself for separate handling, before the main effluent is discharged to the sewage network for purification and ultimate reclamation.

In planning the modernisation of the Cape Town sewage reticulation system, the Cape Town Municipality has effectively separated industrial effluent from domestic wastewater directing the former to the strategically placed Athlone Sewage Works. This Works will mainly handle industrial effluents, while the new Cape Flats Sewage Purification Works situated near Muizenberg will handle domestic effluents.

In order to assist the Cape Town Municipality in obtaining design and operating criteria and operating experience in treating and recovering such widely differing qualities of waters, the Commission has entered into a partnership contract with the Municipality and the CSIR's National Institute for Water Research (NIWR) to construct and operate two separate research and development facilities at the Athlone Sewage Purification Works and the Cape Flats Sewage Purification Works and to undertake the required research.

In view of the fact that the Municipality of Cape Town will in the foreseeable future also be dependent upon reclaimed water as a supplementary source in the proper utilisation of water sources the design of the new sewage purification plants has been based on the practical research results of the NIWR of the CSIR, the University of Cape Town and the Municipality of Johannesburg. The Cape Flats Sewage Purification Plant will therefore be able to biologically remove nitrogen and phosphorus compounds from sewage water and produce for reclamation an effluent of a very high quality. In parallel to this study, studies on the most effective methods of infiltration of reclaimed water into a sandy aquifer and subsequent abstraction will be conducted at an adjacent site.

At the Athlone Sewage Works, which handles industrial effluents with a considerable mineral content, the pilot reclamation plant has now been commissioned. Since it is envisaged that its product will possibly be used for industrial purposes, a survey is currently being conducted to establish the water requirements of local industries. Once this survey has been completed industries with a high water usage will be selected and specific experiments be conducted to determine the practicability of utilizing the reclaimed water in their operations. The practical application of the results will therefore be tested at a national level.

In Pretoria, the Stander Reclamation Plant has been operated for extended periods of time to simulate

conditions in practice and to verify the design criteria and the operating parameters with a view to preparing a detailed technical manual on the research results and findings, as well as a technical guide covering the detailed planning, design and construction of a water reclamation plant.

The Pretoria Municipality has shown a direct interest in the reuse of reclaimed sewage effluent, and is anxious to establish whether a reclamation plant can be operated efficiently by the normal operating staff of a Municipality. Negotiations have been started, in consultation with the CSIR as owner, to transfer the control and operation of the Stander Reclamation Plant to the Pretoria Municipality who will then operate it at intermittent intervals to provide training for their own staff and operators from any other municipalities. They will also develop a publicity programme and will allow visits to demonstrate to municipal and other officials, the practicability of reclamation. At the same time the NIWR will continue with a research programme on the plant and will also undertake allied research projects which fall within its national programme.

At Windhoek the modernised reclamation plant has been brought into continuous operation after the activated carbon columns had been enlarged in line with the latest experience gained at the Stander Reclamation Plant. The quality of the reclaimed water produced is being continuously monitored by four different organisations, namely, the Department of Water Affairs, the National Institute for Water Research, the South African Institute for Medical Research (SAIMR) and the Windhoek Municipality. Epidemiological studies on the Windhoek community receiving reclaimed water are being conducted by the SAIMR.

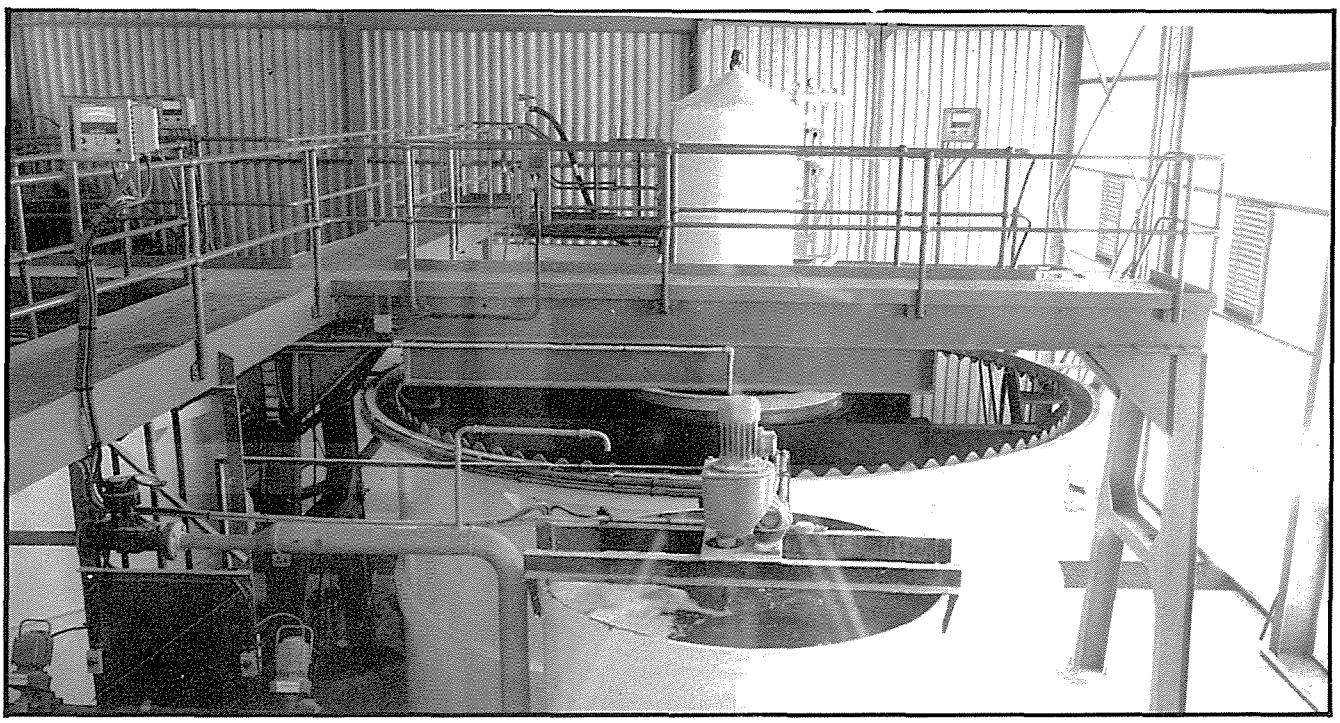
RESEARCH PROJECTS

Reclamation of water at the Athlone Sewage Works, Cape Town

(Existing project: Contract with the Municipality of Cape Town and the CSIR — National Institute for Water Research)

The sewerage system of Cape Town is of such a nature that a large proportion of the waste water directed to the Athlone Sewage Purification Plant consists of industrial effluents. This state of affairs affords an excellent opportunity for studying the reclamation of this type of waste water.

A tri-partite agreement has therefore been entered into by the Water Research Commission, the CSIR and



The lime reactor and primary clarifying process units at the Athlone Water Reclamation Plant.

Cape Town Municipality in terms of which a pilot scale water reclamation plant has been erected at the Athlone Sewage Purification Plant. A biological purification process after lime treatment provides for improved removal of organic material and nitrogen, and quality stabilisation. The lime treatment to a large extent protects the micro-organisms against possible toxic substances which may be present in sewage effluent. The Municipality of Cape Town was entirely responsible for supervising the construction and also for the operation of the plant, including operating costs.

After commissioning of the plant in September 1976 a number of operational problems, especially with the sand filters, were encountered. The problems were solved by replacing the sand filters and the plant was recommissioned in April 1977. The optimisation of the various unit processes is currently being undertaken by the Municipality of Cape Town in collaboration with the CSIR.

Initial tests have indicated that the reclamation of waste water containing large volumes of industrial effluents requires further extensive study before water of a generally accepted standard can be produced. However, there are indications that a good quality water for general industrial use can indeed be produced and purified even to potable water standards by adding a desalination facility.

Under certain circumstances it may prove more economical to distribute reclaimed water for industrial use and therefore a survey is currently being conducted by the CSIR in collaboration with the Municipality of Cape Town to determine the water requirements, with regard to volume and quality, of some industries and groups of industries.

The water being directed to the Athlone plant contains a high concentration of dissolved salts, and research is therefore being done, as part of the national master plan for desalination, by the CSIR on reverse osmosis and by Cape Town University on ion exchange in order to desalinate the water to an acceptable quality.

Technological development of water reclamation and pollution control

(Existing project: Contract with the CSIR — National Institute for Water Research)

The main objective of this project was to develop design and operational criteria for full-scale application of water reclamation in South Africa. It has also been the aim to develop techniques to reduce the production cost of reclaimed water, with the ultimate objective of producing a technical guide on the operation of the plant and a manual on the planning, operation and design of water reclamation plants. Both of these publications will be designed to meet the needs of local, provincial and state authorities and consulting engineers. To achieve these objectives it was essential to operate the Stander Water Reclamation Plant at Daspoort Sewage Purification Works, Pretoria, continuously over a protracted period of time during the year under review and to improve the performance of existing units and introduce new unit processes. The plant was operative during two periods, each of three months, in 1977. Unit process refinement, improved automation and increased operational skill led to improved results at reduced costs. It was possible to reduce operational staff by 20 per cent owing to increased efficiency.

Two possibilities for improving sludge handling were investigated. Criteria for centrifugal dewatering and classification of sludges were derived which should decrease sludge handling costs. Lime reuse after sludge recalcination in a multihearth furnace was also investigated. It proved possible to use the same furnace, with small modifications, for carbon regeneration and recalcination. However, in view of the low cost of lime it is doubtful if recalcination is economically justified.

The carbon regeneration furnace was fully developed as a separate service facility during 1977. Apart from regenerating the full complement of the active carbon used on the Stander plant for two cycles, more than one hundred tons of active carbon was regenerated for the Windhoek plant. As the reclamation plant at Windhoek will be the main consumer of active carbon in future, it is intended to move the regeneration facilities to Windhoek in order to limit costly transportation of carbon.

An oxonation unit process was incorporated into the system early in 1977. The source of ozone is a 2 kg/h silent electrical discharge ozone generator manufactured by a French firm. The ozone contacting system, consisting of a packed column on top of a baffled vessel and an ejector for waste gas reutilization, is a unique system designed by the NIWR. The effectiveness of ozone as a disinfectant of reclaimed water and as a means of breaking down residual dissolved organic components is being investigated. Ozone as such is more expensive than chlorine but this may be outweighed by certain additional advantages of ozonation that are still being investigated.

During 1977 the plant was operated on the final effluent from the activated sludge sewage treatment plant at Daspoort. As a result of the higher quality of the activated sludge effluent, particularly in respect of the ammonia concentrations, it was possible to eliminate the ammonia stripping process, again leading to lower production costs. In spite of the escalation of costs for all inputs, it was possible to reduce the production of

the reclaimed water by 20 per cent compared to the previous year's figures. Based on running costs for May 1977, it is estimated that the cost of producing a potable water from an effluent derived from an activated sludge sewage treatment plant will be 23 c/m^3 on a 5 000 m^3/d scale or 12 c/m^3 on a 50 000 m^3/d scale.

The operator training programme is also progressing well. Three operators from the Stander Reclamation Plant successfully completed the Operator Course in Water Purification and Wastewater Treatment, at the Pretoria College for Advanced Technical Education. An intensive training programme for six operators from the Windhoek plant was conducted during the latter half of 1977. It is intended also to train suitably qualified persons as superintendents in future.

A large number of visitors visited the Stander Reclamation Plant during 1977. More than a hundred of these were overseas scientists and engineers. A new full colour brochure describing the plant, is now available to visitors.

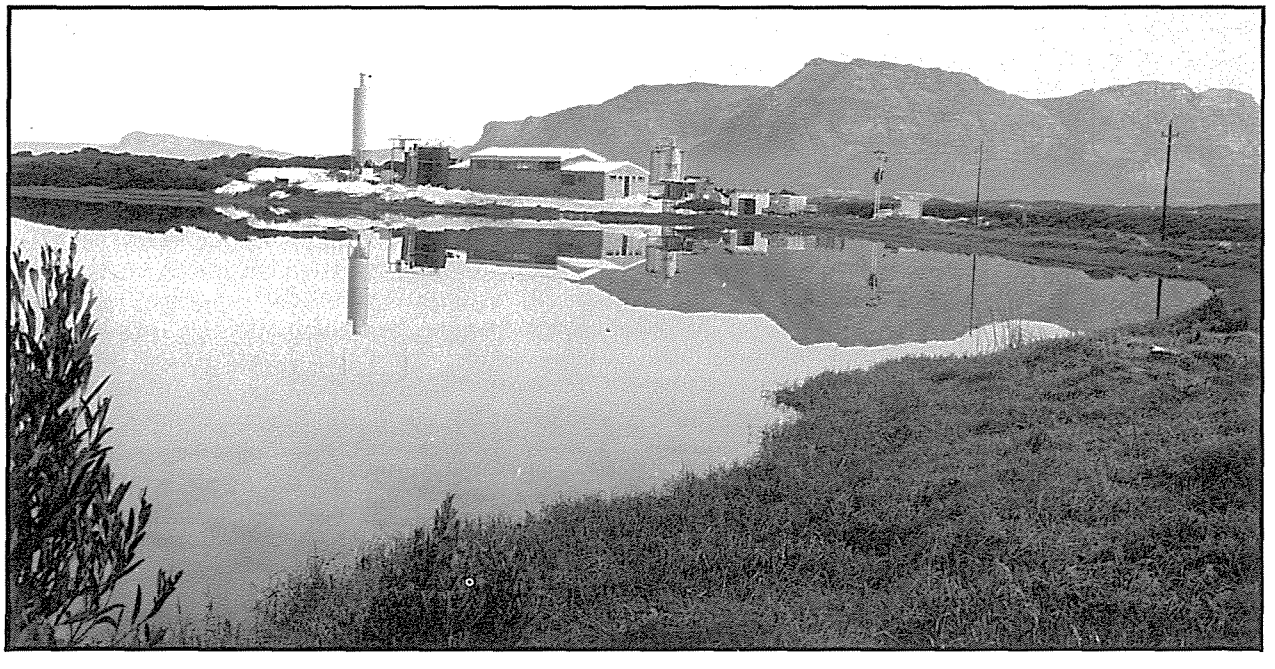
At the International Conference of the International Association on Water Pollution Research on the Advanced Treatment and Reclamation of Wastewater (held in Johannesburg during 1977), where ten papers were presented by members of staff of the NIWR, it was reaffirmed that water reclamation not only provides a source of high quality water but also plays an important role in combating pollution.

Good progress has been made in the preparation of the technical guide and the manual on the planning, operation and design of reclamation plants and it is anticipated that these publications should become available towards the end of 1978.

Reclamation, storage and abstraction of purified sewage effluents in the Cape Peninsula

(Existing project: Contract with the CSIR — National Institute for Water Research and the Municipality of Cape Town)

A few years ago a project on the reclamation and reuse of purified sewage effluents was initiated in order to expand the water resources of the Cape Peninsula. The main objective of the project is to determine the technical and economic feasibility of full-scale water reclamation of purified sewage effluent and its storage in and abstraction from the sand deposits of the Cape Flats, and to derive design criteria for full-scale application.



The interim experimental scale water reclamation plant of the Cape Town Municipality which has been constructed in terms of a contract with the Commission. This plant will form part of the eventual 4,5 Mℓ/d experimental plant for the reclamation and reuse of purified sewage effluent in the Cape Flats.

The construction of the planned complete 4,5 Ml/d reclamation plant was temporarily suspended until such time as the new Cape Flats Sewage Purification Works, which replaces the existing oxidation pond system, becomes operational. However, the Water Research Commission has entered into a contract with the Municipality of Cape Town for the construction and operation of an interim plant which will form part of the ultimate 4,5 Ml/d reclamation plant. This was done mainly to enable the NIWR to complete the infiltration studies being carried out in terms of the original contract. This interim plant is being constructed adjacent to the new Cape Flats Sewage Purification Works. Expectations are that the first module of the latter will become operational during 1979.

Building on the interim plant commenced during March 1977. The Municipality of Cape Town is responsible for supervising construction and will operate the plant, whilst the NIWR will conduct the optimisation studies and exercise analytical control. Upon completion of the interim plant 1 500 m^3 of partially reclaimed water will be available daily. The infiltration and development studies require an extensive investigation into the function of the sand deposits of the Cape Flats. A thorough knowledge of the hydraulic characteristics of the aquifer as well as practical experience of recharging and abstraction techniques are essential.

The intensive geohydrological study of the aquifer has largely been completed and the second phase in the development of the mathematical model for the simulation of the hydrological characteristics of the aquifer has commenced. Preliminary experiments with the model have already indicated deficiencies in knowledge of the aquifer and further aquifer tests are being done to supplement existing information. Basically, however, the accent has moved to long term observations in order to test the accuracy of the simulation model. This mainly entails the measuring of rainfall and evaporation at a number of points in the Cape Flats and the monthly measuring of groundwater levels at approximately 70 points. During July 1977 the water levels were generally higher than over the previous few years — in some cases up to 1,5 m higher than the previous winter. This phenomenon occurs only to a small extent in the built-up areas where stormwater pipes carry the surplus water away. The agricultural areas not served by canals are, however, at a considerable disadvantage. Tens of hectares are currently under water in the lower lying areas where the groundwater level normally approximates the topographic surface.

Quality monitoring continued at a limited number of boreholes in order to obtain information on the chemical, bacteriological and virological quality of the water. Long term observations will be required to give clarification on the apparent improvement or deterioration in the chemical quality of the groundwater at certain points.

During the year under review the development of the experimental infiltration site received priority. An extensive drilling programme was undertaken in the area to the west of Strandfontein Road in order to determine the geology and the hydraulic characteristics of this part of the aquifer. The drilling indicated the presence of a peat layer approximately three metres in depth in the western half of the area. The topographic height of the infiltration areas varies from 14 to 24 m above mean sea level, whilst the groundwater level is approximately 10 m above sea level and the peat layer commences about 4 m below sea level. The total depth of the aquifer varies from 26 to 34 m.

The varying topography of the dune landscape made it difficult to place six infiltration pans on the circumference of a circle with a radius of 100 m, as had been intended, but on the other hand it enabled the pans to be placed at varying heights above the groundwater level. The influence of the diameter of the unsaturated zone on the infiltration rate can therefore be determined.

It is estimated that the infiltration studies will be completed by the end of 1978 and a report will be compiled which will contain a detailed exposition of the findings and of a proposed infiltration and abstraction policy applicable to the sand deposits.

Microbiological quality and health aspects of drinking water

(Existing project: Contract with the South African Institute for Medical Research)

The importance of health aspects of water use is increasingly being realised throughout the world and as in previous years the South African Institute for Medical Research (SAIMR) collaborated successfully with the National Institute for Water Research (NIWR), the National Institute for Virology (NIV), the Department of Water Affairs, the Rand Water Board, the Pretoria Municipality and the Windhoek Municipality, in monitoring the microbiological quality of the reclaimed water in Windhoek and from the experimental plant at Daspoort (Pretoria).

Early in 1977, however, the contract between the Commission and the SAIMR was amended to provide for an expansion of the epidemiological studies at Windhoek, for a programme of toxicological studies on selected synthetic compounds known to occur in surface waters used for water supply, and for the establishment of a toxicology data bank with reference to water use.

Bacteriological monitoring of water in one of the laboratories of the SAIMR

Monitoring at Daspoort

During the year under review water samples were submitted for microbiological testing on a regular basis by the NIWR whenever the plant was in operation. In addition SAIMR technologists collected monthly spot samples for bacteriological and virological testing. Correlation of test results by the laboratories of the organisations concerned was very high indeed, probably as a result of standardization of techniques and materials.

Monitoring in Windhoek

Microbiological monitoring was carried out as in the past by the NIWR, SAIMR, Windhoek Municipality and the Department of Water Affairs (SWA branch).

Virological isolations were done by the SAIMR Windhoek laboratories and positive tissue cultures were sent to the NIV for identification. Viruses were not isolated from any final water samples. The microbiological quality of the reclaimed water therefore was excellent, and equalled and at times exceeded that of water obtained from conventional sources.

Epidemiological investigations with special reference to water-borne disease

Epidemiological studies to evaluate the short and long term health aspects of water reuse were expanded during the year. Some of the data were analysed to allow comparison with epidemiological studies during previous years and no obvious change in the prevalence of bacterial and viral infections could be shown. The mass of additional data will be accumulated for several years and stored in a computer for analysis.

The study by the SAIMR in Windhoek differs from many other studies in that, as a result of the composition of the population, an opportunity exists to obtain age-sex-race-specific data. This holds true not only for the occurrence of potential water-related contagious diseases, but also for mortality and human reproductive studies.

Toxicological studies

As mentioned earlier the SAIMR will undertake toxicological studies of selected synthetic compounds which occur in surface waters. Specific patogen-free

rats will be used for the study and special accommodation for these test animals, as well as other special equipment and facilities, had first to be acquired or constructed. This initial work at Rietfontein near Johannesburg has almost been completed.

Publications

The work done in Windhoek and at Daspoort with regard to augmenting the domestic water supply with reclaimed water is of a pioneering nature. The encouraging results obtained to date have stimulated not only national but also international interest on a wide scale. This is not unexpected in view of the ever-increasing problems encountered in many parts of the world in providing an adequate potable water supply to growing populations. In response to many requests for information it is intended therefore to present the findings and conclusions to date to the scientific community by means of papers to be published in the medical press and to be presented at a forthcoming international symposium.

Adaptation of the Windhoek Water Reclamation Plant to the latest research data and technological development

(Existing project: Contract with the Windhoek Municipality and the CSIR — National Institute for Water Research)

Research in terms of this contract is aimed at modernising the Windhoek Water Reclamation Plant in accordance with the latest available technological information. Experimental data from work by the National Institute for Water Research at the Stander Reclamation Plant at Daspoort, Pretoria, are being evaluated during operation of the large-scale plant at Windhoek. The information and experience gained in this way will be of great value in the implementation of water reclamation systems in the Republic.

The Windhoek Water Reclamation Plant still plays a very important role in the water supply of the city, notwithstanding the fact that water from the Von Bach Dam is also integrated with the city's water supply.

During the year the Windhoek plant has been operated on a continuous basis to enable the operation of the individual unit processes to be optimized. Intensified studies of the ammonia stripping tower, the activated carbon system and operating conditions for chemical stability of reclaimed water have been undertaken and the performance of these units optimised accordingly.

Results of the investigations have indicated that the modernisation of the plant holds definite practical advantages in that water can effectively be reclaimed during all seasons of the year where previously it was impracticable during the winter months.

As a production unit the Windhoek Water Reclamation Plant continues to enjoy wide interest both locally and overseas. During June 1977, after the International Conference of IAWPR in Johannesburg, it was visited by overseas delegates who rated the plant very highly.

Chapter 5

Groundwater research

In the overall planning and development of the Republic's water resources it is essential that surface as well as groundwater resources should be effectively utilized. As far as the former are concerned, the Department of Water Affairs has at its disposal a mass of data for their effective development and utilization. However, the accurate determination of groundwater resources remains a problem, and for this reason it is essential that research in this field should be intensified and expanded. This will ensure that quantitative information will be made available timeously to the relevant organizations responsible for water supply.

By making information on the occurrences and assured yields of the country's groundwater resources available to the planners of water supply schemes at an early stage, planning with regard to the development and utilization of the groundwater resources can usefully be integrated with that of surface sources and this could lead to possible savings in costs. Furthermore, groundwater resources sometimes occur in the immediate vicinity of the site where water is needed and the cost of development of such sources, especially in the case of relatively small amounts, is often considerably less than for the development of surface water supply schemes which in some cases are situated at great distances from the point where the water is required.

As a result of these considerations the Department of Water Affairs and the Commission are collaborating very closely on a long term research and development programme aimed at determining the potential of the groundwater resources of the country as a whole.

During the year under review good progress was made with all the groundwater projects being financed by the Commission and the findings of these investigations are discussed later in this chapter.

With the establishment of the Geohydrology Division of the Department of Water Affairs, negotiations were initiated with the Department in order to determine the manner in which the existing groundwater projects financed by the Commission could usefully be correlated with the long and short term requirements of the Department of Water Affairs. To effect this the Commission appointed Dr J F Enslin, former Director of Geological Survey, as a specialist consultant to revise, in collaboration with the Department, the programmes for the existing projects of the Commission. In developing the programmes mentioned specific attention will be given to the recommendations contained in the Master Research and Development Programme compiled by the Study Group for Groundwater Research.

As far as the short term programme is concerned provision is made for suitable research and development projects in areas where the Department of Water Affairs already has operational groundwater investigation programmes in progress, and where constraints which require further scientific investigation have already been identified.

As far as the long term programme is concerned efforts will be made to develop it in such a way that an overall view of the groundwater potential of the country can be obtained as soon as possible. In compiling this programme it will be essential to obtain information on all projects which have been undertaken in the country up to the present and to evaluate this information in order to identify shortcomings. It is estimated that this evaluation and the proposed long term research and development programme will be finalised by the end of 1978 and that its execution will commence during 1979.

RESEARCH PROJECTS

Utilization of water from the Eerste River by means of storage in sand beds or other methods

(Existing project: Contract with the University of Stellenbosch — Department of Civil Engineering)

This project involves an investigation of the best method to store and make available for use the surplus water of the Eerste River which cannot be stored in conventional reservoirs or handled by planned diversion systems. The possible utilization of the sand deposits in the eastern part of the Cape Flats for the storage and abstraction of this water is being investigated, while information is also being collected on the runoff and planned diversions of water from the Eeerste River, including its main tributary, the Kuils River.

An area of approximately 80 km^2 has already been investigated by means of boreholes from which sand and water samples were obtained and analysed. The sand deposit in the area has a mean thickness of approximately 20 m and according to preliminary estimates an exploitable storage capacity of approximately 75 x 10^6 m^3. The estimated permeability of the sand indicates that it could indeed be used in a practical scheme for the infiltration and abstraction of river water. Since considerable clay and calcrete layers occur in the sand deposit, which could retard infiltration and abstraction of water, work is continuing to determine its permeability and specific yield by means of pumping tests in order to obtain a more dependable picture of the feasibility of the scheme.

The contour lines of the groundwater level as determined in May 1977 indicate that considerable recharge of the groundwater is taking place from the Kuils River. It is also clear that groundwater is flowing to the sea along the full length of the coast line of the area investigated.

The hydrology of the two rivers has been studied and the preliminary estimate is that the total mean annual runoff amounts to 80 x 10^6m^3 of which 30 x 10^6m^3 will possibly be available for infiltration into the sand by 1990. However, this figure may decrease as a result of possible additional diversions for irrigation purposes.

The chemical quality of the groundwater as well as the river water in the area has given an indication that the water which will be produced under such a scheme would probably not be suitable for domestic use without treatment.

At this stage of the project estimates indicate that an average of 30 x 10^6m^3 water per annum will be available for infiltration and that the storage capacity of the sand deposit is sufficient to store the mean runoff of 2,5 years. However, investigations are continuing to enable this potential to be more accurately estimated.

Development and evaluation of techniques for determining the exploitation potential of groundwater resources in the Southern Orange Free State and Northern Cape

(Existing project: Contract with the University of the Orange Free State — Institute for Groundwater Studies)

Large tracts of the Southern Free State and Northern Cape have only groundwater supplies for everyday use. Most of these sources are relatively poorly developed and in the past mathematical calculation of the safe yield was generally not done. The formations occurring in these areas, e.g. the dolerite dykes and basin structures in the Southern Free State and the dolomitic formations in the Northern Cape, in fact possess a considerable groundwater potential. Should the safe yield of these quifers be determined, the groundwater could make a useful contribution to the agricultural and municipal development of these areas. The ultimate objective of this research is in fact to develop techniques for determining the groundwater potential of these structures and to develop suitable computer models in order that the groundwater resources can be advantageously utilised without being exhausted.

During the year under review considerable attention was given to the compilation of computer simulation models. These models can handle a variety of geohydrological parameters, e.g. the permeability of the formations, the volume of water stored in the formations, recharge of the groundwater supply by means of rainfall, and seepage and abstraction of groundwater from the system by means of pumping, springs, evapotranspiration and groundwater movement. By applying these models to an aquifer

system, the potential abstraction from and recharge of the system can be calculated.

During the year under review Prof George F Pinder, Director of the Water Research Programme of the University of Princeton (USA), visited the Institute for Groundwater Studies for a period of one month. During this time he assisted mainly with the solution and application of modelling techniques for South African conditions. Prof Pinder also made available to the Institute a large number of computer programmes, which could be used to model most of the groundwater conditions inland and on the coast of South Africa. The availability of these models, which will now be adapted for South African conditions, leads to appreciable savings since overseas consulting firms charge up to R50 000 for one such model.

An interesting aspect of this research programme is possible correlation between the chemistry of a groundwater sample and its relative age. If the development of this technique is successful it will have far-reaching implications for future groundwater exploitation, and will enable relative mobility, age, recharge locations and recharge rates to be determined more accurately.

At the request of the Atomic Energy Board, water samples are regularly submitted to them for determination of uranium concentrations and it has been agreed that the results will confidentially be made available to the Commission, since they could possibly be of great value in the analysis of the movement of groundwater.

During the year under review a computerised hydrochemical data bank was also developed. It was realized that large volumes of chemical data were being generated as part of the project, and in order to conserve, process and interpret this information it was essential that such a system be designed. Its use will yield a large variety of tabulations, as well as graphic, diagrammatic and statistical processing of the hydrochemical data. This will allow immediate visual evaluations of groundwater. This work has been done in the closest collaboration with the Hydrological Research Institute of the Department of Water Affairs, not only as far as the analysis of water samples is concerned, but also in the development of a data bank.

During the forthcoming year the hydraulic characteristics of the formations in the Southern Free State and in the Northern Cape will be determined by means of drilling programmes and testing. This information will be used to calibrate and verify the computer models which have already been developed.

Development and evaluation of techniques for determining the exploitation potential of groundwater resources along the "Doornberg fault zone"

(Existing project: Contract with the CSIR — National Physical Research Laboratory and the University of the Orange Free State — Institute for Groundwater Studies)

The project entails the development of techniques for the determination of the exploitation potential of groundwater resources in the "Doornberg fault zone" area where it is exposed between Prieska and Koegas and also where it is overlaid by Karoo sediments.

During the year under review research mainly entailed the following:

- A gravitation survey in an area covering approximately 70 000 km^2 and encircled by the towns of Britstown, Prieska, Marydale, Upington, Kakamas, Brandvlei and Van Wyksvlei.
- A programme of deep electrical soundings in the Prieska area to investigate the regional suitability of the upper layer for the occurrence of groundwater.
- Shallow electrical surveys to determine the nature and extent of known groundwater occurrences in the Prieska area.
- Geological and geohydrological mapping in the Prieska area over a region covering 5 200 km^2 and stretching from east to west across the "Doornberg fault zone".

The gravitation survey comprised approximately 1 100 stations (on average 3 km from each other) along 42 routes. The results show the presence of NW-SE stretching gravitation anomalies which are interrupted by a WNW-ESE zone at the altitude of Prieska. The former direction corresponds with that of the "Doornberg fault zone" whilst the latter indicates the direction of the so-called Pofadder shear fault zone. Results of the deep electrical soundings also indicate these two directions. The electrical work also shows that, in the area west of the Doornberg mountains, there is only a small part where the upper layer is cracked in any way. However, this is too insignificant to be able to convert the relevant magmatic and metamorphous formations into a significant aquifer. East of Prieska the deep electrical soundings show a deep trough of sediments. This discovery by the

electrical method is especially important since the sediments, which consist mainly of formations of the Transvaal Super group and possibly also formations of the Pre-Transvaal age, can be up to 5 km in diameter. The waterbearing characteristics of the dolomite of the Transvaal Super group have not yet been investigated in this area.

The shallow electrical surveys in the Prieska area indicate that groundwater which is pumped from high yield boreholes is derived from shallow groundwater sources. These sources are associated with weathering and not with any structures in the fixed formations which can be coupled with the Doornberg episode of fault formation. The weathered zones are shallow and sparsely distributed which indicates that the groundwater potential west of the Doornberg mountains cannot be very extensive.

The geophysical data are supported by the findings of the geological and geohydrological mapping. In particular, the chemical composition of the groundwater occurrences indicate that recharge of the groundwater is very limited and that none of the current groundwater sources belong to a dynamic system. Rainfall in the area amounts to only about 200 mm/annum and decreases towards the west.

Geohydrological studies in the Gamagara catchment using environmental isotopes and complementary techniques

(Existing project: Contract with the University of the Witwatersrand — Nuclear Physics Research Unit)

Environmental isotopes which constantly label water in nature are particularly suitable as tracers for studying the movement of groundwater. The long and short-lived radioactive isotopes (radiocarbon and tritium) can be used for "dating" groundwaters since the time of their infiltration from the surface. Non-radioactive or stable isotopes of hydrogen, oxygen and carbon, which undergo small changes in concentration due to evaporation and chemical exchange, provide a label by which waters from different environments can be distinguished.

Such a large-scale natural tracing experiment which provides information on groundwater such as recharge, movement and storage, has been in progress for three years in the catchment of the Gamagara River in the Northern Cape, important for its agricultural potential and its mining development. Surface water is only sporadically present. Waters infiltrating into the southern outcrop areas (mainly dolomitic) flow northwards and are eventually channelled into what can be regarded as a deep porous trough in the cover of recent Kalahari deposits. These waters, and a greater or lesser proportion of direct rain recharge through the Kalahari deposits, combine to form the total groundwater potential of the region on which animal husbandry and developing mining industry vitally depend.

During the year under review, the study over widely spread areas of the catchment has been considerably advanced. The important rapid infiltration areas as well as outcrop areas which do not seem to contribute significantly to the sub-surface drainage as a whole are now well established by the radiocarbon survey. Chemical and stable isotope observations largely support this classification and have aided in identifying an area of what might constitute the upwelling of older and deeper drainage.

Continued monitoring of a large dewatering operation in the south of the catchment has shown that, with increasing output, the initially almost constant "older" waters are changing and more and more recent water is being drawn in. An extensive survey of the dolomitic areas has indicated large storage of extremely recent recharge. It is now becoming possible to produce simple models to describe the flow of these waters.

Infiltration studies in the Kalahari beds, in which the downward progress of nuclear bomb produced tritium is being followed, are producing information on the rate of movement of rainwater through and the rate of groundwater recharge in these beds.

With information on the underlying geological structures and hydrology increasing, the environmental isotope data are assisting in building up a more complete picture of the groundwater flow as well as providing unique quantitative information.

The project has been extended to mid-1978. Further isotope data is to be collected in view of resumed borehole drilling and changes in dewatering rate; recharge studies are to be continued and chemical analyses done. Most of the time will however be devoted to compiling and correlating data obtained in this work, as well as by geologists and geohydrologists of ISCOR and the Department of Water Affairs.

Chapter 6

Water economy measures

As indicated in Chapter 2, the total water consumption in the urban areas, covering both the domestic and industrial sectors, is a rapidly rising figure, and economies in this field could represent considerable savings of this valuable commodity. This fact was early recognised by the Commission and contracts were entered into to undertake research in this field.

For instance in 1974 the Department of Chemical Engineering (Water Utilization) of the University of Pretoria was contracted to do research on water losses in pipe networks and water consumption patterns in urban areas. These contracts are nearing completion. There is however, much further work to be done on water consumption patterns, since the present work has been confined to the domestic sector — in itself a wide field, embracing houses, flats and high-rise buildings, and all public and official uses. The further work to be done lies mainly in the industrial field, which is a complicated sector, since it covers the multifarious activities of innumerable industries. This work will follow the present project immediately the latter has been completed.

Water economy in power stations has already been given attention by the Commission. Cooling in power stations causes large-scale water loss and this has led the Commission to finance a project on the application of dry cooling as alternative. As mentioned in the previous annual report, this project, which was undertaken by the National Mechanical Engineering Research Institute of the CSIR, was completed by the end of 1976. During the year under review a final report was received and it was clear that further research in this field, especially in conjunction with industry, was desirable. The Commission has therefore decided to continue with further research on dry cooling in collaboration with the Department of Water Affairs and Escom especially since the latter has already done research and development work in this field. Negotiations with representatives of these two organizations have already been held and proposals for future research have been received from Escom, which will be considered by the relevant parties early in 1978.

The work covered in the projects detailed in this chapter will be coupled with the proposed water economy investigations (indicated in Chapter 2), and when the whole spectrum has been covered it is proposed to formulate design criteria upon which future work in this field by local authorities and consulting engineers may be based. This will ensure that future urban water distribution systems will be planned on the most efficient and economical lines.

RESEARCH PROJECTS

Water losses in pipe networks

(Existing project: Contract with the University of Pretoria — Department of Chemical Engineering, (Water Utilization))

This project consists of two phases *viz* the determination of water losses in pipe networks, which includes extensive field investigations, and the examination of methods of prevention and control. The research was carried out in close collaboration with the local authorities concerned.

Losses from ineffective pipelines can in extreme cases amount to 40 per cent of the average volume

supplied, although average losses are much less. Apart from the loss of a valuable commodity, unnecessary costs are incurred in supplying, purifying and reticulating water that is lost through leaks that may go undetected for many years. Losses through leakage must therefore be controlled to the extent where the cost of control together with the value of the water lost is a minimum.

During 1977 extensive field investigations were carried out in Johannesburg, Pretoria and Cape Town. The maximum allowable loss flows for various pipe materials of different ages were determined. When loss flows (determined by means of detection meters) exceed the maximum allowable loss flow, it is a clear indication of unacceptable leakage which must be repaired.

Field studies with special waste detection meters commenced in Johannesburg in August. As part of these investigations, the influence of pressure variation on the loss flow for these areas were also studied.

All the experimental work of phase one was completed during the year under review and almost all subdivisions of phase two including economic studies of water loss control, were completed early in 1977. The final report for this project will be completed in 1978.

Water consumption patterns in urban areas

(Existing project: Contract with the University of Pretoria — Department of Chemical Engineering (Water Utilization))

In order to provide guidelines for future water allocations, water reuse planning and optimisation of water systems, it is desirable to establish water consumption patterns in the domestic and industrial sectors, (whose consumption shows rapid increases each year). It is estimated that this consumption will represent over 55 per cent of the total water consumption of the Republic within 25 years.

During the year under review investigations have been directed at water consumption patterns of cities as a whole, water consumption of residential houses and flats and component water consumption within the household.

Climatological data was correlated against water consumption in order to establish the influence of rainfall, relative humidity, temperature and duration of sunshine on water consumption. In addition, daily consumption figures over a period of one month have been correlated against yearly averages in order to establish those periods when the daily consumption exceeded the annual average each day and those periods when daily consumption never exceeded the annual average consumption.

The effect of constant flow valves on water consumption was investigated in Bantu townships in order to determine their effectiveness as water saving devices. In Daveyton the influence of ethnical grouping on water consumption was also studied.

Water consumption of individual houses in selected suburbs of Pretoria and Port Elizabeth was studied. Detailed information was established for industrial stand consumption, per capita consumption and number of stands at which consumption was less than the average consumption taking into account all factors which influence these figures. Other factors studied included the relationship between consumption per stand and per capita against stand size, stand valuation, valuation of improvements, total valuation and income. In Pretoria, these investigations were also extended to flats.

The influence of private boreholes on water consumption patterns is also being studied in order to establish water consumption outside the home.

The final report for this project will be completed in 1978.

Chapter 7

The water environment

Research on the water environment is important to the Commission for at least two reasons. In the first place, in considering the degree of effluent treatment that should be applied it is necessary to establish the impact of different levels of pollutant on the environment. This is of prime importance for authorities such as the Department of Water Affairs and the S A Bureau of Standards in the setting of regulations governing effluent quality.

Furthermore, it is desirable to understand the dynamic processes at work in the water environment in order that one may be better able to predict the impact of pollution discharges on water bodies and to develop processes whereby the effects of pollution can be minimized or controlled.

Research in the field of water environment is closely related to that of effluent treatment (see next chapter) since treated effluents are discharged to the environment except where direct reuse is practised. Two of the research contracts reported on below illustrate some aspects of the value and importance of such research.

The contract with the National Institute for Water Research (NIWR) on eutrophication concentrates on several dams. The study, initially limited to the Transvaal and Eastern Cape Province, now includes four dams in Natal. These dams have been chosen to represent a cross-section of natural water conditions (silt loads, etc), and of levels of enrichment by phosphorus and nitrogen. Attempts are being made to correlate the deleterious effects found with the level of pollution experienced. Data from dams which have been artificially enriched will also be included.

The contract with Rhodes University on the role of macrophytes in maintaining the trophic status in Swartvlei is designed to afford a greater understanding of the mechanism whereby a large amount of nutrient is "locked up" in the form of biological life present in the macrophyte zone in the shallow borders of the lake, in spite of low levels of nutrient in the open water.

During the year under review, two reports were published which flow partly out of work done under the contract with NIWR. These reports, which are complementary, are:

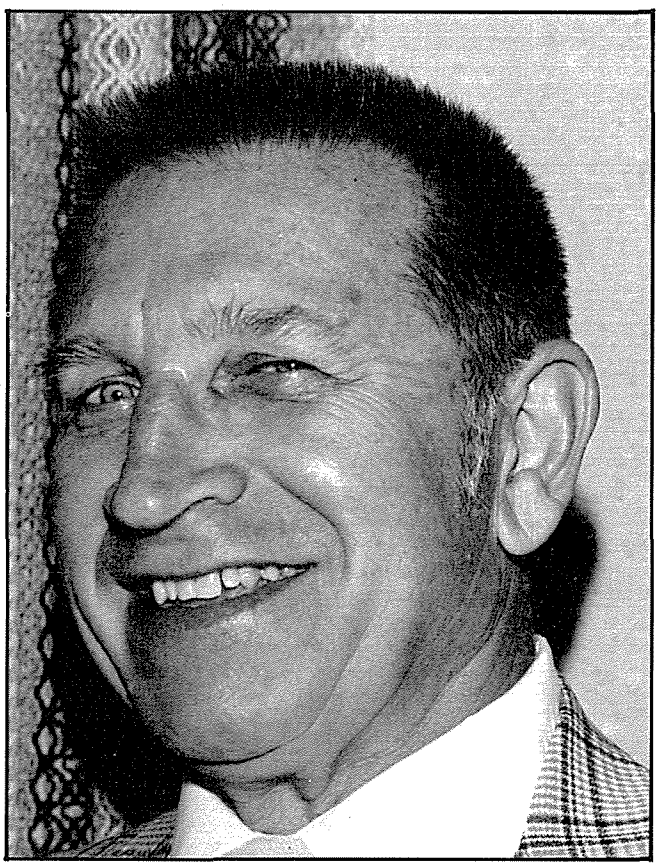
- 'A review of eutrophication and guidelines for its control in South Africa', by D F Toerien (Report WAT 48) published by NIWR
- 'Tussentydse Riglyne vir die Beheer van Eutrofikasie', by D F Toerien and R D Walmsley (Tegniese Verslag No. 1) published by the Water Research Commission.

In the 1976 Annual Report reference was made to the liaison that had been established with the CSIR's National Committee for Environmental Sciences (NCES). As mentioned in Chapter 1, this liaison has been maintained during 1977, and further research projects at universities have been funded by the Commission via NCES.

During the year under review, the Commission also brought to the Republic Dr A F Bartsch, Director of the Corvallis Environmental Research Laboratory of the U S Environmental Protection Agency, to advise on the coordination of research on inland water ecosystems in South Africa. The report subsequently submitted by Dr Bartsch has proved of great value to the Commission, and its recommendations are now being pursued by a special Study Group under the leadership of the Committee for Inland Water Ecosystems (see also Chapter 1).

A third project also reported on in this chapter deals with the combating of water hyacinths in the Hartbeespoort Dam.

Dr A F Bartsch of the Environmental Protection Agency (USA) visited the Republic to advise on research with regard to inland water ecosystems.



RESEARCH PROJECTS

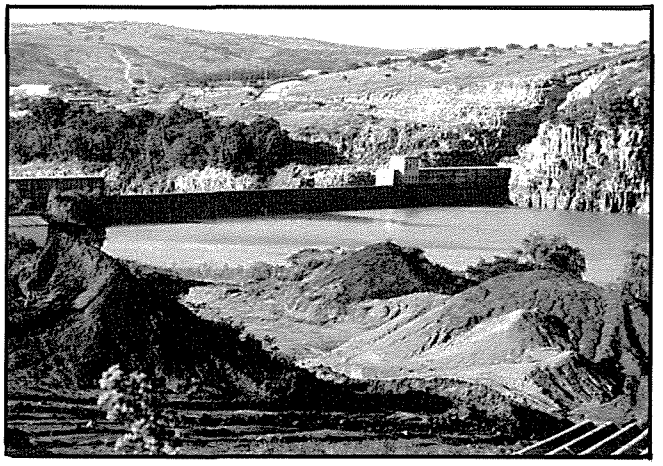
Eutrophication of rivers and dams

(Existing project: Contract with the CSIR — National Institute for Water Research)

The trophic condition of a water body can be related to the quantities of plant nutrients (nitrogen and phosphorus) which enter it. In most parts of the developing world, water management problems have been experienced due to excessive quantities of nutrients being discharged into water systems. This quantification of nutrient loading and its effects on the aquatic environment are extremely important for water resource management.

Research during the year under review has included the routine monitoring of two reservoirs in the Transvaal (Lindleyspoort and Buffelspoort Dams) which were subjected to enrichment with fertilizer (nitrogen and phosphorus) on a weekly basis from May 1976 to May 1977, with the object of observing the behaviour of the two reservoirs before, during and after this enrichment. Preliminary analysis of the data has shown that enrichment of both reservoirs at the same nutrient loading rate produced increases in phytoplankton populations, but these did not reach nuisance proportions. The phytoplankton populations in Buffelspoort were however consistently higher than those in Lindleyspoort, which could possibly be attributed to the fact that the latter was generally more turbid than Buffelspoort in terms of suspended clay particles. These particles appeared to decrease the available light required for growth of phytoplankton and consequently the system was light-limited despite the presence of available nutrients. The recovery of both reservoirs after enrichment is at present being monitored.

Routine studies on the Bridledrift and Nahoon Dams near East London have also continued. As was reported for 1976 these dams were included in the study to shed further light on the role of silt. In addition, monitoring of nutrient loads and algal responses on six other reservoirs in the Transvaal Highveld has commenced. This will continue for a year and will



The Bridle Drift Dam (left) and the Nahoon Dam near East London on which routine studies of the enrichment of water bodies were continued during the year. These are two of the dams involved in a study of eutrophication of rivers and dams in South Africa.

provide the basic data to establish whether there is a predictable relationship between algal biomass within a reservoir and the nutrient load entering it. It is hoped that the results obtained from such an investigation will allow definite recommendations to be made to water authorities on the restrictions which should be laid on nutrient input to reservoirs under South African conditions.

The role of aquatic plants in maintaining trophic conditions at Swartvlei, Wilderness

(Existing project: Contract with Rhodes University — Institute for Freshwater Studies)

Owing to its unspoiled nature, Swartvlei, one of the six Wilderness lakes, provides an ideal site for a quantitative study of the role played by submerged weed beds in the maintenance of trophic conditions in shallow waters.

During the year under review studies on growth and decomposition rates of the major aquatic plant species were completed. Work on the nutrient content and *in situ* uptake rates of phosphorus and nitrogen is also complete. This has resulted in a preliminary model of phosphorus and nitrogen dynamics in these aquatic plant communities. There are, however, still a number of gaps, one of particular importance being the exact fate of the nutrients in the plants following decomposition. At present, laboratory work using radioactive tracers is being carried out to try and follow this important step in the nutrient cycle.

Research under this contract is also aimed at an understanding of the general physico-chemical and biological processes in the Swartvlei system as a whole, and routine monitoring of the vlei and estuary has continued.

Swartvlei lake is connected to the sea via the estuary, and hydrographical studies in the sinuous channel of the estuary have established that the exchange of tidal water during the tidal cycle is largely affected by natural geomorphological features, although the existing rail bridge plays a significant role in limiting the exchange of water to and from the lake.

Chemical studies have yielded no evidence of major polluting sources; indeed the plants of the estuary are heavily dependent upon phosphorus brought in during every tidal cycle from the sea. The influence of flooding of the estuary by fresh water from influent streams is profound, causing loss of dead and living plant material from the estuary and reduction in salinity for up to four weeks following opening of the mouth. The role of these natural events in the ecology of estuarine plants and animals is being evaluated quantitatively.

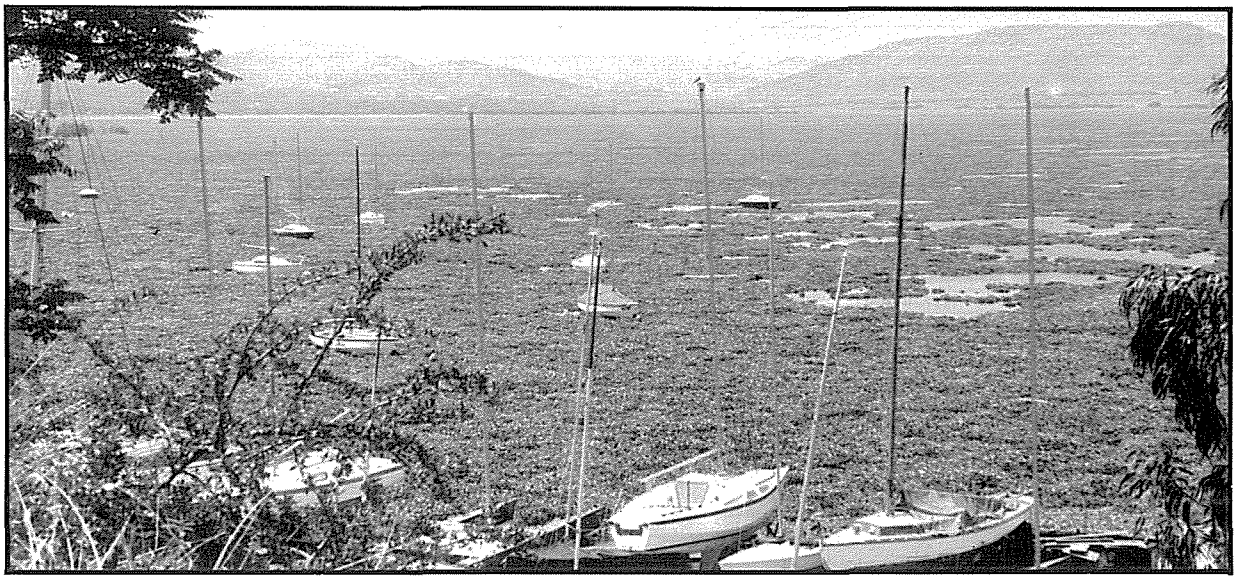
Research programme to study conditions in the Hartbeespoort Dam before and after full-scale spraying of water hyacinths

(New project: Contract with the CSIR — National Institute for Water Research)

Hartbeespoort Dam, near Pretoria, is one of the most pronounced examples of growth of hyacinths in the Republic, receiving as it does both industrial and domestic effluent from the Northern Witwatersrand. Algal blooms have been encountered for many years but over the past ten years infestation with the water hyacinth *(Eichhornia crassipes)* has been experienced to an increasing extent.

While these growths have not interfered with the primary function of the dam (irrigation) they have increasingly interfered with recreational use of the dam, particularly angling, yachting, power boating and water skiing. Towards the middle of 1977 water hyacinths had covered about 55 per cent of the surface of the dam and indications were that, if remedial steps were not taken, the whole surface could become covered by March 1978, which could have a deleterious effect on the water quality. In the light of earlier small and large scale trials with herbicides, the Department of Water Affairs decided on a large scale spraying operation, and in October 1977 the area covered by hyacinth (1 200 ha) was sprayed with a suitable herbicide.

The Water Research Commission suggested to the Secretary for Water Affairs that a research programme be undertaken to coordinate a thorough scientific monitoring of the dam before and after the spraying operation, in order to provide a careful record of the effect of such an operation, and of the decay of the dying vegetation, on the water of the dam, on the sediments, and on various components of the biological life. A careful watch would also be kept on the vegetation on the banks. This suggestion was supported by the Department and approved by the Minister of Water Affairs. The intention is also to

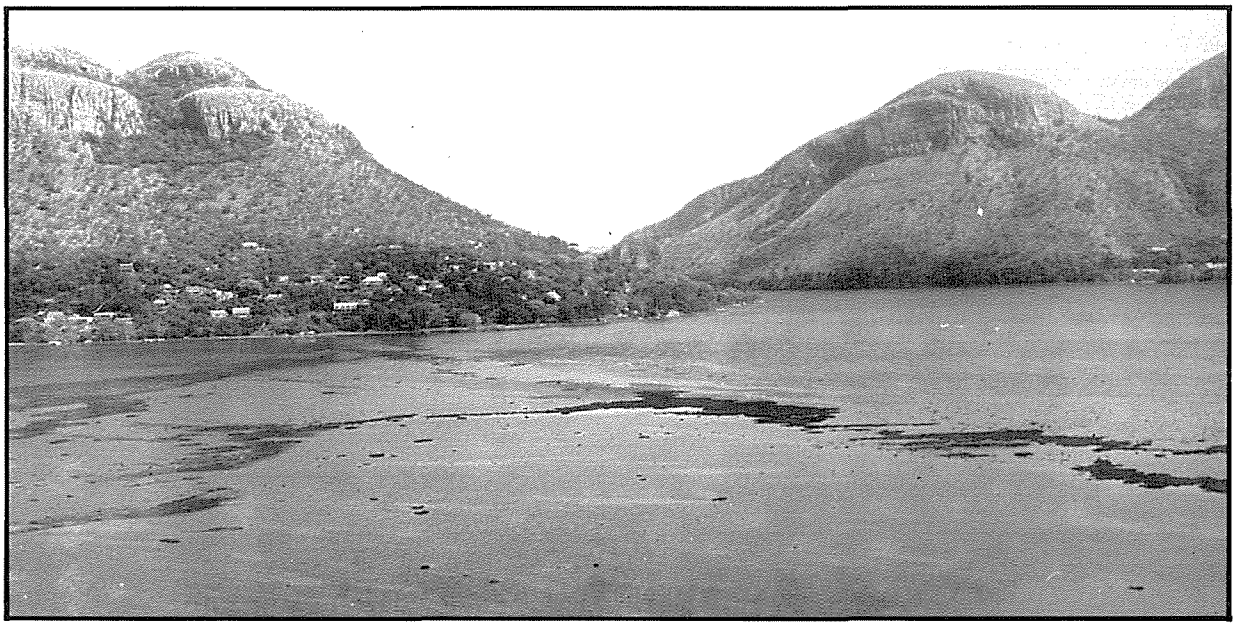


In October 1977 this was the scene at the Hartbeespoort Dam near Pretoria. Water hyacinths were impeding, to an increasing extent, the recreational use of the dam.

provide a report of the spraying and its effects in such a form as to provide some guidelines for safe and effective herbicide applications in similar situations in South Africa.

The whole operation was conducted in close collaboration with the Department of Health, and the scientific monitoring programme, coordinated by the National Institute for Water Research and largely funded by the Water Research Commission, was performed in collaboration with the Department of Water Affairs, the Department of Agricultural Technical Services, the South African Bureau of Standards, and the Department of Nature Conservation of the Transvaal Provincial Administration.

The programme was still in operation at the year end, but initial observations showed the effects on water quality and biological life in the dam to have been less than might have been anticipated, although the spraying operation had been so successful that more than 80 per cent of the surface area under water hyacinths had been cleared. At no stage, for example, did conditions pose any threat fo the fish population of the dam.



This photograph was taken in December 1977 after large-scale application of herbicide on the Hartbeespoort Dam by the Department of Water Affairs. Quality monitoring of the water before and after spraying was done by the NIWR, at the request of the Commission, to determine possible side effects of the spraying.

Chapter 8

Treatment of municipal and industrial effluents

The utilization value of water sources in South Africa could be seriously impaired by the discharge of effluents which have not been adequately purified. It is therefore vitally important that pollution of existing water supplies be limited as far as possible. Efficient waste water purification requires an advanced technology and the Commission expends funds to this end.

The participation of local authority and the industrial sector in water and waste water management, and the high priority the Commission has accorded this in its research programme, were discussed in Chapters 1 and 2. In this chapter more stress is laid on specific problems and research projects.

There are many problems which face the local authority in the field of waste water treatment, and as has been indicated previously, a Study Group has been set up to consider the formulation of a Master Plan for research into the problems. The existing research projects in this field will be incorporated in this plan, and every effort will be made to institute a strong research programme in view of the importance of the local authority in respect to waste water treatment.

The Commission has for a number of years been supporting research by the NIWR and the University of Cape Town on the biological removal of nitrogen and phosphorus compounds from waste water. It is known that these compounds are the principal cause of eutrophication (see previous chapter) and sewage purification plants are one of the most important point sources of nitrogen and phosphorus compounds. Experience with a pilot plant has confirmed the laboratory work and the biological mechanism is reasonably well understood. Several large scale plants are being or have been built and the Commission is planning to contract the NIWR to do a detailed study of all the unit operations of one such large scale unit in partnership with the Johannesburg Municipality, in order to optimise the removal of nitrogenous and phosphorus compounds.

As mentioned in Chapter 2 the large number of existing biofilter installations present a problem since they are unable to effect significant phosphorus or nitrogen removal. Furthermore, since they represent a large capital investment, they cannot summarily be replaced by modern activated sludge processes. Preliminary research on the activated sludge process has yielded promising indications that the nutrients can be removed from the effluents of biofilters. The Commission is therefore planning to sponsor laboratory and pilot scale work along these lines with a number of municipalities and in conjunction with the NIWR.

Since the efficient operating of biological treatment processes can be disrupted by the presence of toxic or intractable materials in the waste waters being treated, the Commission is also sponsoring research in fields related to this aspect of waste water treatment.

Although the Commission already finances a few projects on behalf of the industrial sector there can be no doubt that the inclusion of more research for this sector in future Commission programmes will be fully justified. It will be noted from the project reports that some large industrial groups are involved in the work which has been undertaken in the past year, such as the Leather and Allied Industries (which includes the curing, fellmongering and tanning activities associated with the manufacture of leather); the Textile Industry, one of the country's largest industrial activities; and the Wine Industry. These reports, however, only cover the groups in which research has reached the stage where pilot plants are in active operation, and do not include the many industries with which negotiations are being carried out to determine the justification for research to be sponsored by the Commission, or the lines which such research should follow. Amongst these latter industries, are the Fruit and Vegetable Canning

industry; the Fish Canning Industry and the Mining Industry. In these cases, much progress has been made with the preliminary discussions, and it is anticipated that research work may be commenced during the coming year.

RESEARCH PROJECTS

Research on the activated sludge process

(Existing project: Contract with the University of Cape Town — Department of Civil Engineering)

Various aspects of the activated sludge process are being investigated with the ultimate objective of setting down general design criteria for full-scale application. A significant portion of the research effort is directed towards identifying the conditions for efficient removal of the euthrophying elements nitrogen and phosphorus from waste waters.

Activated sludge investigation

From the behaviour of activated sludge units subjected to cyclic loading patterns, an adsorption postulate would appear to be a valid explanation for the phenomena occurring. Experiments conducted to test the validity of the postulate identified an energy requirement by organisms for adsorption of substrate.

By incorporating the adsorption postulate in a general theoretical model describing the behaviour of activated sludge plants subjected to dynamic loading conditions, experimental data could be closely correlated with the theoretical predictions.

Applying the modified theoretical model further to the particular case of the contact stabilization process, the validity of the model is further verified. Again, experimental data dorrespond closely to the theoretical predictions.

Phosphorus removal in the activated sludge process

The relative roles played by calcium phosphate precipitation and biological (luxury) phosphorus uptake were investigated. It has been shown that the contribution of precipitation to phosphorus removal is small compared with that of a biological mechanism, and is very dependent on pH. For a precipitation mechanism, it is immaterial whether anaerobic, anoxic or aerobic conditions prevail.

Although the exact conditions necessary for inducing excess biological (luxury) phosphorus uptake have not as yet been identified, it is evident that the organisms must be subjected to some from of anoxic stress conditions. There are several hypotheses suggesting the conditions necessary but experiments have failed to show which hypothesis is correct. It is evident that other factors, as yet unidentified, need to be considered. Evidence from these investigations suggests that sludge recycled to the anoxic reactors must be depleted of stored substances exerting a chemical oxygen demand (COD) and that the presence and concentration of nitrate are also important.

Additional studies have been directed towards the effect of temperature on phosphorus and nitrogen removal. Nitrate profiles in the primary anoxic reactor show a two-phase denitrification behaviour. This supports earlier work carried out in the Department.

Aerobic digestion

A theoretical treatment of the kinetics of aerobic digestion put forward at an earlier date has been verified experimentally. By including a primary anoxic reactor in the digestion system, 90 per cent of the nitrates generated during digestion is removed by denitrification and the phosphorus level in the supernatant is maintained between 10 and 20 mg ℓ^{-1} . No phosphorus release was evident in the anoxic reactor although the actual anoxic retention time reached 9 hours.

Aerated lagoons

A theory describing the kinetics of aerated lagoons has been set out based on a simplification of the general activated sludge theory put forward at an earlier date. The predictive value of the theory has been verified using experimental data obtained from the literature.

From this work it is evident that the best approach to design is to assign a retention time of 1 to 2 days for the first lagoon in the series, principally with the objective of flocculating the pollution energy onto the active mass. In subsequent lagoons flocculated volatile solids are allowed to settle and undergo fermentation.

Energy requirements for complete mixing have been evaluated against experimental data. It is evident that mixing energy requirements decrease as the volumes of the lagoons increase.

Pilot plant studies

A pilot scale investigation into the conventional activated sludge process was undertaken in order to verify the theories and models obtained at laboratory scale level. No fundamental differences in behaviour were observed between pilot plant and laboratory scale

results even though the laboratory units were 1 : 2000 scale of the pilot plant.

Flotation and flocculation studies

Although in terms of the existing contract flotation studies are complete, the Department is currently engaged in such studies in an advisory capacity. The projects currently involve solid-liquid separation problems at fellmongeries and tanneries and investigating scale-up effects by conducting parallel laboratory scale experiments with concurrent pilot plant trials.

As a consequence of certain problems experienced during earlier flotation studies, a convenient means of assessing the flocculation propensity of a waste was desired. By scrutinising existing flocculation theories it was recognised that a batch testing technique should be feasible.

Development of criteria for removal of nitrogen and phosphorus from sewage effluents by means of improved biological treatment processes

(Existing project: Contract with the CSIR — National Institute for Water Research)

This project comprises the development of process criteria for the biological removal of nutrients, especially nitrogen, phosphorus and organic carbon compounds, from sewage effluent. Laboratory scale units are used to identify and optimise the various operational parameters, followed by practical application and evaluation using a 100 kl d^{-1} pilot plant in Daspoort.

The research has confirmed that the phenomenon of enhanced phosphate removal is essentially a biological process. To induce and maintain the phenomenon the phosphate accumulating sludge must be subjected to anaerobic conditions before such enhanced uptake occurs. It is therefore imperative that dissolved oxygen, nitrate and nitrate concentrations in the sludge recycle stream be limited and that the chemical oxygen demand of the feed be sufficiently high to allow rapid reduction of these substances.

Two laboratory units, operated in parallel at 20 °C and 14 °C respectively, are used to study aspects such as residence time requirements of the various process stages, permissible levels of dissolved oxygen, nitrate and nitrite in the sludge recycle stream, role of chemical oxygen demand and the effect of temperature. Each process stage has been subdivided in from 4 to 6 completely mixed reactors in series to allow a detailed assessment to be made of reaction progress as a function of time. In this way the process criteria can be quantified.

A characteristic of many investigations regarding biological phosphate removal is that the process is studied only over relatively short periods for a given process configuration and mode of operation. In view of this the pilot plant for biological nitrogen and phosphate removal is now being used to continuously study process behaviour over an extended period of one year, using a set design and fixed operational procedure. By this means one can determine which effluent quality objectives may be realistically achieved under practical conditions. Such a study is indispensable when attainable effluent quality specifications have to be formulated for new large-scale sewage treatment plants. Results obtained to date show that nitrogen, phosphate and organic carbon compounds (the latter expressed as chemical oxygen demand) can indeed be removed reliably in a properly designed process. Plant operation is relatively simple and the process is quite insensitive to common operator errors or even to considerable mixed liquor losses. Effluent concentrations of the above-mentioned substances have been less than 5,1 and 30 mg ℓ^{-1} respectively for the majority of time, implying excellent removals from the corresponding inflow concentrations of about 30,6 and 250 mg ℓ^{-1} .

Until now settled sewage has been used as waste water sources for these studies. Even better results may, however, be achieved by using raw sewage as primary source or by utilizing raw sludge as additional energy source. These aspects, and the handling of the biological sludge produced as part of the nutrient removal process, warrant active further research.

A process design guide for biological phosphate and nitrogen removal is now being prepared.

Removal of sludge and wash water at water purification installations

(Existing project: Contract with the University of Pretoria — Department of Chemical Engineering (Water Utilization))

The aim of this project is to develop technology and criteria for the economic treatment and disposal of

water works sludge and wash waters derived as effluents from water purification works. Sludge arising from the treatment of polluted waters can cause odour problems and, where discharged into the water environment, can cause corrosion and possible toxicity.

As a follow-up to the investigations already done at the water works at Witbank, Bronkhorstspruit, Brits, Temba and Rietvlei, sedimentation sludge and filter wash water at the Zuikerbosch water works of the Rand Water Board were studied. Feed water at this site is drawn mainly from the Vaal Dam for purification.

Zuikerbosch, in fact, consists of three purification works; two are operated with lime and activated silica and one with an organic poly-electrolyte as primary coagulant. With the kind cooperation of the Rand Water Board these works, which were found to be ideal for the purpose, formed the basis of the investigation. At the former two stations aluminium sulphate is used as secondary coagulant. More than 90 per cent of the suspended material is removed in the primary sedimentation units of the first two stations with the result that the lime and poly-electrolyte treatments become the major sources of sludge. The filter wash water is reclaimed by means of recycling to the feedwater inlet.

Aspects studied included sludge qualities, sludge volumes, kinetics of sedimentation of sludge suspensions, general dewatering characteristics and methods of sludge treatment.

Vacuum filtration, filter pressing, centrifugal sludge dewatering, sand drying beds and sludge lagoons were evaluated in the laboratory to determine the effectiveness of sludge dewatering. With the exception of sludge lagoons, all techniques proved that the required percentage of solid substances for landfill purposes could be achieved.

A pilot scale sludge dewatering apparatus and a mobile centrifuge were also used at the water works to evaluate sludge dewatering. Both techniques showed that the required percentage of solid substances could be achieved for landfill purposes and the quality of the effluents were also such that they could be recycled, without any problems, to the feedwater inlet. There are indications, however, that centrifugal sludge dewatering may be the best method.

Final disposal of sludge residues was also investigated. The residues are currently being investigated by means of chemical analysis, followed by a biological performance test, with special reference to the neutralisation value of the products in comparison with agricultural lime.

Sludge and wash water characteristics and sludge treatment methods are also being studied at the water works of the Municipality of Durban, and water works in other parts are visited.

Research into water management and effluent treatment in the textile industry

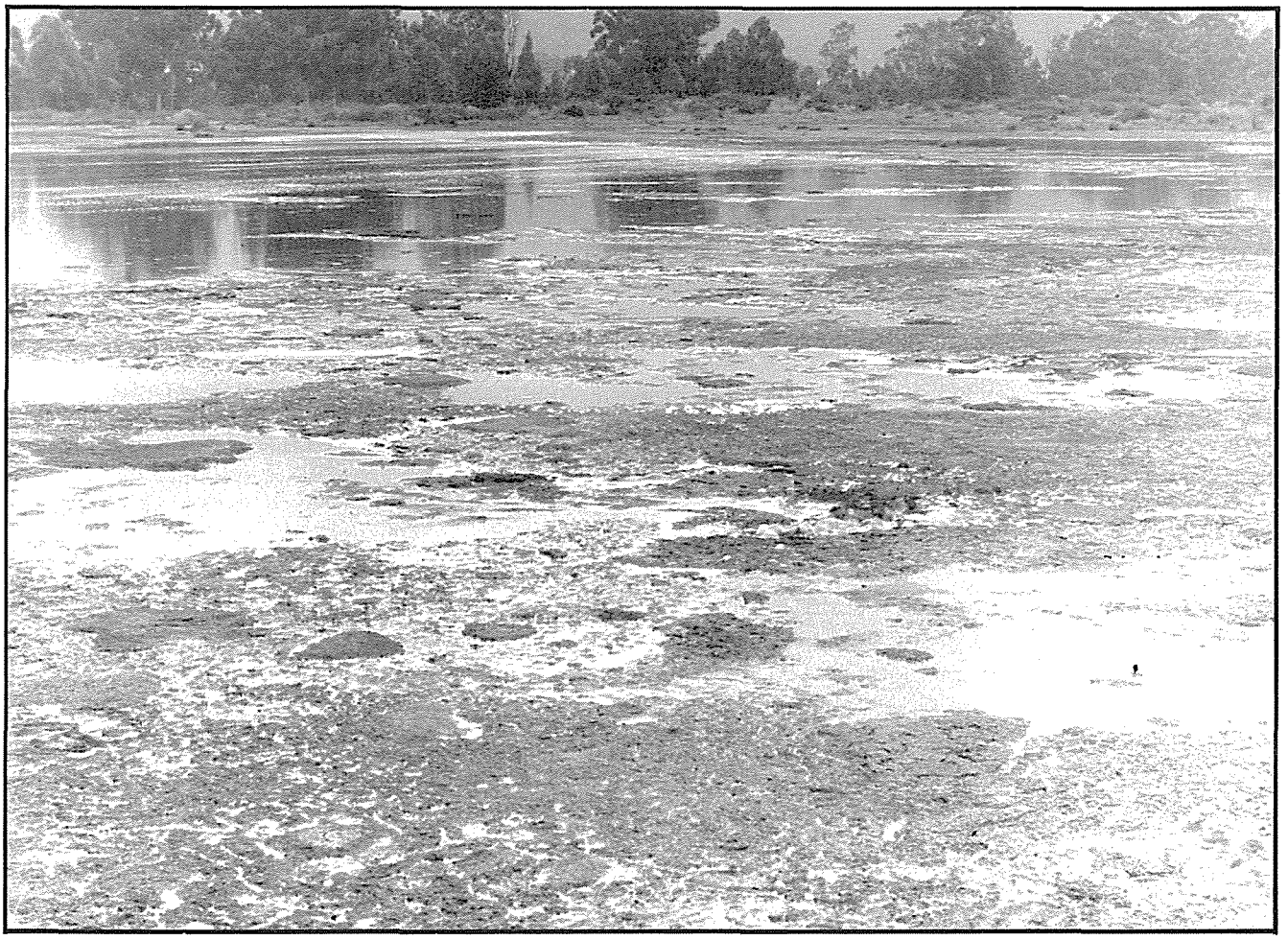
(Extention of existing project: Contract with the University of Natal — Department of Chemical Engineering (Pollution Research Group)).

The existing contract was confined to research on water recycling and chemical recovery for effluents from selected wet processing textile operations, but in the course of the research it was apparent that it would be advantageous to amend the terms of reference to cover the wider field of water management and effluent treatment within the textile industry. The original contract was amended accordingly.

In general, substantial progress has been made on the closed loop recycling systems for wool scouring, desizing and dyehouse effluents. Preliminary characterisation and investigations have also been made on other high strength effluents, such as those of printing and kiering. A large proportion of textile effluents originate from washing and rinsing operations. Thus a detailed study has been made of washing efficiency in relationship to cloth quality and an effective control system for regulating water usage is under development. In certain areas, 40 per cent water reductions have been possible with associated savings in heat.

Wool scouring effluent

This highly polluting effluent has been disposed of hitherto by lagooning after partial recovery of the wool grease. Efforts to increase the grease recovery by flotation have only been partially successful as the results obtained have been inconsistent. Although improvements are possible using collector flotation, there are several major technical problems to be overcome before a commercial system could be designed. Also, a completely degreased wool scouring effluent is still highly polluting and hence a reassessment of the total treatment concept has been made. By slightly modifying the scouring procedure, two effluents can be produced which are much easier to treat singly than when combined as in normal scouring effluents. This system is being assessed in collaboration with a major wool scourer and laboratory feasibility studies are being made. Initial projections indicate that nearly 100 per cent water recycling can be achieved by this process which involves replaceable dynamic membraned ultrafiltration. Also the suint components are recovered as a low-grade fertilizer, the grease recovery is over 95 per cent and large savings can be made on detergent builder and heat.



A typical storage dam for scouring effluent at a commercial wool scouring concern. The layer of grease covering the water surface is clearly visible. The Chemical Engineering Department of the University of Natal is investigating methods for treating this highly polluting effluent.

Desizing effluent

A semi-technical scale ultrafiltration plant using high temperature spiral membranes has been installed at a cotton textile mill near Durban. In order to achieve steady state conditions in desizing, the effluent is stored and then processed by the ultrafilter over several days to recover the polymer size as a concentrated solution for reuse in sizing. The results obtained are comparable to those predicted from laboratory scale tests.

A lengthy trial is at present under way to assess the reuse potential of the recovered size over many cycles and to determine the flux rates, permeate quality and stability of the membranes under continuous high temperature (80 °C) operation. This information will be used to design a pilot plant so that a realistic study can be made of the system under factory conditions including reuse of the reclaimed hot water in desizing.

Dyehouse effluents

Following successful semi-technical process development of a closed loop recycle system for wool/synthetic dyehouse effluents, a continuously operating pilot plant is being installed at the largest worsted mill in the Republic.

The unit operations consist of ion exchange, electrocoagulation, sedimentation and filtration of the effluent produced by the dyeing machines. The treated water will be reused as process water in the dyehouse and tests will be made on the recovered dyeing auxiliary chemicals. The pilot plant will be used to assess the technical and economical viability of the process and for the development of suitable control systems needed for a full-scale treatment/recycle plant.

Removal of metal ions from dilute solutions in an electrolytic precipitator

(Existing project: Contract with the University of the Witwatersrand — Department of Chemical Engineering)

Excessive concentrations of metals in industrial effluents discharged to sewers may adversely affect the performance of sewage purification works. Although technology exists for treating these effluents, it has not found wide application owing to the cost of equipment and chemicals and the absence of sufficient space on most plants.

The Department of Chemical Engineering of the University of the Witwatersrand, under contract to the Commission, is investigating the efficiency of removing these metals in dilute solutions by electrolytic precipitation using particulate electrodes. This process involves compact equipment and does not require the addition of chemicals.

During the year under review an attempt was made to assess the effluent problems of the electroplating industry on the Witwatersrand. Following a number of visits to plants, it was concluded that electroplating companies could be placed into three categories depending on the type of plant and the nature of the work done. A different effluent control strategy would have to be applied to each of these categories to minimise the discharge of harmful effluents to the sewage system.

Following the survey of the effluent problems in the electroplating industry on the Witwatersrand, it was concluded that, if good housekeeping measures are adhered to, the electrolytic precipitator would find wide application in the industry. This would require the technique to be adapted to treating dilute solutions of mixtures of metals such as copper, nickel, chromium and zinc.

It was reported last year that copper could be removed easily and economically but that lower efficiencies were obtained for the other three. Research during the year under review has shown that by making certain modifications to the apparatus it is now possible to remove nickel at an efficiency which compares well with that of copper. This work will be extended to determine the optimum design parameters for chromium and zinc following which a pilot unit will be constructed for test work on an electroplating plant.

Research in connection with water management and effluent problems in the hides and skins, curing, fellmongering and tanning industries

(Existing project: Contract with the CSIR — Leather Industries Research Institute)

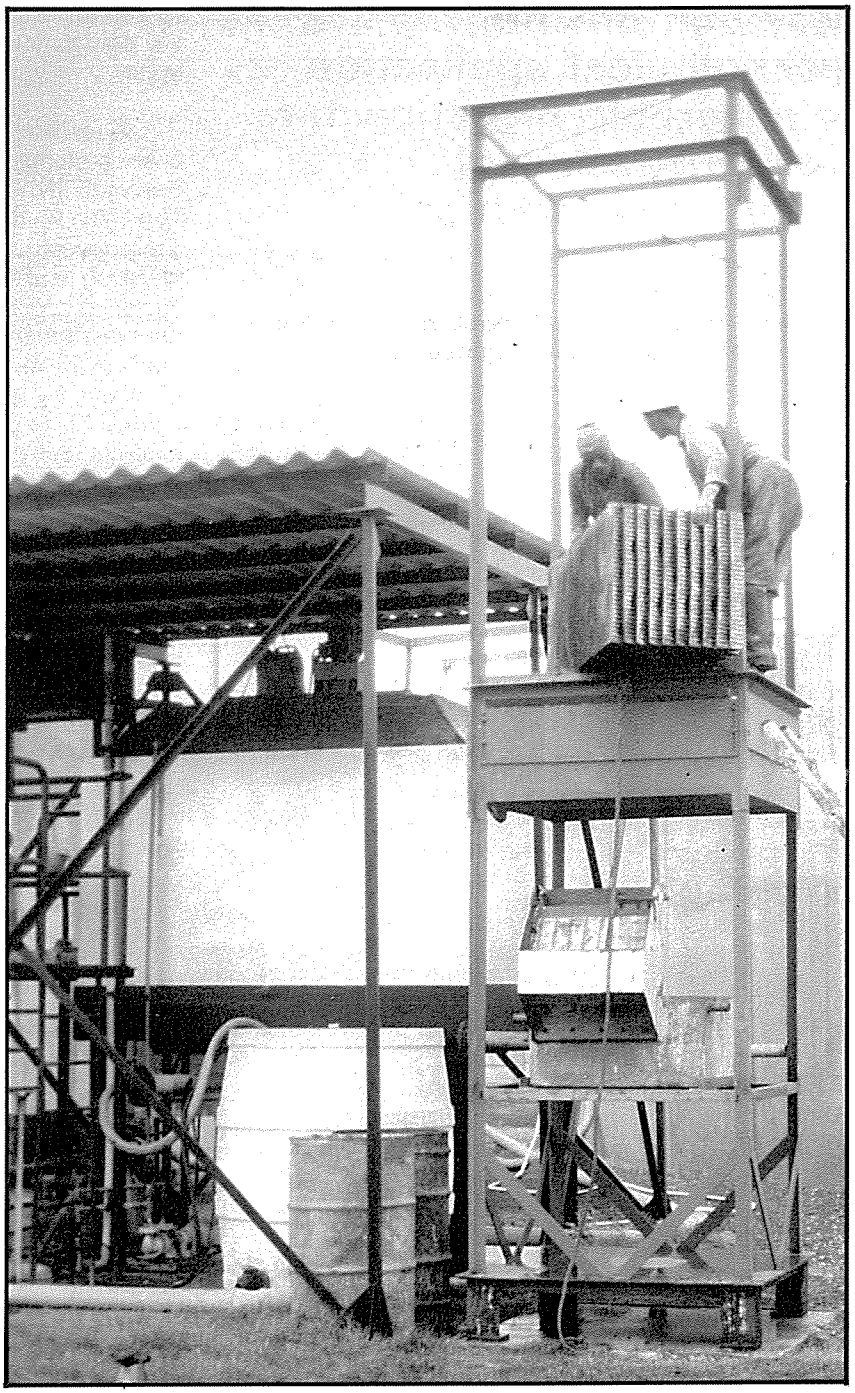
As part of an overall investigation into the environmental problems experienced by the hides and skins industry, a systems study was carried out to determine, inter alia, present practice regarding water management, the potential for waste water reuse and the possible impact of waste water discharges on the environment. This problem had become one of urgency in view of the difficulties which the curing, fellmongering and tanning industries were encountering in meeting the standards of effluents required for discharge to sewerage systems or the environment, coupled with the possibilities of a 'shut-down' due to this problem of disposing of the effluent.

The research programme approved by the Coordinating Research and Development Committee for the Meat, Hides and Skins, Leather and Allied Industries, was initiated with pilot plant investigations in Port Elizabeth and King William's Town into the treatment of process waste waters from the fellmongering and tanning industries respectively. Following these studies, which will continue into 1978, two additional investigations have been commenced at Pretoria and at Wellington, where conditions vary from those at the first two plants.

Fellmongering

The two principal sources of waste water from a fellmongery are the sheepskin soaking and washing process and the lime-sulphide unhairing process. Effluent from the latter process is characterised by its extremely high oxygen demand, pH and sulphide content. Pilot plant results have demonstrated that, after quality equalisation, this effluent is amenable to biological oxidation by an acclimated activated sludge and that biological oxidation can proceed without prior reduction of the pH or the addition of sulphide oxidising catalysts. The results have indicated that treatment of lime-sulphide waste waters by the activated sludge process can produce an effluent of a standard suitable for discharge to a municipal sewer or directly to the sea. Investigations are continuing to establish the effect of loading rates on the performance of the activated sludge process in order to obtain the necessary data and experience for full-scale plant design.

A biofilter being installed at a pilot plant for the treatment of process waste water of a large fellmongering concern in Port Elizabeth. This research is being done in terms of a contract between the Commission and the fellmongery.



Tanning

Pilot plant studies commenced with an investigation into the treatment of segregated waste water discharged from the beamhouse process, which yields high pH lime-sulphide effluent. These waste waters constitute less than 30 per cent of the volume but contain up to 80 per cent of the organic load discharged from a tannery. From initial results these liquors have appeared to be somewhat resistant to biological oxidation and laboratory studies are proceeding to determine which factors are causing inhibition. The pilot plant programme on the treatment of mixed tannery effluent has continued.

Several tanners situated in rural areas and unable to meet the General Standard for waste water discharge have resorted to the use of oxidation-evaporation ponds. As these tanners are being placed under increasing pressure as regards pond odour, studies on the sources of odour and methods of control are proceeding.

Sludge conditioning, dewatering and disposal form an integral part of industrial effluent treatment and as such are being investigated at both pilot plants. Studies on the application of flotation techniques to the desludging of tannery and fellmongery effluents have been initiated with equipment and expertise from the University of Cape Town.

Research on the technological application of anaerobic digestion for the purification of spent wine residues

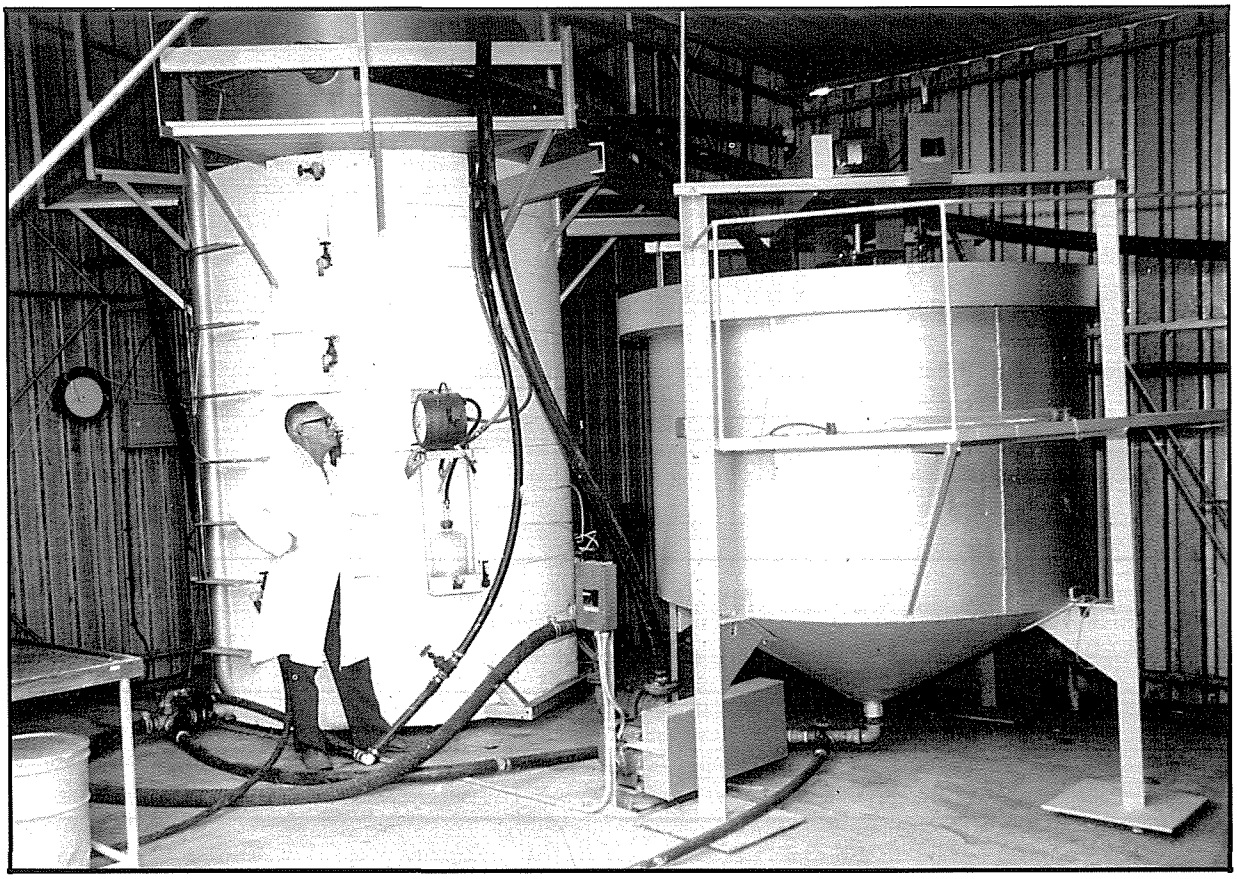
(Existing project: Contract with the CSIR — National Institute for Water Research)

The noxious nature and high pollution potential of spent wine, which is the residue after distillation of the alcohol from fermented grape juice, create disposal problems for the distilleries or local authorities concerned. Conventionally it has been treated by means of lagoons, but this has been found unsatisfactory and often leads to river pollution.

Various operational problems are, however, also being encountered in the application of the anaerobic digestion process for the full-scale treatment of spent wine. The main problem has been the poor settling characteristics of the anaerobic sludge responsible for the purification, resulting in loss of biomass from the system.

A research programme extending over 2 years has been implemented by the National Institute for Water Research (NIWR) under contract to the Commission. The NIWR has erected pilot-scale plants at the Stellenbosch sewage works to investigate various physical and biological factors that influence the digestion process, with special emphasis on improving the retention of solids in the system. Provision has been made in the research programme for studying the effect of mixing by gas and sludge recirculation, temperature control by internal steam injection as compared with external preheating, together with the separation of the digester solids by flotation and sedimentation.

The research to date has established various operational conditions for successful digester operation; for example, steam heating has been found to be harmful to the system, and the plant may be operated effectively at lower suspended solids concentrations than previously believed. By these means, the volumetric load rate of the pilot Clarigester (7 m^3) was increased to 5,5 kg chemical oxygen



The pilot scale Clarigester of 7 m^3 which is used in an experimental investigation into the treatment of spent wine effluents.

demand (COD) per cubic metre per day at 35°C, which is four times the rate that could be achieved in the full-scale plants. The degree of purification attained was 97 per cent, based on an initial COD concentration of 25 000 mg/ℓ^{-1}.

A successful solution at Stellenbosch will stimulate confidence in the process and pave the way for further application in the wine-growing areas of the Western Cape.

Water pollution and reclamation of effluents in the Pretoria-Witwatersrand-Vereeniging-Sasolburg complex

(New project: Contract with a firm of consulting engineers in collaboration with various local bodies)

This project, which comprises a detailed study of pollution control and reclamation of effluents in the PWVS urban-industrial complex, has progressed very significantly during the year under review.

Prior to the beginning of 1977, the Hydrological Research Unit of the University of the Witwatersrand was engaged in the preparation of a mathematical model of the hydrological conditions in the PWVS complex, but early in 1977 this work was incorporated in the overall investigation of the whole system, conducted under the direction of Messrs. Stewart, Sviridov and Oliver, who had been appointed as Project Manager, to coordinate the various phases of the research.

Emphasis has been placed upon the daily variation of mineral salts in the Barrage, and the cell-type model, which has been developed and fully tested, can generate, for various time horizons, the time series of salinity (TDS) in all or any of the 130-odd cells into which the Barrage has been subdivided. In order to provide realistic inputs to this model it has been necessary to create the Vaal system model which simulates (in quantity and quality) the natural runoff in all rivers affecting the Barrage. This Vaal system model has to simulate the behaviour of all the reservoirs in the system and provides output in the form of a time series of storage states at all the dams e.g. Sterkfontein, Grootdraai, Vaal Dam and Bloemhof at specified time horizons (e.g. 1980, 1990, 2000).

A series of flow and quality monitoring stations has been set up in the catchment area and work is in progress on developing a model to simulate the movement of effluents from various sources (both point and diffuse sources) within the southern PWVS system to the Barrage. The comprehensive model will then be dependent on input only in the form of data on rain and evaporation in the catchments and water demands throughout the system.

One aspect of the project, namely that concerned with the population survey and prediction of population growth and economic activity, has been studied by the Urban and Regional Planning Unit of the University of the Witwatersrand with the object of providing a basis for predicting the spatial distribution of water demand and effluent generation within the system. A report on population distributions and growth predictions has been completed.

Work has also commenced on the development of a study of water resources and effluent conveyance, treatment and reclamation optimization programmes and a contract is under consideration for the development of the necessary programmes.

Chapter 9

Irrigation

South Africa has now reached the stage where the area under irrigation amounts to approximately 900 000 ha. Although there are indications that this area may be considerably expanded, the expansion is mainly hampered by a shortage of water and, to a lesser extent, by a shortage of suitable soil. It must also be remembered that water consumption by agriculture, according to current growth trends, will constitute only approximately 45 per cent of the total water consumption at the turn of the century. It is therefore essential that the general standard of agricultural water use be raised to a higher level.

Since water use for cattle-breeding is insignificant in relation to the total agricultural water use, it is obvious that the greatest possibilities for water economy exist in the improvement of the standard of irrigation. Water economy in agriculture will not only benefit agriculture, but also the country as a whole.

Study Group for Irrigation Research

The Study Group for Irrigation Research, established by the Commission in 1974 to investigate the state of irrigation and irrigation research in South Africa, has identified several areas of irrigation in which improved practices will lead to a decrease in water requirements. Some of the most important are the following:

Water requirements of crops

At this stage it still happens that irrigators and planners have to make use of recommendations with regard to crop water requirements which are not supported by test results. In this regard complete, accurate data are of great value in the planning, design and operation of irrigation schemes and will contribute greatly to placing the scheduling of irrigation on a more scientific basis.

A coordinated research programme aimed at systematically investigating the water requirements of commercial crops will therefore have to be initiated.

The water requirements at different growth stages of the crop, as well as the moisture-critical stages during the growth season, are important facets requiring attention.

Irrigation techniques and equipment

Of the total area currently under irrigation in South Africa, the largest portion is still irrigated by means of surface irrigation, followed by a considerable area under sprinkle irrigation, whilst the area currently under trickle and microjet irrigation constitutes only approximately one per cent.

In South Africa, as elsewhere in the world, the effectiveness of surface irrigation is often low. However, investigations have shown that should the currently known design principles be applied, and should water losses from dams and canals on farms be eliminated, the effectiveness of surface irrigation can almost be doubled.

The greater adaptability of sprinkle irrigation is mainly responsible for the increase in the use of these systems. A further development is the increase in mechanised irrigation systems. During 1976 the area under mechanised irrigation systems increased by 2 500 ha, and surveys by the Department of Agricultural Technical Services have led to the expectation that the use of these systems will increase considerably in future. An evaluation of irrigation equipment and the standardisation of certain components are therefore aspects which should receive serious attention.

Irrigation extension

The activities of the Study Group for Irrigation Research clearly indicated that a gap exists between irrigation research and irrigation practice. Many research results with far-reaching practical implications are available but are not applied effectively. The transfer of irrigation research results is an aspect which should receive serious attention.

The above presents an indication of the most important constraints in the field of irrigation. In some cases the Commission already supports research and in other respects a real effort will be made to encourage research in these fields.

Coordination of irrigation research

As mentioned in Chapter 1, the Department of Agricultural Technical Services and the Commission, in collaboration with the Department of Water Affairs, have initiated the establishment of a Coordinating Committee for Irrigation Research (CCIR). The following functions have been assigned to this overall committee which will operate at high level:

- Identifying shortcomings and constraints in irrigation research, indicating main priorities and referring them to relevant organizations for further action and recommendations.
- Compiling and maintaining a register of current irrigation research projects.
- Advising the relevant government departments and organizations with a view to promoting irrigation research, and the utilisation and conservation of water.
- Considering research project proposals with inter-departmental implications.
- Submitting proposals to the relevant organizations in respect of liaison procedures and methods of financing research.
- Submitting recommendations to the Water Research Commission on the financing of specific research projects.
- Continuously considering the best methods for coordinating irrigation research and the ensuing coordination mechanisms.

Not only organizations actively engaged in irrigation research will be represented on the Committee, but also other organizations which will be able as a result of their irrigation planning activities to indicate constraints in irrigation practices. The Committee will therefore be constituted as follows:

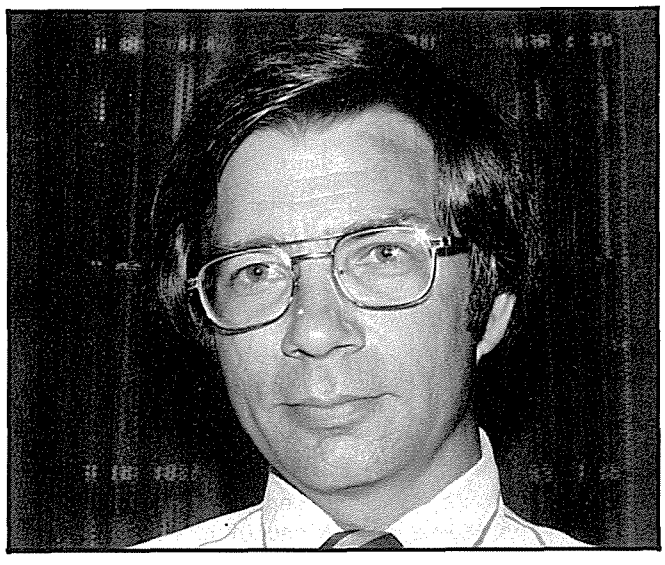
- The Secretaries of the Departments of Agricultural Technical Services and of Water Affairs, and the Chairman of the Water Research Commission, will be *ex officio* members of the Committee.
- Additional representatives from the Departments of Agricultural Technical Services and of Water Affairs, and the Water Research Commission.
- Representatives of the National Institute for Water Research of the CSIR, and the Departments of Bantu Administration and Development, and of Agricultural Economics and Marketing.

It is envisaged that the lead taken by this Committee will contribute greatly to the promotion of irrigation research.

Overseas consultant

During 1976 it emerged that the Department of Agricultural Technical Services intended undertaking a research project on the chemical changes in soil and water during irrigation. Since this research in connection with soil salinisation could possibly have developed into a project of national importance, the Commission considered it advisable to bring an overseas specialist to South Africa as consultant to conduct a local investigation of the salinisation situation.

On the recommendation of the Soils and Irrigation Research Institute of the Department of Agricultural Technical Services the Commission invited Dr J D Rhoades, section leader of the U S Salinity Labo-



Dr J D Rhoades of US Salinity Laboratories in Riverside, California, visited the Republic as a specialist consultant to make recommendations on research with regard to chemical changes in soil and water during irrigation and also to evaluate current and future research projects in this respect.

ratories, Riverside, California, to come to South Africa as a consultant to the Water Research Commission. Dr Rhoades was requested, *inter alia,* to evaluate and make recommendations on the envisaged project and other and future research projects on salinisation.

During March 1977 Dr Rhoades was in South Africa and visited a number of irrigation schemes and research institutions. On completion of his visit Dr Rhoades compiled a report which is currently being studied by the relevant government departments with a view to implementing his recommendations.

RESEARCH PROJECTS

Investigations of soil compaction at the Vaalharts Irrigation Scheme

(Existing project: Contract with the University of the Orange Free State — Department of Soil Science)

The research being done by the Department of Soil Science of the University of the Orange Free State, under contract to the Commission, on the causes and effects of and a solution to the soil compaction problem in the irrigation areas of the Free State and the Northern Cape has reached an advanced stage. Soil compaction is one of the most important factors causing poor root development in South African soils and in the case of crops grown in soil with a potentially deep root zone, it is currently an important yield limiting factor at the major irrigation schemes in the central areas of South Africa.

Quite a few informative deductions and recommendations can already be made. During the year under review the progress within each of the four research categories, *viz,* the field investigation, field tests, laboratory studies and pot tests, was as follows:

- The field investigation, which was done to determine the relationship between soil compaction, root development of the most important cash crops, and cultivation practices, will be repeated during subsequent seasons. From this first investigation it was clear that compaction of the undersoil, as a result of compaction caused by the tractor wheel during ploughing, prevented the roots of most of the crops from utilising the undersoil at all. This phenomenon occurred generally in cotton and maize. Winter grain roots proved to be the best utilisers of the undersoil.

- Recent cultivation practice, aimed at reducing soil compaction and compared to existing cultivation practices by means of field tests with maize and cotton, led to a considerable increase in harvest yield. This improvement can be ascribed mainly to the successful combating of soil compaction and the reduction in nitrogen leaching. These tests are to continue during the next few seasons.

- In the laboratory most of the investigations into the influence of soil compaction on the hydrological characteristics of various soils have already been completed. The relationship between penetrometer resistance, volume density, moisture content and texture on the one hand, and between saturated and unsaturated hydraulic conductivity potential, volume density and texture on the other hand, have already been determined. Other factors influencing the relationships mentioned are also receiving attention. An investigation into solving the soil compaction problem by means of chemical structure-forming substances has already yielded promising results.

- A series of pot tests with three different soils and four crops has been completed in which the interaction between soil compaction, root development, nutrient intake and surface growth was investigated. Final deductions will be possible after the statistical processing of the results has been completed. Drastic decreases in root lengths and, in some cases, nutrient intake, were found.

The effect of internal plant moisture stresses on the growth and production of certain agronomic crops

(Existing project: Contract with the University of the Orange Free State — Department of Agronomy)

For the establishment of a scientifically based irrigation programme where the available water supply is optimally used, it is necessary to know when agronomic crops will react most favourably to the application of water. In order to obtain maximum yield with minimum water application, it is essential to monitor the specific crop throughout its whole growth season for drought sensitivity. This is done by comparing significant correlation coefficients of plant water potential and plant moisture stresses with growth and yield of the crop. This requires an extensive series of data on moisture supply and corresponding growth and production values. These data can be obtained through the application of different levels of irrigation during different seasons. By applying, each season, a great number of varying levels of irrigation, sufficient information can be obtained over a few seasons.

This research at the Vaalharts Agricultural Research Station is being done in the following phases:

- Irrigation tests are being done with different crops over several seasons. These tests give for current irrigation practices an indication of the water requirements of the relevant crops. This part of the research is already in its second year. Separate tests are being done with wheat, maize, cotton and groundnuts. Irrigation is applied when evaporation from an American Class A evaporation pan attains certain levels. This technique provides for the estimation of drought-sensitive periods. The levels of the evaporation pan correspond to evapotranspiration losses of the relevant crop which bring about different levels of moisture supply. The information obtained in these experiments is of limited value since it is based on certain estimates.

- The next step is to convert each level of irrigation for each season for the relevant crop to daily values of internal plant moisture stress and plant water potential. This work has already commenced. The neutron moisture meter with which the soil moisture on plots will be determined has been calibrated for the relevant soil conditions. The computer programme which calculates moisture stress days can be controlled by taking actual soil moisture readings. Soil moisture observations are also required to determine the evapotranspiration ratio over the growth season of each crop individually, which in turn is required for the computer programme. The pressure bomb apparatus has been completed and properly tested for determining the water potential of plant material.

- The final phase of this research will consist of statistical processing of the data obtained by which the sensitivity of each crop to drought conditions over the relevant growth season can be determined. For these periods relationships between water supply on the one hand and growth and yield on the other hand are determined, so that the influence on yield of a specific irrigation regime at a specific moment can eventually be accurately determined.

Results obtained with irrigation tests during the past season show significant differences between groundnuts, cotton and maize in the vegetative growth stage. Results indicate that large differences in internal plant moisture stresses during the growth season of the relevant crops will probably also occur. Whilst significant differences were found neither in the irrigation treatment of wheat nor during the reproductive stage of maize (due to too much rain at that stage), the results are useful and can be converted to indicate moisture stresses which occurred in the two crops during the relevant season. They can also be used in determining the stages of sensitivity to droughts during growth (second phase) and in establishing relationships between moisture deficiencies and the growth and production of crops.

The probe of a neutron moisture meter with which soil moisture can be determined. This apparatus is used in determining the plant moisture stresses on the growth and production of certain agronomic crops.

Research on the soil factors affecting the optimal utilization of irrigation water in Bantu Homelands

(Existing project: Contract with the University of Fort Hare — Department of Soil Science)

A considerable portion of the agricultural products required by the Bantu homelands can be produced under irrigation and irrigation plays a very important role in view of problems associated with dry land crop production.

The availability of water supplies constitutes a limiting factor and therefore optimum utilization of irrigation water is of paramount importance to these areas. For the realization of this objective and for the continued long term productivity of irrigable soils, irrigation practice should be based on reliable scientific data. For this reason the Commission has entered into an agreement with the University of Fort Hare in terms of which the University's Department of Soil Science is investigating soil factors affecting optimal utilization of irrigation water.

Two aspects are being studied:

- Determination of the amount of water which different soils can store in available form for different crops and under different climatic conditions.

  This parameter has been called profile available water (PAW). During the year under review one of four proposed techniques for its determination has been tested for mature maize growing on a Jozini series soil at Alice. The mean value obtained for PAW from 16 determinations was 148 mm. Because of the method of determination used this is considered to be a reliable estimate of the true value of PAW under the conditions described. A comparable estimate of PAW using conventional methods of determination is between 75 and 90 mm. A higher value makes heavier, less frequent irrigation possible. If this information is applied in practice it should lead to more efficient use of irrigation water.

  The results obtained also provide evidence to support the use of visual symptoms of plant water stress for irrigation scheduling.

- Determination of important physical and chemical soil parameters in relation to irrigation and drainage.

  An important aspect of the investigation is an attempt to develop a relatively simple and reliable method of obtaining the parameters necessary to ensure efficient water application under surface irrigation. Instead of using the normal empirical approach to the problem, an attempt is being made to employ useful theoretical concepts to improve the extrapolative value of the results obtained. Field data for infiltration have been obtained on a soil of the Jozini series; for post-infiltration changes in soil-water content and potential down the profile; and for an advance/recession curve on an irrigation bed. From the literature it would seem that prediction of hydraulic conductivity and infiltration may be possible from soil water content-potential curves. A computer programme to assist with this process is being written. It is intended to test these procedures using the field measurements which have been made.

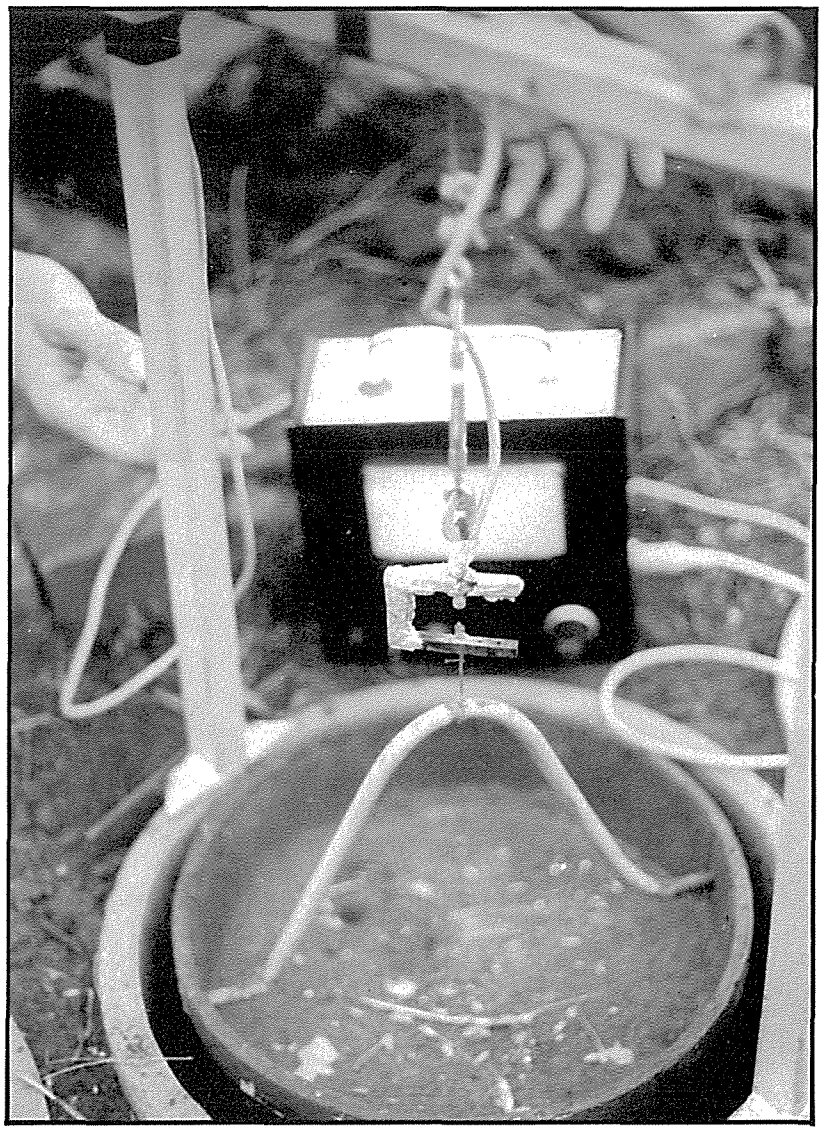
Water requirements of agronomic and vegetable crops

(Existing project: Contract with the University of Pretoria — Department of Plant Production)

The real water requirements of crops and programming of the application of water are undoubtedly the most important factors in the optimum utilization of irrigation water. In order to determine these factors accurately, extensive and continuous research is required which will include the systematic investigation of the water requirements of crops with a view to the refining of irrigation programmes, the determination of water yield functions for the crops and the simplification and testing of the practical application of the evaporation pan in the programming of irrigation.

The year under review was characterised by a number of results which indicated that factors affecting the water requirements of crops are much more complicated than has been generally accepted. Extremely sophisticated instrumentation is essential to the accurate and continuous investigation of these factors. Since such equipment is very expensive and in some cases totally unavailable, equipment which meets the specific research demands of the project is being developed, at relatively low cost, in collaboration with the Department of Electronic Engineering of the University.

An electronic weighing apparatus which has been designed for determining plantwater consumption from small lysimeters is already in use. A data collector has also been developed in which data obtained from 20 or



The electronic weighing apparatus developed by the Department of Electronic Engineering in collaboration with the Department of Plant Production of the University of Pretoria for determining plant water consumption from small lysimeters.

more sensors can be stored on a continuous basis, either directly or after integration. These data can be recalled by means of a teleprinter onto paper or fed directly into the computer for further processing.

Soil moisture abstraction in relation to free water evaporation in various agronomic and vegetable crops is already being carefully studied. Recommendations in respect of irrigation programmes, which hitherto have mainly been based on overseas results and have arbitrarily been modified for South African conditions, can already be corroborated, with small modifications, by the test results of this project.

An important facet of the project is the implementation of research results on farms. Preliminary irrigation programmes are therefore being demonstrated to farmers by means of cooperative tests at two sites near Groblersdal. Endeavours will also be made to bring home to farmers the scientific method of programming through the local farmers' study groups.

Evapotranspiration and water use studies by means of weighing lysimeters: Evapotranspiration as a function of soil, plant and atmospheric factors

(New project: Contract with the Department of Agricultural Technical Services — Soil and Irrigation Research Institute)

This project is the second in a series of projects being undertaken by the Department of Agricultural

Technical Services under the general heading: "Evapotranspiration and Water Use Studies by means of Weighing Lysimeters."

Although the first project in the series, entitled: "Lysimeter Design and Construction", has been successfully completed, the Department found that the execution of the second project was impeded by the unavailability of a suitably qualified plant physiologist and an electronics technician on a full-time basis.

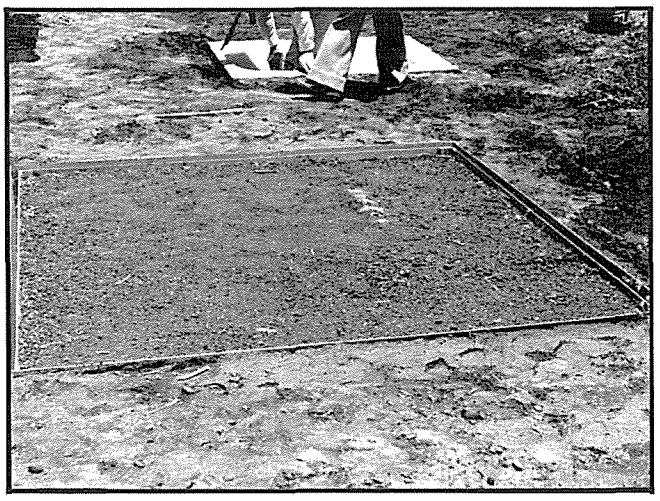
Negotiations between the Department and the Water Research Commission led to an agreement that the Commission would contract the required personnel overseas and second them to the Soils and Irrigation Research Institute.

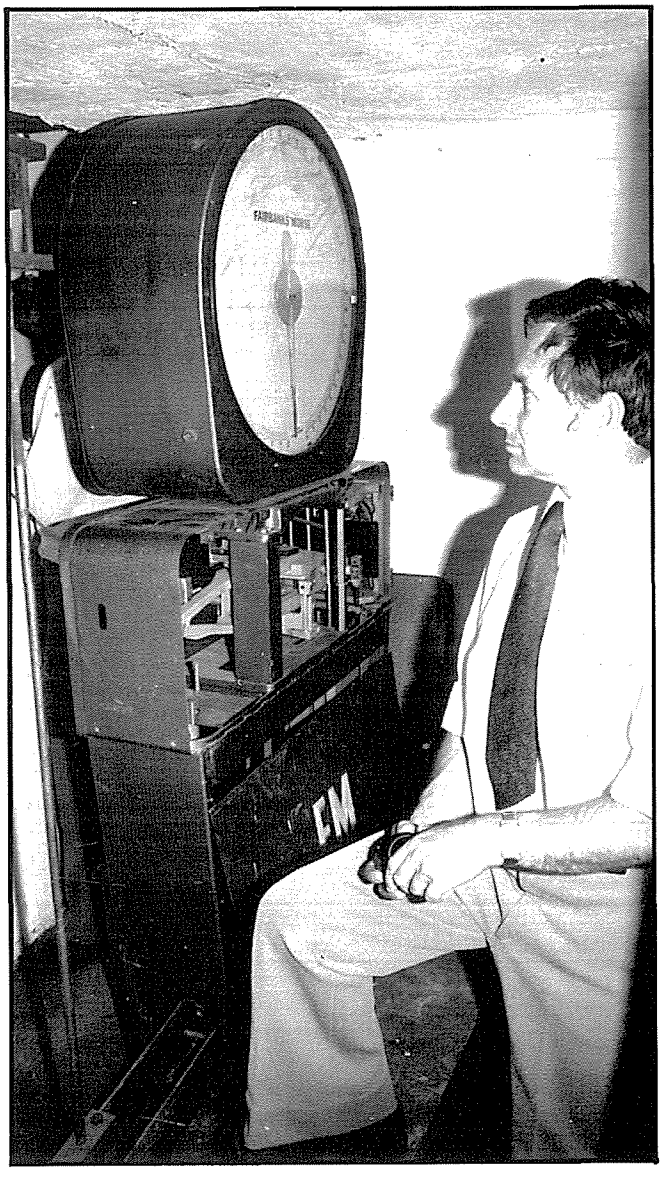
The main objective of the project is to study and predict the inter-active effects of atmospheric evaporative demand, availability of moisture in the soil, and plant control mechanisms on the rate of water transport through the soil-plant-atmosphere system.

The ability to predict actual water consumption of crops on a day-by-day basis is needed for scientific irrigation scheduling and for assessment of peak irrigation requirements for agricultural planning.

Present meteorological formulae are adequate for prediction of potential evapotranspiration, i.e. water consumed when soil moisture approaches a non-limiting condition. However, it is anticipated that situations will arise where it will not be possible, or economic, or even advisable to cater for the full evaporative demand the atmosphere imposes on a crop. If certain stresses can be tolerated without significant or disproportionate yield losses, then real water savings will be possible by restricting irrigation accordingly.

In the past estimates for irrigation requirements of crops in South Africa were based on a very limited quantity of experimentally determined consumption use





The weighing lysimeter, with its instrumentation, which is used for determining the water consumption of crops. The surface soil container appears above and at right the weighbridge of the lysimeter used by the Soils and Irrigation Research Institute is shown.

data, expressed as ratios to Class A pan evaporation. These ratios were then used to widely extrapolate irrigation requirement estimates, on the basis of Class A pan evaporation data, to other climatic areas, other irrigation frequencies, soils of different textures and different water-holding capacities, etc.

Clearly this is a very approximate approach, but the best that could be justified on the strength of current knowledge.

At this stage, two phases of study would seem to be essential:

- A continuing study of promising models reported in the literature. Models of two kinds should receive attention: those designed to test and clarify knowledge about processes in the soil-plant-atmosphere system; and those designed to give a practical means of making accurate irrigation requirement assessment of crops.

- The verification of such models by field testing and the adjustment to local needs and conditions. In the process of such testing, researchers will of necessity have to master basic techniques and methodologies of multi-disciplinary, micro-environmental studies relating to crop water relations research which to date has been somewhat neglected in South Africa.

Development of effective irrigation methods for application to steep lands, with special reference to micro-methods

(New project: Contract with the University of Stellenbosch — Department of Civil Engineering, Chair of Irrigation Engineering)

The irrigation of good quality steep lands (which occur fairly generally along the proposed canals of the Western Cape Water Project) has to be evaluated against two other uses of the canal water, *viz* urban water supply and irrigation of lower-lying, less steep and more remote lands.

Information in this regard is therefore of great importance to organizations responsible for planning and decision making.

The Commission accordingly entered into an agreement with the University of Stellenbosch in terms of which the University's Department of Civil Engineering will investigate the following aspects:

- Improving measuring equipment for the accurate measuring of water supply and application. Since the cost of water from the Western Cape Water Project will be relatively high, and excessive application on slopes of 1 : 10 to 1 : 5 can cause water-logging on lower-lying land, it is essential that the irrigation water should be applied as economically and effectively as possible, and that the application of water should be controlled as accurately as possible. Improved application techniques and scheduling methods also require that better water measuring and control in canals should be sought. Existing measuring techniques suffer from relatively high errors. It is desirable that accuracy should be improved but the cost of measuring equipment should also be taken into consideration. This investigation aims at a comparative study of known and lesser known measuring methods, with and without automation, in irrigation canals and diversions.

- Investigating the uniformity of application and soil moisture distribution in different application methods, and a critical comparison of existing and new irrigation methods on steep lands. Although sprinkle irrigation is highly adaptable, also to steep lands, it still has inherent deficiencies, *inter alia:*

  —Water losses as a result of wind conditions.

  —Difficulty of maintaining high soil moisture without excessive water losses.

  —A tendency for surface runoff on slopes to occur causing redistribution of water and therefore irregular supplementation of soil moisture.

There are indications that the different methods of micro-irrigation hold high promise for economic and effective application of water on steep lands. This facet of the project will use vegetable yield and uniformity of application as measures for comparison and will entail laboratory as well as field investigations.

The research activities will take four years and will commence in 1978.

Research on intensive freshwater fish production using the raceway system

(New project: Contract with the Transvaal Provincial Administration — Department of Nature Conservation)

In South Africa, as in many other parts of the world, the importance of the freshwater fish production of inland water bodies is being increasingly recognized,

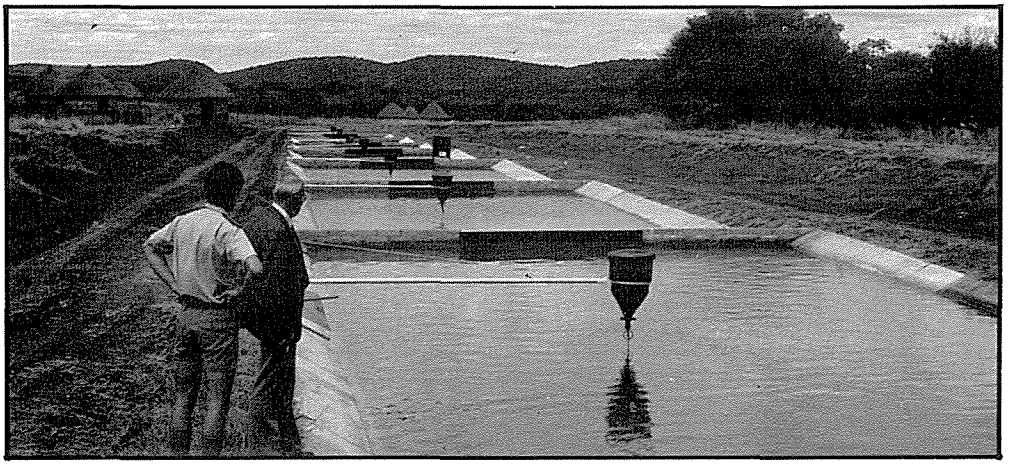
and attention is being given to determination of the fish productivity potential of some of our large dams.

In many parts of the world very high yields of fish are obtained from fish farming (i.e. in ponds designed and constructed for the purpose). However, in this country the importance of minimising evaporation and seepage losses of our limited water resources militates against any unnecessary creation of further evaporative surfaces.

Another approach is now being investigated, which embodies some elements of the more efficient approaches to fish production without the excessive creation of fresh water surfaces. This approach involves an investigation of the so-called 'raceway system' whereby canals associated with irrigation schemes can be used for intensive fish production. This exploits the fact that fish growth rates are greatly increased in moving water systems where oxygen supply is improved and where waste products are rapidly removed from the fish's environment. Thus a valuable protein by-product may become available at little extra cost and with little water loss.

In 1976 the Department of Nature Conservation of the Transvaal Provincial Administration constructed an experimental raceway at the Lowveld Fisheries Research Station at Marble Hall, Eastern Transvaal, with the assistance of a grant from the Water Research Commission, and the Commission is now providing financial assistance for an initial three year research programme which is designed to assess growth rates and yields obtainable in such systems. The experimental unit consists of a series of seven canal segments, each segment being 21 metres long, 8,6 metres wide and 0,95 metres deep. Each segment received an initial charge of 2 000 carp fingerlings.

The results of the first season's trials were encouraging, and the second series was commenced in September.



A view of the experimental raceway system at the Lowveld Fisheries Research Station at Marble Hall in the Eastern Transvaal which is used to determine the fish production potential of this type of system. The food containers visible above the water surfaces constitute a self-feeder system.

Chapter 10

Surface hydrology

Since the Republic is dependent upon river flow for 90 per cent of its water consumption, and only 8,1 per cent of the already low mean annual rainfall is converted into runoff*, the Commission is paying special attention to research on surface hydrology.

Owing to the nature and inconsistency of rainfall in South Africa the rivers are very unstable, ranging from very low flow values to disastrous floods, and mean annual flow rates exhibit great extremes. It is therefore extremely difficult to venture predictions and it is of the greatest importance continuously to obtain as many hydrological data as possible with regard to river flow by means of direct measurements, in order to be able to study statistically the basic relationships between rainfall and surface runoff.

Large-scale collection of stream flow data is an extensive and costly task, which thus rightly belongs with a government organization which has the means and the manpower at its disposal. Indeed, this function is undertaken mainly by the Department of Water Affairs with additional observations at research stations by the Department of Forestry. Valuable data are being obtained and processed, on a continuous basis, and used by the Department of Water Affairs in the planning, design and management of water schemes.

In terms of its terms of reference, as contained in the Water Research Act, the Commission is involved only with the research aspects of hydrology and it endeavours to promote hydrological research by means of research contracts with universities and other organizations.

The objective is the development of new theories and techniques for predicting the behaviour of the country's lifestreams and for determinating the potential of available water resources. In this way the Commission endeavours to supplement the work already being done by Government Departments.

*Report of the Commission of Enquiry into Water Matters, p. 40 (RP34/1970)

In this regard contracts already exist with the Universities of Natal (Department of Agricultural Engineering), Zululand (Department of Geography) and Rhodes (Department of Geography), dealing with rainfall-runoff ratios in small catchments under varying climatic, geographic, topographic and soil utilization conditions.

An important project on the development of the runhydrograph concept by processing historic flow data is being undertaken for the Commission by the Civil Engineering Department of the University of Natal. Stream flow data collected by the Department of Water Affairs are intensively used in this project. It is expected that this project will lead to the development of a run-hydrograph manual which will be of great value to engineers in hydraulic planning and design.

By financially supporting the Hydrological Research Unit of the University of the Witwatersrand the Commission gains access to a research group with considerable expertise in engineering hydrology and this unit is undertaking several projects of direct importance to the Commission. The Commission also makes wide use of the advisory service of this unit.

By supporting hydrological research at universities the Commission has not only created centres of expertise which generate research results and new knowledge, but has also stimulated the interest of post-graduate students, which will hopefully lead to more trained hydrologists becoming available to serve the country.

As mentioned in Chapter 1, the Commission has, as far as the coordination of hydrological research is concerned, progressed well in establishing a high-level Coordinating Research Committee for the Hydrological Cycle (CRCHC). This Committee will start its activities early in the new year and will be operated by the Department of Water Affairs with representation from the Department of Water Affairs, Forestry, Agricultural

Technical Services and of Transport, the CSIR and the Commission. The terms of reference of the CRCHC are that it will concentrate on policy aspects, in terms of the country's requirements, and broad principles of the co-ordination of research regarding the hydrological cycle in South Africa.

It will progressively transfer the detailed in-depth coordination to Coordinating Research and Development Committees.

Further particulars about the abovementioned projects are given below.

RESEARCH PROJECTS

Financial support for hydrological research

(Existing project: Financial support of the Hydrological Research Unit of the University of the Witwatersrand)

The Hydrological Research Unit (HRU) at the University of the Witwatersrand has been in existence since 1959. Initially the Unit was an informal research group which enjoyed the financial support of the civil engineering profession through the S A Institute of Civil Engineers. In 1970 it became a formal research unit which was supported financially by the CSIR. Since 1973 the Water Research Commission (WRC) has also been contributing in terms of an agreement that the Unit will undertake, when required, investigations on behalf of the Commission.

During 1976 the University Council decided that the HRU would become a research unit of the University Council as from 1 January 1977. Under the new dispensation the Unit is controlled by a Control Board to be appointed by the University. Representatives of the CSIR, the Department of Water Affairs and the WRC serve on this board. Furthermore the University Council approached the CSIR and the WRC for financial support, in the form of a basic grant, for the operation of the Unit.

The CSIR decided that it would make an annual contribution for a period of three years, after which the grant would be reconsidered. The WRC's support consists of an annual contribution which is made on a rand-for-rand basis in respect of the total annual contribution of the University Council and the CSIR. This contribution of the WRC is forwarded to the Unit through the CSIR.

The applied and basic hydrological research being done by the Unit is of great value to the Department of Water Affairs, the WRC and practising engineers. Data with regard to water resources and their potential and predictions of daily, monthly and annual stream flow, flood occurrences and flood peaks, and rainfall-runoff relationships play an important role in engineering planning and the design of water structures, and also in pollution control. The development of mathematical models and synthetic hydrographs, according to which the behaviour of river systems can be predicted, and the application of systems analyses for optimal water utilization are also of great importance.

Since both the Department of Water Affairs and the WRC are represented on the Control Board, close cooperation can be maintained between the Hydrology Division of the Department of Water Affairs and the Unit. In this way unnecessary duplication of research can be avoided.

In addition to the grant by the WRC mentioned above, two research agreements were also entered into by the Unit and WRC during 1977. (This chapter contains a report on water resource studies whilst the other project, namely flood occurrences, is reported on in Chapter 11).

Development of the concept of the runhydrograph in the analysis of flood hydrographs

(Existing project: Contract with the University of Natal — Department of Civil Engineering).

The runhydrograph is a concept based on the mathematical and statistical processing of existing hydrographs. These hydrographs may make it possible to identify important parameters in the runhydrograph for gauged catchments and to develop synthetic runhydrographs for ungauged catchments. Results generated during research by the Department of Civil Engineering of the University of Natal could be useful to civil engineers and those concerned with floods.

The processing of instantaneous continuous streamflow records and the capturing of these records on magnetic tape ready for computer analysis progressed steadily during 1977. These streamflow records form the basis for the development and regionalization of the concept of the runhydrograph.

The records at 226 stations were processed and captured on magnetic tape. Record lengths varied from approximately 10 years to 60 years, giving a total of approximately 5 000 years of continuous record at present on magnetic tape. These records are also very useful as a data bank for the Department of Water

Affairs, for direct analysis in reservoir design and reservoir operations and for numerous research investigations apart from the runhydrograph concept.

Excellent cooperation from the Department of Water Affairs was again enjoyed during this year. The Department kindly allowed five of their employees to work full time on this project.

The concept of the runhydrograph allows the extraction of whole families of hydrographs with the same return period, at the same time providing information on both the peak flow rates and total volumes of runoff. The three parameter Pearson Type III function is used to describe the shapes of the hydrographs and the parameters for this function can hopefully be regionalized over the Republic of South Africa.

Before the regionalization of parameters is attempted, the streamflow records are tested for errors and for consistency and homogeneity. It seems, at present, as if about half of the available records should be rejected because of human interference with the river flows. This should then leave about 130 good streamflow stations as basis for the regionalization.

Analyses of the first riverflow records are promising and a final report is expected early in 1979.

Research on water resources

(New project: Contract with the University of the Witwatersrand Hydrological Research Unit)

Water resources appraisal is one of the fields requiring urgent research attention. Many facets of water research require a background of stream flow history, or of stream behaviour prediction or of interplay of complex water supply and demand systems against which to interpret results. Simulation of the behaviour of a system in relation to any change that may be envisaged is a highly desirable means of evaluating the effects of that change.

The watershed models developed in the Hydrological Research Unit have been tested against the Stanford Watershed Model with data from the highly instrumented Jukskei catchment and found to compare very favourably. Nevertheless continued efforts are being made to improve the models.

Parameters of the model have been evaluated for many gauged catchments in various parts of the country, and hydrology has been generated for ungauged sites in a large number of catchments. This work will continue because of the continual demands for this type of information. The models are continuously being perfected through use and parameters evaluated for widely varying regions.

When a sufficiently large part of the country has been covered, the work of systematizing parameter evaluation will recommence, i.e. correlation with observable catchment characteristics.

Hydrology generated by the watershed models provides basic input to a wide range of other research projects and studies, e.g. the Pretoria-Witwatersrand-Vereeniging complex, flood studies, flood plain management, trends in land-use, apportionment of water rights, determination of storage requirements, reservoir operation, pollution abatement, hydrobiology, limnology, spillway design, etc.

Hydrological investigations of small catchments

It is estimated that the annual runoff of rivers in the Republic constitutes some 8,1 per cent of the mean annual rainfall. Approximately 90 per cent of the country's water consumption is derived from river flow and it is therefore vitally important to study the relationship between rainfall and runoff more intensively.

Mathematical simulation models, based on data collected by the Departments of Water Affairs and Forestry, have been developed for the prediction of river flow in large catchments. These models have to be modified and refined to be applicable to small catchments.

In an effort to achieve this objective the Commission has contracted three universities, *viz* Natal, Zululand and Rhodes, to study smaller catchments varying in mean rainfall, vegetation, land utilization, soil type, topography and geology.

Investigations in the Grahamstown area

(Existing project: Contract with Rhodes University — Department of Geography)

The completion in 1976 of the instrument network for gauging rainfall, runoff and evaporation data in the Ecca Catchment has resulted in more emphasis being placed during 1977 on the development and refinement of digital simulation models.

The flow in the river channels has been monitored

continuously since March 1976 and these data have provided the basis for calibrating and testing four hourly models and three daily models in each of the five study catchments. Research on the models has been geared towards

- identifying and correcting inadequacies in model structure under semi-arid small catchment conditions
- comparing the performance of the models in the light of their various complexities
- examining the feasibility of transferring model parameter values from the gauged to the ungauged catchments.

The selected models contain a variety of uses, a variety of time intervals for input data, a variety of complexities of model structure, and the use of a variety of infiltration functions. Many modifications to the models have been made with the aim of improving their general applicability so that they can be used in either large or small catchments under a variety of hydrological environments. It is envisaged that research on the selected models will be completed early in 1978 and that the final report on the project will be completed towards the end of 1978.

The establishment of the research catchment near Grahamstown and the work being done on the project have provided a strong incentive to the students in the Department of Geography to specialize in Hydrology. Increasing numbers of post-graduate students are making use of the data measured in the catchment for their research in various aspects of hydrology.

Investigations in the Natal midlands

(Existing project: Contract with the University of Natal – Department of Agricultural Engineering)

The hydrological network of the Cedara Catchments, consisting of five streamflow gauging structures and thirteen recording raingauges and including a first order meteorological station, has been fully operational for over a season now. At the De Hoek and Thabamhlope Research Stations near Estcourt recordings are being made at seven weirs and with six autographic raingauges.

In the first year of the project very few interesting hydrological events occurred within the Cedara Catchments. However, historic data from the De Hoek and Thambamhlope catchments have been digitised and analysed. Using these data, research has been carried out on the moderation of flood waters by marshes and vleis, on the effects of slope and aspect on the water balance, on the kinetic energy of rainfall as it affects erosion, and on rainfall intensity-duration-frequency relationships.

Current research is focusing on developing a computor model suitable for simulation of floods in small rural catchments. The model is based on physical characteristics like topography, soils and various land uses, information on which will be easily obtainable by, for instance, a dam designer. Existing simulation models of water yield and floods have also been modified for use in small catchments.

An important research project has been completed for Natal on probable maximum rains falling in one day, two days and seven days for return periods of 10, 25, 50 and 100 years. This information will be useful in the design of structures in medium to large catchments in Natal.

Investigations in the Natal coastal area

(Existing project: Contract with the University of Zululand – Department of Geography)

The construction of five measuring structures and two cableways for a stream flow velocity meter to determine the runoff of the Ntuze River has been completed. Rainfall and evaporation over the whole of the study area are measured by means of 13 autographic rain gauges, 22 standard rain gauges and 5 A-evaporation pans. Other climatological data are collected at a weather station at the University. These data are digitised and used as model inputs.

Colour aerial photographs on a scale of 1 : 10 000 have been obtained and used in the preparation of surveys of soil utilization, vegetation, geology and soils. A detailed map of slopes has also been prepared.

The research programme is aimed at developing the prediction model in such a way that it will be practically applicable, reasonably economical in determining parameters and able to calculate rapidly. To be of practical use, such a model theoretically has to produce the following:

- Syntheses of long term records for the catchment
- Extrapolation of similar catchments in the same representative area
- Extrapolation to catchments with different combinations of geology, geomorphology, soils and vegetation
- Prediction of the effect of soil utilization changes which fall within the ambit of the studied soil utilization pattern.

A weir in the Mtunzini catchment being used for studying runoff in small catchments.

The monthly and daily Pitman models developed by the Hydrological Research Unit of the University of the Witwatersrand are used as a basis for the study. However, these models pose problems when they are applied to small catchments and attention is given especially to the following parameters:

- Geology and soils
- Soil moisture, groundwater and groundwater movement
- Soil utilization
- Geomorphological parameters such as the compaction coefficient, drainage density, form factor, average slope, relief relationship, stream flow rates, etc.

Chapter 11

Flood occurrences and flood damage

Floods which cause extensive damage occur fairly generally in South Africa. Data of the Department of Water Affairs show that floods which cause large scale damage in various parts of the country can be expected to occur on average once every two years. In addition to damage to irrigation lands and crops which are situated in the flood plains of rivers, communication and transport connections are also affected. Furthermore it is a general phenomenon that cities and towns, with associated industrial development, occur in the flood plains. The tendency to change to more lucrative perennial crops in irrigation farming and the increasing value of residential areas and industrial plants also have the result that monetary implications of floods will be higher in future.

Against this background it is clear that data on flood damage can be important in planning development along rivers and streams. The possibility and economic justification of preventive measures for limiting flood damages, as well as of emergency relief measures where flood damage has in fact occurred, constitute one facet of this problem. A second but probably equally important facet is the direct effects of damage to installations and the general disruption of essential services. In order, therefore, to ensure that flood plains are planned on a realistic basis, it is essential that reliable information should be available on the possible extent of flood damage and its impact.

In South Africa in the past reliance was placed on sporadic and incomplete estimates of direct flood damage while almost no information was available on indirect and non-tangible flood damage. Overseas information in this regard is of little value since, apart from the fact that the nature and extent of agricultural, urban and industrial development in those flood plains differ widely from the South African, deficiencies exist in the methodology of data collection which cause doubt to be cast on the applicability under South African conditions of damage prediction models developed overseas.

This state of affairs had the result that the Department of Water Affairs, in 1974, after the flood events of that year, requested the Water Research Commission to initiate a research project with, amongst others, the following objectives:

- Development of a survey methodology which could serve in future as a model for similar surveys
- Identification of different categories of flood damage
- Determination of the relationship between the depth and duration of a flood and the resultant damage
- Investigation of the extent to which expenditure of flood protection works is justified by the advantages of works of this nature.

Negotiations with the Universities of Stellenbosch and the Orange Free State led to agreements with the Bureau for Economic Research (BER) of the University of Stellenbosch and the Institute for Social and Economic Research (ISER) of the University of the Orange Free State in terms of which they would undertake research on the flood damage resulting from the floods of 1974. As a result of the extent of the 1974 floods a geographic division in respect of the river stretches to be investigated by each of the two universities, was agreed to.

This research has now reached the stage where

some of the results are available in the form of reports. The extent of the investigation will result in the final report consisting of four parts, namely:

- Part I: A methodology for determining flood damage — compiled jointly by the BER and ISER
- Part II: Findings with regard to flood damage in three river valleys in the North Western and Eastern Cape Province — compiled by the BER
- Part III: Findings with regard to the 1974 flood damages for different river stretches of the Orange, Vaal, Riet, Seekoei en Hartbees Rivers — compiled by the ISER
- Part IV: An evaluation of the problems surrounding flood damage determination in the Republic of South Africa — compiled jointly by the BER and ISER.

Parts I and II have already appeared whilst Parts III and IV will be published in the course of 1978.

During 1977 the agreement with the ISER was extended to provide for an investigation of the flood damage as a result of the 1975 flood in the Vaal River. The main motivation for this extension has been the fact that the physical characteristics of floods in the Vaal River differ greatly from those in other rivers and that other types of damage, including residential damage, occur along the Vaal River. Extending the investigation will therefore greatly improve the reliability of mathematical models.

An agreement has also been entered into with the Hydrological Research Unit of the University of the Witwatersrand for research on flood occurrences. This research is aimed at developing a procedure whereby a flood can be routed through a river system in such a manner that downstream damage is limited to a minimum. The flood damage models developed by the BER and ISER will play an important role in this investigation.

RESEARCH PROJECTS

Research on flood occurrences

(New project: Contract with the University of the Witwatersrand — Hydrological Research Unit)

The objective of this project is, briefly, to provide the facilities for routing the runoff resulting from significant precipitation on a catchment through the river system and reservoirs, and through the downstream flood plain, in such a way as to minimize damage. The runoff will be predicted by means of models requiring raingauge-observed or radar-monitored precipitation data. Telemetered raingauge observations will also be used as soon as the system has been perfected by the Department of Water Affairs. These routing facilities will be of significant value for purposes of planning, design and management in the catchment, at the dam and in the flood plain.

At this stage a model has been developed for generating the hydrograph of flood inflow to Vaal Dam, given the rainfall reported at sampling stations in the catchment, supplemented by weather reports for the next day. By means of the model the anticipated flood hydrograph can be routed through the reservoir, and pre-releases optimized to accord with predetermined criteria.

Another component of the study will comprise economic analyses to determine the extent to which monitoring systems, sophisticated reservoir control systems, flood plain protection works, flood-proofing of facilities on the flood plain, and other measures (including further research effort) can be warranted in specific circumstances. This work has started and models are being generalized to facilitate application in any region or flood circumstances. This research will be complementary to extensive studies already being done and applied in practice by the Department of Water Affairs.

In the execution of this research collaboration between the Hydrological Research Unit, the Division of Hydrology of the Department of Water Affairs and the National Institute for Telecommunications Research is maintained, especially regarding the development of techniques for real-time linking of the weather-radar output directly to the catchment, flood routing and release optimization models.

Research on flood damage

(Existing project: Contracts with the University of the Orange Free State — Institute for Social and Economic Research; and the University of Stellenbosch — Bureau for Economic Research)

Institute for Social and Economic Research (ISER)

The ISER is responsible for research in respect of certain stretches in the Orange River, Vaal River and the Karoo. All relevant information with regard to the flood

damage of 1974 has been collected and its processing and evaluation has almost been completed. The first phase, which deals with the methodology of determining flood damage, has been completed.

From the analyses thus far certain broad relationships between flood damage and certain flood parameters such as depth and duration have been found. It is clear, however that knowledge of a broader spectrum of town and/or urban damage is required to compile, for example, a useful residential model for determining future flood damage. Lack of pertinent hydrological data has had the result that progress has not extended much further than the two parameters mentioned.

Research in the Vaal River has commenced and at this stage it is already clear that the extension of research on this river will bring about a more complete coverage of damage categories than was found in the Orange River and other stretches during the 1974 flood. Apart from providing considerable additional data with a view to expanding the residential model, this will also afford an opportunity to investigate the aspect of indirect damage in more detail. Damage to business undertakings, which occurred only sporadically during the first phase of the research, will be better clarified during this investigation.

Apart from the fact that the Vaal River is of national importance, the extension of research there will enable insight into a wider spectrum of the flood damage problem in South Africa to be obtained and attention to be given to refining the techniques used to date.

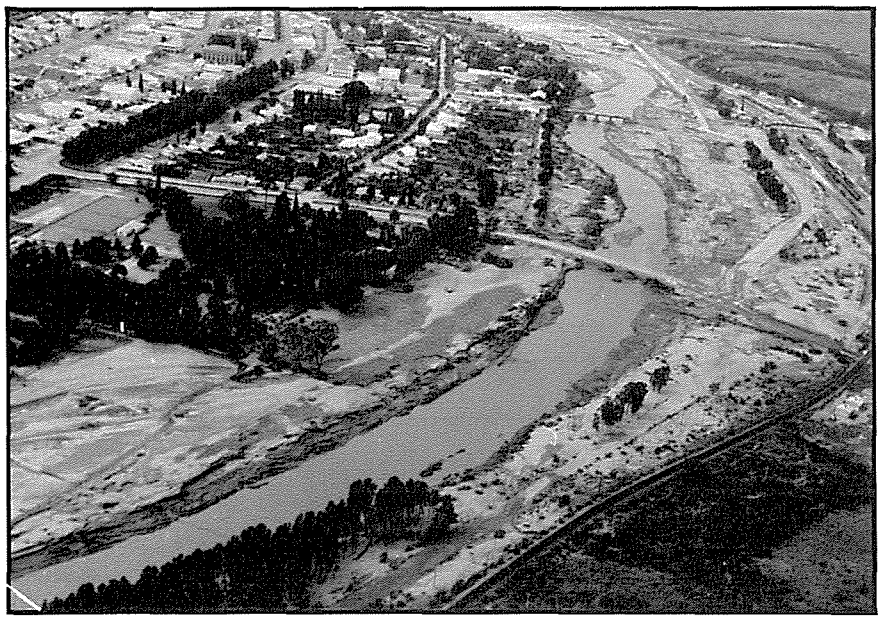
The Bureau for Economic Research (BER)

In 1975 the Bureau for Economic Research, University of Stellenbosch, commenced an investigation into the economic impact of the 1974 floods in the Sak River, Great Fish River and Sundays River valleys. This investigation has now been completed and a few of the most important findings are briefly discussed below.

In the North Western Cape Province the area of investigation stretched along the Sak River over a distance of approximately 470 kilometers from the Sak River Poort in the Nuweveld Mountains to Rooiberg Dam just south of Kenhardt. The total calculated flood damage in this area amounted to R1 496 323. The major part of these damages, i.e. approximately 73 per cent, could be ascribed to damage to fixed improvements with the exception of buildings. This category included wire fences and cattle drinking troughs, but consisted mainly of damage to weirs in the river, irrigation canals, etc. The mean flood damage per kilometre of river was R3 192,16 for the Sak River as a whole, but varied from R430,75 per kilometre in the area north of Brandvlei to R5 134,37 per kilometre for the area between Brandvlei and Williston.

Two river valleys in the Eastern Cape Province were investigated namely the Great Fish River and Sundays River valleys. Approximately 949 kilometres of river stretches of the Little and Great Brak River, Little Fish River and the Koonap River were included in the Great Fish River valley. Total calculated flood damage for all the stretches in the Great Fish River valley amounted to R9 967 896. This figure does not include certain indirect losses which could not be determined exclusively, and also excludes certain non-tangibles such as loss of life and damage to cultural-historical structures. The 1974 floods also caused considerable disruption in the transport and power network of the Eastern Cape Province. In Cradock several houses of cultural-historic value were destroyed. The calculated flood damage in Cradock amounted to R3 062 640 and in Middelburg (CP) to R194 247.

One of the largest single categories of damage in the Great Fish River valley was losses to buildings which



Cradock from the air shortly after the town had been struck by a flood. Cradock is situated in one of the river stretches involved in a study of the flood damage which occurred during 1974.

amounted to R2 076 574 and constituted approximately 21 per cent of all damages. Losses in soil and crops constituted approximately 28 per cent of all losses, and losses in fixed improvements, excepting buildings, approximately 42 per cent. The mean flood damage per kilometre of river for the rural area along the Great Fish River and along the tributaries of the Great Fish River amounted to R7 069,80 (excluding flood damage in Cradock and Middelburg).

In the Sundays River valley approximately 507 kilometres of the Gats and Sundays River were involved in the investigation. Total calculated flood damage for 1974 amounted to R1 946 351 and 3 people died in the flood waters. Losses in soil and crops constituted approximately 37 per cent of these losses, and losses in fixed improvements, excluding buildings, (mainly irrigation works) about 44 per cent. The mean flood damage per kilometre stood at R3 838,96 for the areas of investigation in the Sundays River.

Indirect losses included in the calculations in all the areas of investigation mainly comprised losses in income, hardship and first aid. Indirect losses as a percentage of total losses amounted to approximately 1 per cent in the Sak River valley, approximately 6 per cent in the Great Fish River valley and approximately 13 per cent in the Sundays River valley. These figures do not include an allocation for the disruption of power and transport networks mentioned above.

Chapter 12

Rainfall stimulation

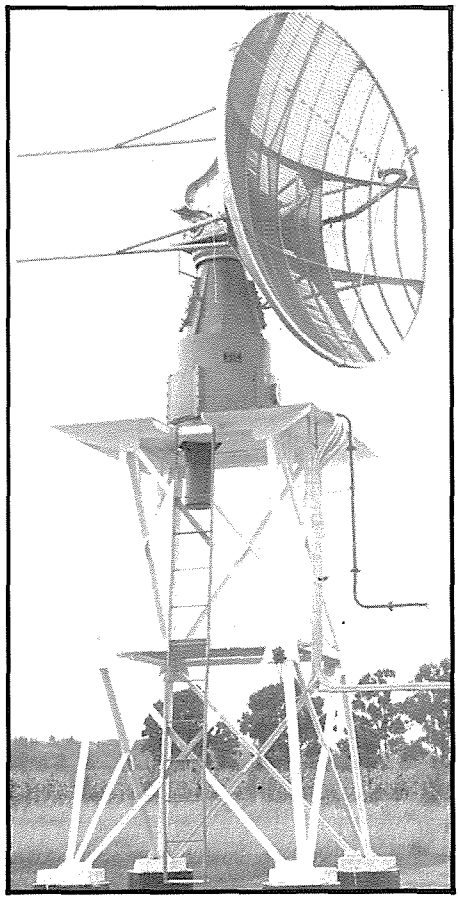
In a country like South Africa with a relatively low, inconsistent and poorly distributed rainfall it is essential that attention should be given to scientific research on the stimulation of rainfall. It is even more necessary in the light of indications that South Africa will have to cope with a water shortage by the end of this century.

Although over the past two decades in countries such as the USA, Israel, Australia and also behind the Iron Curtain, research on rainfall stimulation has been done and the basic principles are well known, it is essential that research should be done locally since it is difficult to transfer research results from one geographic area to another. Furthermore, research of this nature cannot be completed rapidly because of the amount of data to be collected and the in-depth studies to be undertaken with regard to local weather conditions and meteorological variables.

Against this background the Commission in 1976 undertook in terms of an agreement with the Department of Transport to provide specialist staff to the Weather Bureau for a research project on rainfall stimulation. During the year under review the Commission has also decided to support research on the effect of the hail suppression project at Nelspruit on the rainfall pattern of the area with a view to determining the potential for rainfall stimulation in the area.

Apart from the artificial stimulation of rainfall the abstraction of moisture from the atmosphere can also directly be done by means of hygroscopic materials. In this regard the Commission decided a few years ago to finance a project by the Chemical Engineering Department, University of Pretoria, to establish if this was technically and economically feasible.

As mentioned in the previous annual report, the project was completed and the technical feasibility of moisture abstraction clearly proved. However, at this stage it is not economically profitable nor justifiable to have large scale work undertaken. A final report on the project was completed during the year under review and the findings will be summarised in an article intended for publication.



The radar antenna of the weather modification station at Bethlehem forms an important part of the equipment used by the Weather Bureau in studying the artificial stimulation of rainfall.

RESEARCH PROJECT

Research on the artificial stimulation of rainfall at Bethlehem

(Existing project: Contract with the Department of Transport — Weather Bureau)

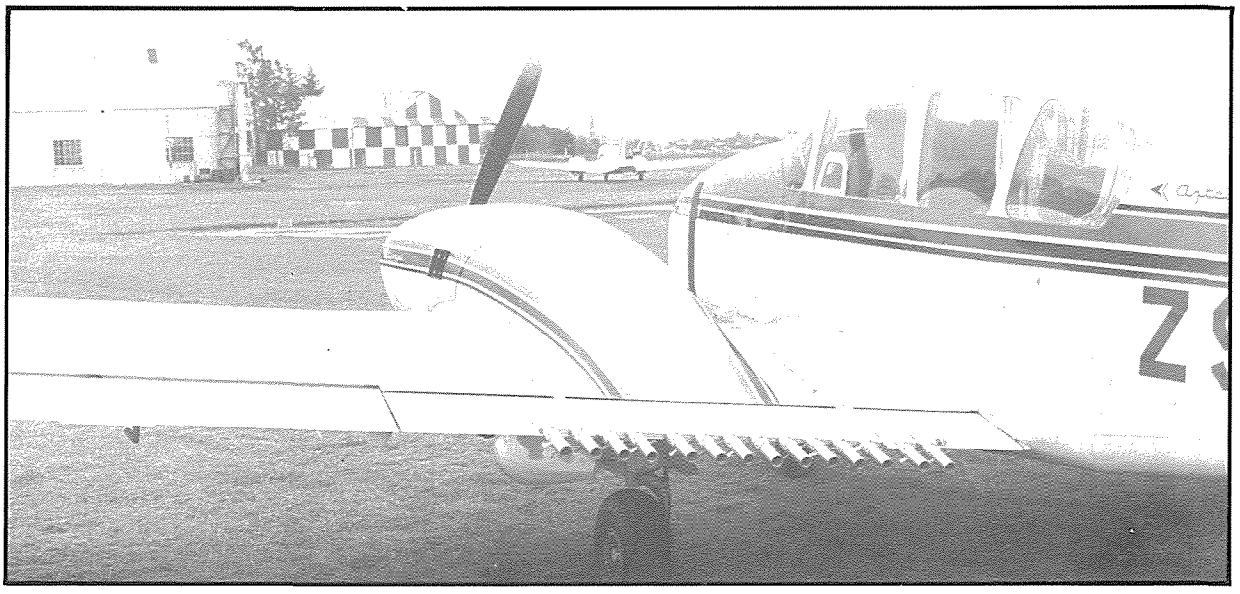
As indicated above it has been deemed necessary that research on rainfall stimulation, the results of which can hardly be projected from one country to another, should be undertaken in South Africa.

Following upon negotiations between the Department of Transport (under which the Weather Bureau falls) and the Commission it was decided that the latter would recruit expert staff for secondment to the Weather Bureau. The Weather Bureau, which in the meantime had built up a sound infrastructure of equipment and facilities, would take the lead in the execution of a weather modification project at Bethlehem in the Orange Free State. This area was chosen mainly because it is situated in the catchment of the most important reservoir in the Republic — the Vaal Dam. A successful increase in rainfall in this area would obviously be of the greatest national importance. The project commenced late 1976 and in February and March of the year under review the team spent approximately six weeks in Bethlehem to acquaint themselves with equipment and procedures. This period was regarded as training and not as part of the data collection campaign.

The period from April to September was dedicated to detailed planning of future field activities and analysing data which had been collected earlier but had not yet been processed. Attention was also given to expanding and supplementing the rain gauge network in the project area. The advent of the rainy season in October saw 252 active observers already involved in measuring precipitation. Procedures were also designed for recording rainfall data in such a way that later processing would be facilitated. Historic rainfall data for the past 15 years have been recorded on magnetic tape to allow statistical analyses to be done.

One of the analyses proposed is to determine which percentages of the annual precipitation occur in the form of country-wide rain, scattered showers and single showers, and also whether these percentages vary in so-called good or unfavourable years of rain. The results of such an investigation could indicate whether it would be profitable to devote more attention to one or more specific types of weather conditions than to others with a view to potential advantages of increasing precipitation by means of cloud seeding.

During the year project staff have addressed meetings of several farmers' associations and agricultural unions to explain the aims of the project. In general a very favourable reaction has been observed in the farming community.



In doing research on rainfall stimulation the Weather Bureau inter alia uses this type of aircraft. The tubes through which cloud seeding is done are clearly discernable on the wing.

Chapter 13

Desalination

The important role of desalination in South Africa's future water economy is being accorded one of the highest priorities by the Commission. A Master Plan for desalination research was prepared by a specialist consultant to the Commission in 1975, and this plan was subsequently endorsed by the relevant Coordinating Research and Development Committee in 1976. In this plan the main emphasis is directed at ion exchange and membrane processes such as reverse osmosis and ultrafiltration.

Research on the ion exchange process commenced several years ago with the WAT process for desalination of seawater and was undertaken by the CSIR's National Institute for Water Research (NIWR) under contract to the Commission. This project has been completed and the final report has been accepted. Several novel aspects of scientific and practical interest arising from this project are to appear in a number of scientific publications.

The experience and knowledge gained in the WAT process, has made it possible to review known ion exchange processes, and to suggest a new system for the simultaneous removal of dissolved inorganic salts and residual organic materials from waste waters.

The Commission has consequently sponsored research at the University of Cape Town in collaboration with the NIWR, on these suggestions. The work has already progressed to the construction and operation of a laboratory pilot plant. This plant has met expectations and is now being optimised using purified mineralised sewage water from various sewage works in the Cape Peninsula which are receiving large quantities of industrial effluents. It is the object to erect a pilot plant, probably at the Athlone sewage works. In this investigation special attention will be paid to the simultaneous removal of both dissolved organic and inorganic substances.

A further avenue of ion exchange research that is being explored is the use of special ion exchange resins capable of being regenerated by hot water available from, say, waste heat sources instead of chemical solutions which may increase the mineral salt concentration in the waste water. This process has been developed in Australia and has been tested on a pilot plant stage in Australia and Japan. A scientist of the NIWR will be going to Australia, at the Commission's expense, to acquaint himself thoroughly with the process, for the purpose of making appropriate recommendations as to the development of a research and development programme in South Africa in collaboration with the Australian experts.

The application of membrane processes has concentrated on two avenues, the first being the direct application of commercial reverse osmosis units to the desalination of brackish waters, purified sewage waters, seawater and industrial effluents and the second avenue being a study of improvements in the production of membranes and membrane supports.

Studies on the desalination of brack ground water at Vetkuil, Beaufort West, using commercial reverse osmosis have been successfully completed by the NIWR. To transfer this technology to similar situations of brack water in South Africa, a manual is being prepared by the NIWR defining the criteria for selection of suitable membranes, and modes of operation that should be selected for any particular water being considered. This manual will be made available to planners, engineers, local, provincial and state authorities, and the farming community.

The application of reverse osmosis and ultrafiltration to the further treatment of purified sewage water is being conducted by the NIWR on both purified domestic and purified mineralised industrial waste waters. Similar work is being done on the treatment of

effluents from the textile industry with the specific purpose of establishing the possibility of recovery and reuse of process chemicals and thereby reducing the pollution load of the final effluent from the industry. Particular attention is being paid to the problems of fouling and renovation of used membranes.

In studying the desalination of seawater it has been ascertained that although the distillation process is well established, its energy requirements are high. Desalination by reverse osmosis uses less energy and has reached the stage of commercial exploitation. In providing for the expected increase in demand for fresh water by the Central Namib State Water Scheme, the Department of Water Affairs (S.W.A. Branch) has therefore decided to erect a pilot plant, based on the reverse osmosis process and with a capacity of 300 kl/d, at Swakopmund. The Commission, the Department of Water Affairs (S.W.A. Branch) and the CSIR entered into a tripartite agreement whereby the Department of Water Affairs has undertaken to construct and operate the desalination facility whilst the NIWR of the CSIR will provide the necessary scientific component.

An in-depth study of the effects of efficient pretreatment of the seawater and the type of commercial membrane systems selected on the technical and economic feasibility of the process will be made.

Basic research on the development of new improved reverse osmosis and ultrafiltration membranes by the NIWR and Stellenbosch University under contract to the Commission has progressed well and it is now possible to commence the construction of large test membranes and their membrane supports for further evaluation.

RESEARCH PROJECTS

Treatment of waste water by ion exchange

(Existing project: Contract with the University of Cape Town — Chemical Engineering Department)

The ion exchange investigation is aimed at establishing a process which will simultaneously remove inorganic salts and residual organic material from purified mineralised sewage plant discharges. This could possibly result in a complete tertiary treatment in which, in addition to the above substances, undesirable nutrient chemicals, toxic heavy metals and organic colour bodies will also be removed.

Initial laboratory tests in which the ion exchange reactions were studied in detail have shown that the overall process is feasible, and a laboratory pilot plant was constructed and tested. The laboratory pilot plant consists of five ion exchange columns capable of treating 5 000 litres of effluent per day.

Initial tests on the pilot plant were conducted with tap water and were used to establish the hydraulic stability of the interlinked five-column system and to distinguish the parameters which had to be monitored for adequate control purposes.

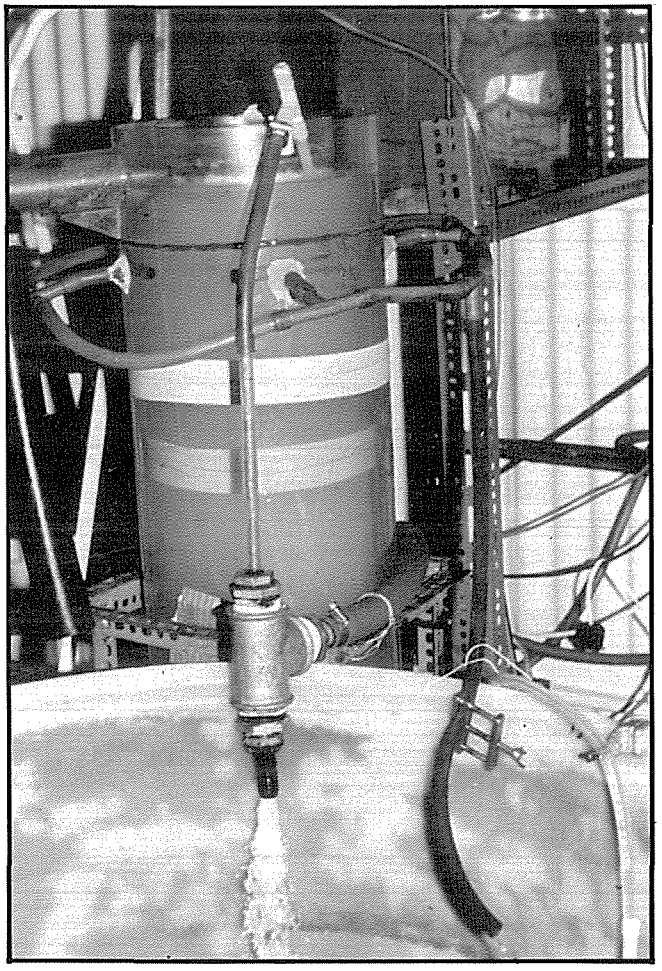
Following the hydraulic test period, chemical tests using a synthetic feed solution were conducted. The ion exchange reactions in each column were observed, and the desalination and regeneration levels of the feed water and resin were established. These tests demonstrated the simultaneous hydraulic and chemical stability of the system. Desalination levels of greater than 90 per cent were attained and regenerant chemicals were recovered at purities of better than 90 per cent. The plant was able to effect a 20-fold concentration of the salts present in the synthetic feed solution, enabling a concentrated waste brine stream to be discharged whilst recovering 87 per cent of the feed water as high quality product.

The next series of test conducted in the laboratory pilot plant dealt with the ability of the plant to desalinate a mineralised domestic sewage effluent and demonstrated that the process can give complete tertiary treatment. The organic and salt levels of the product water were comparable to tap water, whilst the total water recovery of the plant was increased to 92 per cent. The waste brine stream containing the organic material and salts originally present in the feed represented 6 per cent of the effluent leaving the plant. The third stream contains the regenerant chemicals at a purity of better than 90 per cent.

Further tests on the laboratory pilot plant will be conducted on Athlone sewage plant water (see also project on reclamation of water at Athlone Sewage Works, Chapter 4), and will include optimisation of the ion exchange system with a view to achieving high water recoveries and high waste and regenerant stream concentrations. The results will be used to determine the economics and cost of water desalination using this ion exchange process, as well as the details required for the design and construction of a demonstration plant.

Research on and development of desalination of sea water at reverse osmosis pilot plant, Swakopmund

(New project: Contract with the Department of Water Affairs (South West Africa) and the CSIR — National Institute for Water Research)



Desalinated sea water flows from a part of the apparatus used in the pilot plant for the desalination of sea water at Swakopmund in South West Africa. Reverse osmosis is the desalination process being applied.

Rapid increases in projected demands for water from the Central Namib State Water Scheme which supplies coastal and non-coastal bulk consumers near Swakopmund and mining areas inland, led the Department of Water Affairs to investigate the technical and economic feasibility of a desalination plant at Swakopmund. Examination of a number of economic and technical factors in cooperation with the Water Research Commission and the National Institute for Water Research (NIWR) resulted in the selection of a reverse osmosis technique to be tested on pilot plant scale at Swakopmund.

Recent advances in membrane technology have resulted in a number of commercial sea water reverse osmosis systems becoming available. Experience with small plants and work done by the United States Office of Saline Water (now Office of Water Research and Technology) at their well-equipped test centres have opened the way for potential users of large scale sea water desalination to consider reverse osmosis as a practical process.

The most common process for sea water desalination is evaporation (multi-stage flash or multi-effect boiling). Reverse osmosis is at present the only other process which is economically competitive. Its major advantage of low energy consumption is especially important for an area such as South West Africa where energy is expensive — particularly so after the recent increase in the cost of energy.

Pilot plant facilities are being established at Swakopmund which will permit pre-treatment and desalination of sea water by reverse osmosis with a production capacity of approximately 200 m^3/d of potable water for supply to Swakopmund. The primary objectives are to gain experience of operation of pre-treatment processes and to evaluate the performance of a number of commercial membrane systems. In this way it will be possible to obtain information which will facilitate full-scale plant design and solution of any operating problems which may arise before the installation of a full-scale plant can be considered. In addition, valuable operational experience in the process will be gained.

The facility will also allow research to be done on possible improvements to the presently available technology, particularly in regard to cheaper pre-treatment methods.

The Department of Water Affairs will construct and operate the pilot plant while the NIWR will carry out a supporting programme of related research. The Water Research Commission will grant assistance for research and development aspects in accordance with its Master Plan for Desalination Research.

Research on the development of membrane support systems and modules

(New project: Contract with the CSIR — National Institute for Water Research)

By the end of 1976 the preparation of new and improved reverse osmosis and ultrafiltration membranes by the Membrane Development Group of the University of Stellenbosch had reached the stage where it had become advisable to be able to cast the membranes on a larger scale and in a practical format. This would lead to greater control over the membrane casting process, giving repeatable results which would enable better observation and evaluation of the effects of planned changes in polymer constitution.

A logical and essential expansion of the proposed large scale membrane production facilities is the development of suitable membrane support systems and modules to allow construction of complete reverse osmosis systems which can be tested in pilot plants on a small scale. The Commission therefore contracted the National Institute for Water Research (NIWR) of the CSIR to develop such support systems and modules with the short term aim of properly evaluating the new membranes, which are produced locally, under practical conditions. In the long term any significant results obtained with the project may lead to a decision to commercial exploitation of the local membranes, either by selling the expertise or even by local membrane production, should this prove to be practical and economical.

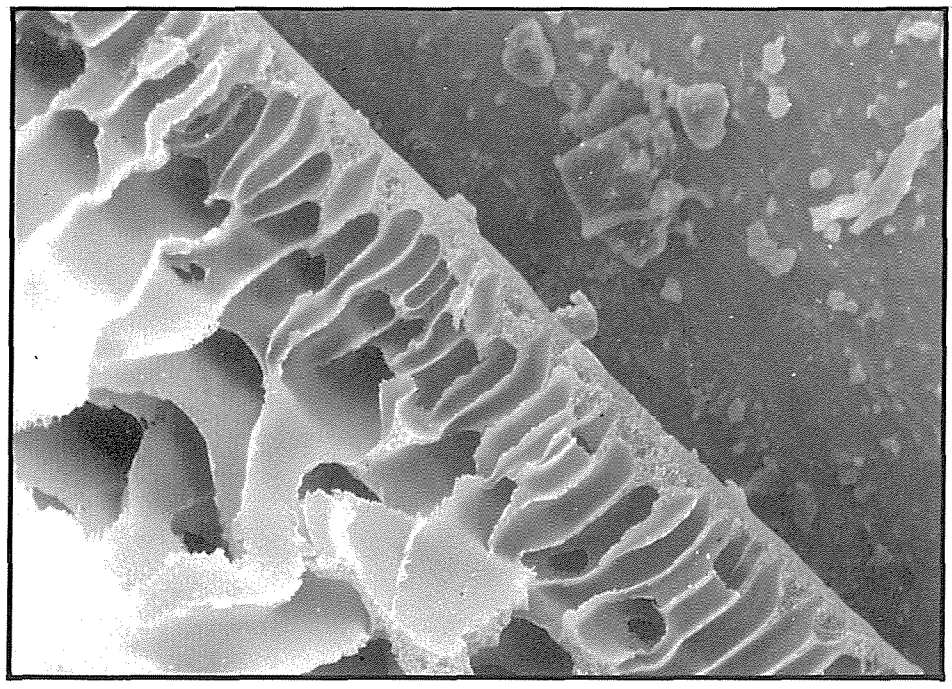
The University of Stellenbosch's membrane development programme, financed formerly by the Commission but currently by NIWR, has been integrated very closely with this project and both projects relate closely to membrane application projects which are supported and undertaken by the Commission and the NIWR respectively. The projects also form an integral part of the Water Research Commission's Master Plan for Desalination Research.

During the year under review an extensive literature survey of the various reverse osmosis and ultrafiltration systems has been completed. Special attention was given to production methods of membranes and modules for the following systems: tube, mini-tube, hollow fibre and spiral.

Good progress was made in casting cellulose-acetate membranes in paper and synthetic fibre tubes. Initially the synthetic fibre tubes were manufactured by hand but this technique produced irregular tubes. Equipment has therefore been designed to produce the tubes mechanically on a continuous basis. Equipment has also been designed to test reverse osmosis and ultrafiltration modules under practical conditions.

In the meantime the casting of flat membrane sheets has continued. Here too manual methods were used and it was once again necessary to design continuous casting equipment in order to obtain more even results.

It should be possible to commission this equipment early in 1978. It will be especially suitable for producing composite membranes currently being developed by the Stellenbosch group and which are yielding promising results.



An electron micrograph of a section of a polysulphane ultrafiltration membrane developed by the membrane development group of the University of Stellenbosch. In this picture the membrane has been enlarged 1 400 times.

Research on the desalination of treated sewage

(New project: Contract with the CSIR — National Institute for Water Research)

The reclamation of sewage is already a proven, practically feasible method for supplying supplementary water for industrial and domestic use.

A problem arises, however, in that as a result of the normal increase in the mineral concentration (which occurs in the use cycle) the salinity content of the reclaimed water may become so high that it may be unsuitable for unlimited reuse. It is therefore necessary to research desalination possibilities in order to extend the application potential of reclamation. The Commission has therefore entered into an agreement with the CSIR in terms of which the NIWR will undertake this task.

A preliminary literature survey of desalination application in the field of sewage reclamation showed that the relatively new reverse osmosis and ultrafiltration membrane processes hold the greatest promise.

An immediate start was made with preliminary investigations into the application possibilities of reverse osmosis at the Athlone Sewage Purification Plant in Cape Town and the NIWR's pilot plant at Daspoort, Pretoria. Fortunately reverse osmosis equipment which had been used in the project on the desalination of brackish water could be used for this purpose after slight modifications.

Very promising results have thus far been obtained with the treatment of reclaimed water and an excellent quality of water is produced.

However, this work is being continued to determine if the membrane process can possibly be successfully applied to purified sewage (i.e. prior to application of the advanced reclamation process), with corresponding savings on costs.

Small scale ultrafiltration tests are currently being done with equipment which has been specially designed for the purpose and built in the NIWR workshop. A larger pilot plant has also been designed to evaluate ultrafiltration. This unit will be suitable for testing promising new membranes currently being developed in Israel, as well as locally developed ultrafiltration membranes.

The greatest problem that has been encountered up to date has been spoiling of the reverse osmosis membranes and attention is being given to cleaning methods and to pretreatment methods for the feed water in order to meet the spoiling problem. In-line flocculation followed by filtration seems at this stage to be a promising process.

Chapter 14

Transfer of information and technology

One of the most important tasks of the Commission, as stated in the Water Research Act, is to collect, assimilate and disseminate knowledge with regard to water research and its application, and to promote development work for the purposes of such application. In the execution of these tasks the Commission has developed several activities which are reported on in this chapter.

Publications

Two of the Commission's publications, *Water SA* and *SA Waterbulletin,* are directed mainly at the dissemination of information whilst a second category, namely technical manuals, promotes the practical application of information as part of the technology transfer programme.

Water SA

Water SA is a scientific journal which contains original research articles and review articles on all aspects of water science. The journal was launched by the Commission with the first issue in April 1975 and it appears quarterly. As mentioned in Chapter 1 the journal has been well received locally as well as overseas and currently there are approximately 1 200 subscribers of whom a quarter are in other countries. Requests to be placed on the mailing list are still received regularly.

Water SA also enjoys world-wide coverage by means of abstracting services. Summaries of articles in this journal now appear in the following abstracting services:

Chemical Abstracts
Biological Abstracts
Engineering Index
Pollution Abstracts
Oceanic Abstracts
Current Contents
Water Resources Abstracts
Hydata
Selected Water Resources Abstracts
Desalination Abstracts
Water Research Centre information

SA Waterbulletin

This bilingual newsletter which was launched by the Commission in August 1975 contains articles, news items and items of interest on local as well as overseas aspects of water. The bulletin especially features the different organisations active in the field of water in the Republic. Good collaboration has been established with the manufacturers and distributors of new equipment and processes related to water and information on equipment and processes now appears regularly in the *SA Waterbulletin.* The bulletin is published quarterly and the mailing list is growing steadily; there are currently approximately 1 200 subscribers.

Technical manuals

As mentioned in Chaper 1, the Commission has decided to publish technical manuals as part of its programme of technology transfer. These manuals may be based on results of projects being financed by the Commission and which have been finalised, or on results obtained during the execution of a project. The idea is to publish reports in which the research knowledge will be packaged in a practically usable form. These manuals therefore are an effort to get knowledge applied and should be seen as an extension of information dissemination.

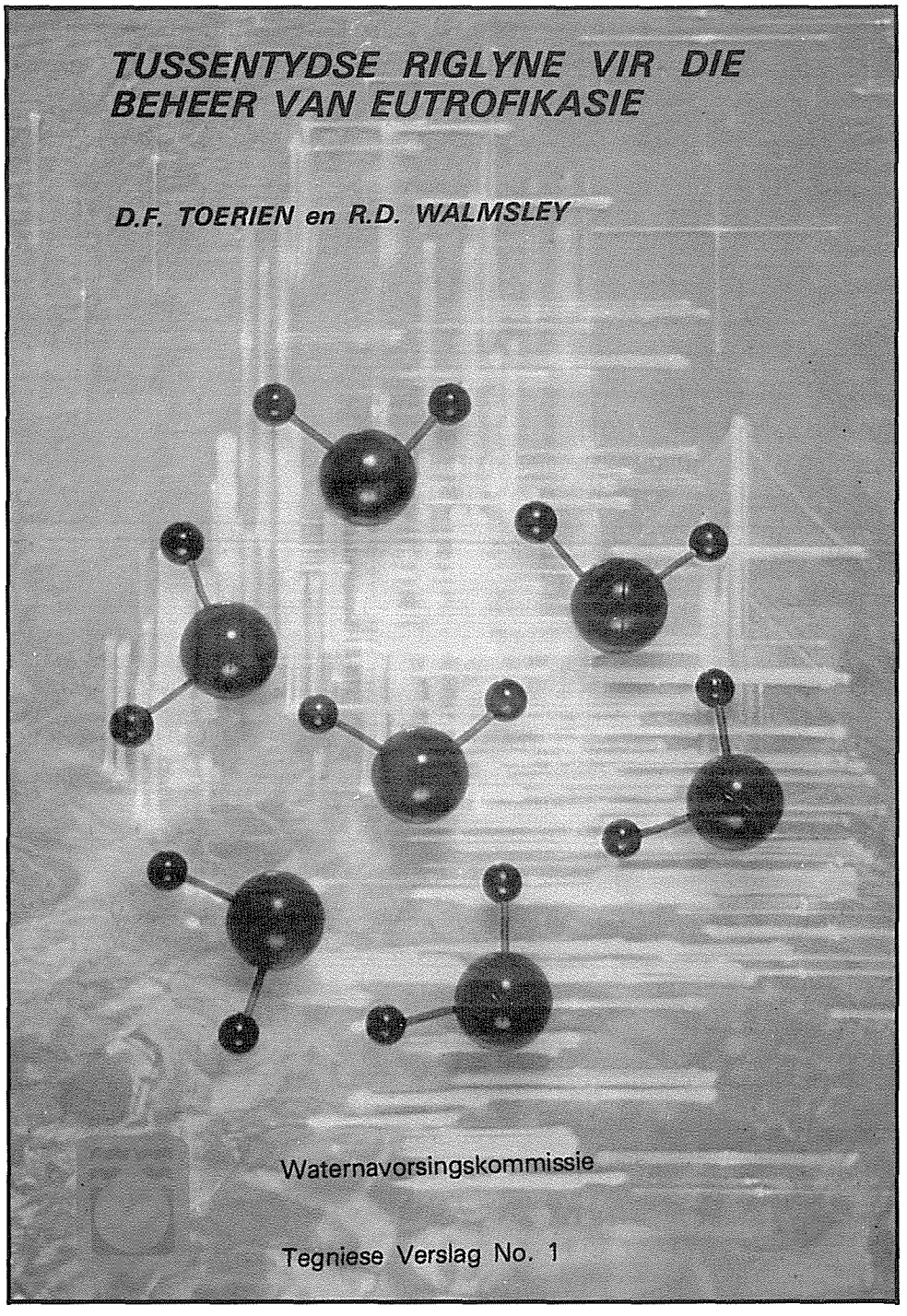
In this regard the first publication has appeared during the year under review and was entitled "Tussentydse riglyne vir die beheer van eutrofikasie" (English: "Interim measures for controlling eutrophication").

These guidelines are meant for planners, local authorities, government departments and other organizations involved with the planning, control and management of water sources in South Africa. The information was partly derived from research done by the NIWR with financial support from the Commission. A print of the cover page of this first technical report appears elsewhere in this chapter.

A second manual, on water reclamation, is being prepared and should appear during 1978.

Final project reports

On completion of a project a final project report is submitted to the relevant steering committee and the Commission. Depending upon the nature of the results a decision is taken on their publication, dissemination and application. It may be that the final report is written in such a form that it may as such be selectively distributed and that no further publication takes place. The findings, however, are normally published in *Water SA* or in the Technical Reports in which case potential users of the information will be notified.



The South African Water Information Centre

Since 1974 the South African Water Information Centre has been operated under contract as an independent unit by the Council for Scientific and Industrial Research on behalf of the Commission.

During the year under review the development of the Centre's computerised bibliographic data base, *Waterlit,* has been completed and additions to the base now take place on a continuous basis. The base contains information on articles on water and related sciences which have appeared in local and overseas journals and reports and which are available in South Africa. Currently the base contains more than 12 000 items which are supplemented at a rate of approximately 700 per month. These items had appeared in more than 400 journals and in several reports.

The information in *Waterlit* is distributed by means of a selective dissemination of information (SDI) service. An interest profile is compiled for each user, such a profile consisting of combinations of key words. This is compared, by means of a computer, with the items being added to the base each month. Corresponding items are recalled, printed on cards and sent to the user. The Centre currently has more than 80 individual profiles as well as two macroprofiles, both of which are sent to approximately 70 municipalities. These macroprofiles deal with water purification and solid wastes. Macroprofiles on other subjects are currently being prepared. The majority of personal profiles deal with aspects of waste water treatment, biology, hydrology and water treatment.

By means of the computer retrospective searches are done on the combined bibliographic data base consisting of material in *Current Literature on Water* (a data base developed during 1971—1975 which actually served as predecessor to *Waterlit*), *Waterlit* (1976—) and the base of the Department of Water Affairs (1972—). The combined base contains more than 50 000 references to articles and reports. During the year under review 140 retrospective searches were done and the system demonstrated to 104 visitors.

Apart from the profile and retrospective search services the Centre also maintains current awareness services such as *Selected Journals on Water* and the *Water Patent Bulletin,* each of which is distributed to approximately 100 subscribers. The former consists of the contents pages of a number of the most important journals in the field of water whilst the latter contains abstracts of patents in the field of water which have appeared in the *South African Patents Journal.*

A new publication of the Centre is the abstracts bulletin, *SA Waterabstracts,* which contains abstracts of all articles on water which have appeared in South African journals. The bulletin is very popular, locally as well as overseas, and is distributed to approximately 500 persons and organizations. Some of the information contained in *SA Waterabstracts* is used by the Water Resources Scientific Information Centre in the USA for its publication *Selected Water Resources Abstracts.*

As far as the type of user is concerned it may be mentioned that the current awareness and retrospective services are currently supplied mostly to scientists and engineers at the National Institute for Water Research (CSIR), the Departments of Water Affairs and Agricultural Technical Services, universities, municipalities, industries and consulting engineers. The services will steadily be expanded to eventually serve the whole water community in South Africa.

The services of the Centre are promoted in several ways. For example, relevant organizations and persons are visited and such personal contacts normally lead to the compilation of interest profiles. Not only Commission projects are visited but also other water projects.

The Centre's activities are also actively propagated at suitable scientific conferences and seminars by talks or the presentation of a poster. Furthermore the services of the Centre are demonstrated from time to time and articles written for certain journals.

An important development during the year under review has been the incorporation of the Department of Water Affairs' information system in that of the Centre. Officials of this Department index articles which are then included in *Waterlit.* The Centre thus now provides a service to the Department and this also prevents duplication of work at the latter organization. Work is being done on a similar basis for the Department of Agricultural Technical Services.

Technology transfer

The methods described above for the dissemination of information constitute one way of promoting technology transfer (that is, the application of research results). In Chapter 1 several other approaches and methods followed by the Commission in this regard were mentioned. In fact, there is no single activity which can be called *technology transfer* (TT), but it points to a large variety of activities which contribute, individually or complementary, to the application of research knowledge.

The methods which the Commission has already developed or plans to develop in future can be summarised as follows:

Continuous determination of water technology requirements in South Africa:

- Operating applicable Coordinating Research and Development Committees and Study Groups
- Continuous contact with operational organizations

Consumer directed packaging of research results:

- Evaluation of research results in respect of application possibilities
- Packaging and distribution of results by means of manuals, symposia, etc.

Involving operational organizations in research contracts — i.e. partnership research:

- Formulation of problem directed projects which are suited to partnership research
- Involvement and contracting of operational organizations in the research
- Supervision and operation

Including TT in the formulation of new research contracts:

- Negotiating with project leaders to accept TT as an inherent aspect of the project
- Accentuating TT during the execution of the project.

Demonstrations:

- Arranging with contractors to utilise test plants, constructed in terms of Commission contracts, as training and demonstration plants
- Arranging demonstrations where applicable

Attending and follow-up of technical exhibitons:

- Selective mobilisation of South African attendance at exhibitions
- Evaluating and following up information, especially with regard to organizations which already apply relevant technology

Liaison with overseas organizations active in TT:

- Extension of information exchange agreements with overseas research organizations
- Evaluation and possible repackaging of useful information received from abroad

Selective utilization of overseas consultants:

- Using overseas consultants to identify new technology and useful research results on behalf of the Commission
- Contracting overseas consultants to visit South Africa in connection with selected problem areas and to compile a report with recommendations on research and available technology against the background of overseas experience

Collaborating with Government Departments in respect of TT:

- Liaison with Government Departments in order to determine departmental technology requirements
- Development of procedures by which the Commission can assist Government Departments with the identification and transfer of technology

Determining the role in the RSA of consultants and equipment manufacturers and distributors in respect of technology transfer and their involvement in TT programmes:

- Collection of relevant information

Determining the routes along which local authorities and industries have in the past noted innovations with regard to the management of water and waste water and have applied them; utilising this information in TT strategies:

- Collection of relevant information

General information activities for promoting TT:

- Publication of *Water SA, SA Waterbulletin* and possibly a TT newsletter
- Preparation of information pamphlets
- Where applicable, production of films to illustrate specific technologies.

Chapter 15

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 1977 to 31 December 1977.

The Commission derives its income from rates and charges on water usage. In terms of section 11 of the Water Research Act, the Minister of Water Affairs has announced the following rates and charges for the Republic in respect of the 1977 financial year in Government Notice No 367 of 11 March 1977:

"(1) Forty cents (40c) in respect of each hectare of land scheduled in terms of section 63 (7) or, where applicable, section 88 of the Water Act, 1956 (Act 54 of 1956), or in respect of which an allocation has been made in terms of section 56 (3) of the said Water Act, 1956, to be irrigated at any time during the period 1 January 1977 to 31 December 1977 with water supplied or made available from a Government dam and distributed by means of an aquaduct irrespective of whether or not such aquaduct belongs to or is controlled by the Government, an irrigation board or other statutory body. This rate shall be recovered by or by direction of the Secretary for Water Affairs simultaneously with any rate which I may levy in respect of the land concerned during the said period in terms of section 66 or section 56 (3) of the said Water Act, or, if no such rate is levied, the rate levied hereby shall be payable to the Secretary for Water Affairs upon demand.

"(2) Twenty cents (20c) in respect of each hectare of land scheduled as in paragraph (1), but where the water supplied or made available is not distributed by means of an aquaduct. This rate shall be recovered in the manner described in paragraph (1).

"(3) Twenty cents (20c) in respect of each hectare of land scheduled in terms of section 88 of the aforementioned Water Act, to be irrigated, at any time during the 1977/78 or, as the case may be, the 1977 financial year of any irrigation board or other statutory body, with water supplied or made available from a water work belonging to such irrigation board or other statutory body. This rate shall be recovered by the irrigation board or other statutory body concerned and shall be remitted to the Secretary for Water Affairs within thirty (30) days of the close of the financial year of the said irrigation board or other body.

"(4) Two-tenths of a cent (0,2c) per cubic metre in respect of metered water supplied or made available during the period 1 January 1977 to 31 December 1977 from a Government water work for purposes other than the irrigation of land. This charge shall be recovered by the Secretary for Water Affairs simultaneously with any charge I may levy in terms of section 56 (3) or section 66 of the Water Act during the said period.

"(5) Two-tenths of a cent (0,2c) per cubic metre in respect of the quantity of water supplied or made available for use for urban, industrial or domestic purposes during the period 1 January 1977 to 31 December 1977 by the Rand Water Board, by any regional water supply corporation established in terms of the Water Supply Ordinance, 1945 (Ordinance 21 of 1945), of Natal, by the Western Transvaal Regional Water Company (Pty) Ltd, by any water board or irrigation board established in terms of the aforementioned Water Act and by any local authority serving a White population in excess of 2 000 according to Report 02-05-01, published by the Secretary for Statistics: Provided that there shall be deducted from the total quantity of water used, supplied or made available by an above-mentioned public supplier during the said period the quantity of water supplied or made available from the Government water work in terms of paragraph (4) or the quantity obtained from any other such public supplier during that period. The total amount payable in terms of this paragraph in respect of water used, supplied or made available shall be remitted by the supplier concerned to

the Secretary for Water Affairs, Private Bag X313, Pretoria, as follows:

(a) In respect of the period 1 January 1977 to 30 June 1977, not later than 30 September 1977; and

(b) in respect of the period 1 July 1977 to 31 December 1977, not later than 31 March 1978."

In terms of section 11 of the Water Research Act as amended, the Minister of Water Affairs has announced the following rates and charges for South West Africa in respect of the 1977/78 financial year in Government Notice No 1943 of 23 September 1977:

"(1) Forty (40) cents in respect of each hectare of land to be irrigated at any time during the period 1 July 1977 to 30 June 1978 with water supplied or made available from a Government water work. This rate shall be recovered by, or by direction of, the Secretary for Water Affairs and shall be payable simultaneously with any rate which may be levied in respect of the supply of such water.

"(2) Two tenths of a cent (0,2c) per cubic metre in respect of metered water supplied or made available during the period 1 July 1977 to 30 June 1978 from a Government water work for purposes other than the irrigation of land. This charge shall be recovered by, or by direction of, the Secretary for Water Affairs simultaneously with any charge that may be levied in respect of such water supplied.

"(3) Two tenths of a cent (0,2c) per cubic metre in respect of the quantity of water, excluding water referred to in paragraph (2), supplied or made available for urban, industrial or domestic purposes during the period 1 July 1977 to 30 June 1978 by the Municipalities of Windhoek and Tsumeb. The rates shall be recovered by the said Municipalities and paid over to the Director of Water Affairs, Private Bag X13193, Windhoek, 9100 —

(a) in respect of the period 1 July 1977 to 31 December 1977, not later than 31 March 1978; and

(b) in respect of the period 1 January 1978 to 30 June 1978, not later than 30 September 1978."

WATER RESEARCH COMMISSION

STATEMENT 1

BUDGET 1978

	R	R
ESTIMATED INCOME		
Rates and charges in terms of Section 11 of the Water Research Act		3 134 000
Interest on investment		200 000
		3 334 000
Appropriation from accumulated funds		1 581 900
TOTAL ESTIMATED INCOME		4 915 900
ESTIMATED EXPENDITURE		
Administrative expenses:		
Salaries and allowances	488 800	
Subsistence and travelling expenses	124 000	
Postal, telegraph and telephone	18 500	
Printing, stationery, advertisements and publications	66 000	
General expenditure	99 600	
		796 900
Research Projects:		
Approved projects		
Development of research on the reclamation of water at the Athlone Sewage Works, Cape Town	29 600	
Technological development of water reclamation on the basis of the Windhoek plant	71 000	
Eutrophication of rivers and dams	194 300	
Technological development of water reclamation and pollution control — Daspoort	89 500	
Reclamation, storage and abstraction of purified sewage effluents in the Cape Peninsula	84 990	
Research on the treatment of waste water by ion exchange	92 000	
Research on the activated sludge process	68 400	
The removal of metal ions from dilute solutions in an electrolytic precipitator	25 860	
The role of aquatic macrophytes in Swartvlei, Wilderness, in maintaining trophic conditions	33 000	
Hydrological investigation of small catchments in the Grahamstown area	18 700	
Hydrological investigation of small rural catchments with specific reference to flood events	43 100	
Hydrological investigation of small catchments in the Mtunzini district	25 000	
Biological denitrification and the removal of phosphate	78 000	
An investigation on the optimal utilization of water from the Eerste River by means of storage in sandbeds or other methods	83 000	
South African Water Information Centre	138 000	
The development and evaluation of techniques for the determination of the exploitation potential of ground water resources in the Southern Orange Free State and Northern Cape	160 680	
The development and evaluation of techniques for the determination of the exploitation potential of ground water resources along the Doornberg fault zone and in the Kalahari	200 500	
Research on water consumption patterns in urban areas	11 500	
Research on the removal of sludge and wash water at water purification installations	3 600	
Research on water losses in pipe networks	4 000	
Geohydrological studies in the Gamagara catchment using environmental isotopes and complementary techniques	96 060	
The development of the concept of the runhydrograph in the analysis of flood hydrographs	15 750	
An investigation into soil compaction under irrigation at the Vaalharts State Irrigation Scheme	19 200	
An investigation into the influence of internal plant moisture stress on the growth and production of certain agronomic crops	8 500	
Research on flood damage — Institute for Social and Economics Research	75 700	
Research on the microbiological quality and health aspects of water for re-use	275 320	
Research on the soil factors affecting the optimal utilization of irrigation water in Bantu homelands	28 000	
Research on water requirements of certain agronomic and vegetable crops	21 340	
Research on the purification and re-use of effluents from the hides and skin curing, fellmongery and tanning industries	50 000	
Research on and development of desalination of seawater by reverse osmosis on the pilot plant at Swakopmund	32 500	
Research on desalination of treated sewage	35 800	
Research on development of membrane support systems and modules	53 300	
Research on the technological application of the anaerobic digestion process for the purification of spent wine residue	9 500	
Water management and effluent treatment in the Textile Industry	152 700	
Research on the development of effective irrigation methods for application on steep lands, with special reference to micro-methods	30 000	
Research on flood occurrences	30 800	
Research on water resources	63 800	
Water pollution and effluent reclamation in the Pretoria - Witwatersrand - Vereeniging - Sasolburg Complex	230 000	
	2 683 000	
Other possible projects	635 000	
		3 318 000
Contracting of overseas researchers and expertise		411 000
Research and other grants		180 000
Specialist and Consultation Services		210 000
TOTAL ESTIMATED EXPENDITURE		R4 915 900

WATER RESEARCH COMMISSION

STATEMENT 2

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD 1 JANUARY 1977 TO 31 DECEMBER 1977

1976	Expenditure		1977
R		R	R
288 532	Salaries and allowances		371 329,60
12 148	Subsistence		16 193,01
2 433	Motor transport		3 369,66
47 151	General transport		56 501,94
1 284	Commission members' allowances		737,50
3 625	Postal and telegraph services		3 768,74
8 570	Telephone services		10 234,83
7 150	Printing and stationery		7 879,23
3 777	Advertisements		2 096,02
32 398	Publications and Information		49 839,85
6 686	Lease and maintenance of office equipment		7 796,62
4 722	Entertainment		3 772,73
17 418	Office rental		21 715,25
1 203	Maintenance of and alterations to offices		251,22
788	Electricity		1 165,56
102	Maintenance and lease of furniture		—
—	Typing services		40,00
1 115	Insurances and licences		3 575,63
31 424	Collection fees		34 004,28
720	Audit fees		763,00
572	Legal costs		91,50
2 207	Registrations and subscriptions		7 548,91
2 255	Miscellaneous petty expenses		2 430,18
6 118	Depreciation		5 537,94
	Research projects:		
184 228	Development of research on the reclamation of water at the Athlone Sewage Works, Cape Town	50 798,89	
567 495	Technological development of water reclamation on the basis of the Windhoek plant	70 664,66	
88 601	Eutrophication of rivers and dams	123 160,00	
359 824	Technological development of water reclamation and pollution control — Daspoort	270 803,00	
43 576	Research on desalination of brackish water	—	
429 215	Reclamation, storage and abstraction of purified sewage effluents in the Cape Peninsula	552 923,00	
19 185	Natural draught dry cooling heat exchangers	192,20	
—	Financial support of the University of the Witwatersrand Hydrological Research Unit	60 000,00	
—	Research on recycling of water and recovery of chemicals in the textile industry	34 150,36	
57 595	Research on the treatment of waste water by ion exchange	60 614,82	

1976	Income			1977
R		R	R	R
	Rates: Government irrigation schemes with canal systems:			
	Received	21 238,66		
	Less: Adjustment in respect of previous years	8 136,20	13 102,46	
	Plus: Outstanding 1977		51 951,05	
65 674				65 053,51
	Rates: Government irrigation schemes without canal systems:			
	Received	718,95		
	Plus: Adjustment in respect of previous years	3,74		
			722,69	
	Plus: Outstanding 1977		2 470,60	
3 285				3 193,29
	Rates: Irrigation Board Schemes:			
	Received	24 031,98		
	Less: Adjustment in respect of previous years	11 378,57		
			12 653,41	
	Plus: Outstanding 1977		1 746,28	
27 875				14 399,69
	Charges: Metered water from Government Schemes			
	Received	2 057 863,43		
	Less: Adjustment in respect of previous years	8 097,74		
			2 049 765,69	
	Plus: Outstanding 1977		201 809,79	
2 098 040				2 251 575,48
	Charges: Municipalities:			
	Received	918 119,83		
	Plus: Adjustment in respect of previous years	9 890,21		
			928 010,04	
	Plus: Outstanding 1977		11 279,30	
926 494				939 289,34

68 628	Research on the activated sludge process	61 677,73
19 680	The removal of metal ions from dilute solutions in an electrolytic precipitator	6 168,32
28 332	The role of aquatic macrophytes in Swartvlei, Wilderness, in maintaining trophic conditions	54 120,16
46 432	Hydrological investigation of small catchments in the Grahamstown area	40 898,97
—	Hydrological investigation of small rural catchments with specific reference to flood events	117 122,32
129 411	Hydrological investigation of small catchments in the Mtunzini district	42 512,61
57 218	Biological denitrification and the removal of phosphate	69 736,00
81 800	An investigation on the optimal utilization of water in the Eerste River by storage in sandbeds or by other means	89 445,24
72 703	Development of the WAT-process for the desalination of sea water	6 451,00
79 111	South African Water Information Centre	—
19 693	Research on production of water by abstraction of water vapour from the atmosphere by means of hygroscopic materials	—
160 244	The development and evaluation of techniques for the determination of the exploitation potential of ground water resources in the Southern Free State and Northern Cape	111 567,00
175 495	The development and evaluation of techniques for the determination of the exploitation potential of ground water resources along the Doornberg fault zone and in the Kalahari	196 033,86
21 402	Research on water consumption patterns in urban areas	32 652,11
17 278	Research on the removal of sludge and wash water at water purification installations	28 340,77
16 815	Research on water losses in pipe networks	21 622,75
74 929	Geohydrological studies in the Gamagara catchment using environmental isotope and complementary techniques	58 186,90
—	The development of the concept of the runhydrograph in the analysis of flood hydrographs	58 245,24
50 870	Research on flood damage — Bureau for Economic Research	13 463,00
15 022	An investigation into soil compaction under irrigation at the Vaalharts State Irrigation Scheme	18 010,32
17 776	An investigation into the influence of internal plant moisture stress on the growth and production of certain agronomic crops	9 161,99
42 007	Research on flood damage — Institute for Social and Economics Research	37 017,51
112 305	Research on the microbiological quality and health aspects of water for re-use	79 007,77
—	Research on the soil factors effecting the optimal utilization of irrigation water in the Bantu Homelands	7 460,47

	Charges: S.W.A.:		
	Received	36 173,81	
	Plus: Outstanding 1977	22 368,77	
45 248			58 542,58
297 391	Interest on investments		306 199,61
549	Sundry Income		177,44
421 306	Excess of expenditure over income		186 861,21

1976	Expenditure		1977	1976	Income	1977
27 473	Research on water requirements of certain agronomic and vegetable crops	25 351,45				
85 060	Research on the purification and re-use of effluents from the hides and skins, curing, fellmongery and tanning industries	65 656,27				
—	Research on and development of desalination of sea water by reverse osmosis on the pilot plant at Swakopmund	25 356,00				
—	Research on desalination of treated sewage	42 804,00				
—	Research on development of membrane support systems and modules	16 608,00				
11 000	Research on the technological application of the anaerobic digestion process for the purification of spent wine residue	5 069,00				
—	Water management and effluent treatment in the Textile Industry	117 455,87				
—	Research programme for studying conditions in Hartbeespoort Dam before and after full scale spraying of the water hyacinths	11 080,00				
—	Water pollution and effluent reclamation in the Pretoria-Witwatersrand-Vereeniging-Sasolburg Complex	91 107,71				
			2 782 697,27			
	Contracting of overseas researchers and expertise:					
43 711	Weather modification	140 985,61				
—	Evapotranspiration	11 244,01				
			152 229,62			
33 154	Research and other grants		146 300,59			
146 196	Specialist and consultation services		133 421,47			
R3 885 862			R3 825 292,15	R3 885 862		R3 825 292,15

WATER RESEARCH COMMISSION

STATEMENT 3

BALANCE SHEET AS AT 31 DECEMBER 1977

1976	Liabilities	1977	
R		R	R
	Sundry creditors —		
18 304	Revenue paid in advance		47 957,81
	Fund account		
5 564 024	Balance at 31/12/76	5 564 024,37	
	Less: Excess of expenditure over income, 1977	186 861,21	
			5 377 163,16
R5 582 328			R5 425 120,97

1976	Assets		1977	
R		R	R	R
	Capital assets — +			
5 000	Land (Cost)		5 000,00	
	Motor vehicles	8 026,63		
	Less: Depreciation	2 799,38		
8 027			5 227,25	
	Office equipment	29 874,05		
	Less: Depreciation	1 493,70		
26 894			28 380,35	
	Office furniture	24 897,11		
	Less: Depreciation	1 244,86		
20 212			23 652,25	
				62 259,85
	Current assets —			
3 870 004	Investments		3 695 458,27	
	Sundry debtors —			
	Outstanding revenue:			
	Prior to 1977	14 081,61		
	1977	291 625,79		
309 787		305 707,40		
1 255 881	Project advances	1 162 327,04*		
3 700	Subsistence and transport advances	5 800,00		
50	Deposits	50,00		
			1 473 884,44	
50	Cash on hand		50,00	
82 723	Cash in bank		193 468,41	
				5 362 861,12
R5 582 328				R5 425 120,97

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

Pretoria, 14th April, 1978

(Sgd) GJ Stander
Chairman

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, as read with section 14(1) of the Water Research Act, No. 34 of 1971, and in my opinion it has been drawn up so as to reflect a true and fair view of the financial affairs of the Water Research Commission.

(Sgd) FG Barrie
Auditor-General

Department of the Auditor-General
Cape Town, 20th April, 1978

ANNEXURE
PROJECT ADVANCES

R1 162 327,04 — This amount represents the net outstandings in respect of advances made to the C.S.I.R. and other organisations for the following projects:

PROJECT	R	R
Development of research on the reclamation of water at the Athlone Sewage Works, Cape Town	77 199,16	
Eutrophication of rivers and dams	13 753,59	
Technological development of water reclamation and pollution control — Daspoort	11 447,29	
Reclamation, storage and abstraction of purified sewage effluent in the Cape Peninsula	289 775,31	
Research on the treatment of waste water by ion exchange	3 427,18	
Research on the activated sludge process	6 013,03	
The removal of metal ions from dilute solutions in an electrolytic precipitator	15 446,93	
The role of aquatic macrophytes in Swartvlei, Wilderness, in maintaining trophic conditions	36 605,08	
Hydrological investigation of small catchments in the Grahamstown area	3 573,95	
Hydrological investigation of small rural catchments with specific reference to flood events	3 477,90	
Hydrological investigation of small catchments in the Mtunzini district	54 181,94	
An investigation on the optimal utilization of water in the Eerste River by storage in sandbeds or by other means	22 334,99	
Development of the WAT-process for the desalination of sea water	10 779,34	
South African Water Information Centre	91 736,80	
Research on production of water by abstraction of water vapour from the atmosphere by means of hygroscopic materials	140,47	
The development and evaluation of techniques for the determination of the exploitation potential of ground water resources in the Southern Free State and Northern Cape	110 980,82	
The development and evaluation of techniques for the determination of the exploitation potential of ground water resources along the Doornberg fault zone and in the Kalahari	69 072,98	
Research on water consumption patterns in urban areas	1 667,68	
Research on the removal of sludge and wash water at water purification installations	1 981,55	
Geohydrological studies in the Gamagara catchment using environmental isotope and complementary techniques	95 580,76	
The development of the concept of the runhydrograph in the analysis of flood hydrographs	689,56	
An investigation into soil compaction under irrigation at the Vaalharts State Irrigation Scheme	341,05	
An investigation into the influence of internal plant moisture stress on the growth and production of certain agronomic crops	484,03	
Research on flood damage — Institute for Social and Economic Research	12 413,17	
Research on the microbiological quality and health aspects of water for re-use	35 337,35	
Research on the soil factors effecting the optimal utilization of irrigation water in the Bantu Homelands	34 638,53	
Research on water requirements of certain agronomic and vegetable crops	2 775,80	
Research on the purification and re-use of effluents from the hides and skins, curing, fellmongery and tanning industries	14 609,83	
Research on and development of desalination of sea water by reverse osmosis on the pilot plant at Swakopmund	9 244,00	
Research on desalination of treated sewage	5 609,42	
Research on development of membrane support systems and modules	6 892,00	
Research on the technological application of the anaerobic digestion process for the purification of spent wine residue	2 431,00	
Water management and effluent treatment in the Textile Industry	38 667,04	
Research on the development of effective irrigation methods for application on steep lands, with special reference to micro-methods	750,00	
Research on flood occurrences	21 410,00	
Research on water resources	32 810,00	
Research programme for studying conditions in Hartbeespoort Dam before and after full scale spraying of the water hyacinths	28 920,00	
Water pollution and effluent reclamation in the Pretoria-Witwatersrand-Vereeniging-Sasolburg Complex	50 381,98	
		1 217 581,51
Less: Excess expenditure over advances for projects:		
Technological development of water reclamation on the basis of the Windhoek plant	49 873,07	
Biological denitrification and the removal of phosphate	325,12	
Research on water losses in pipe networks	3 437,35	
Research on flood damage — Bureau for Economic Research	1 618,93	
		55 254,47
		R1 162 327,04