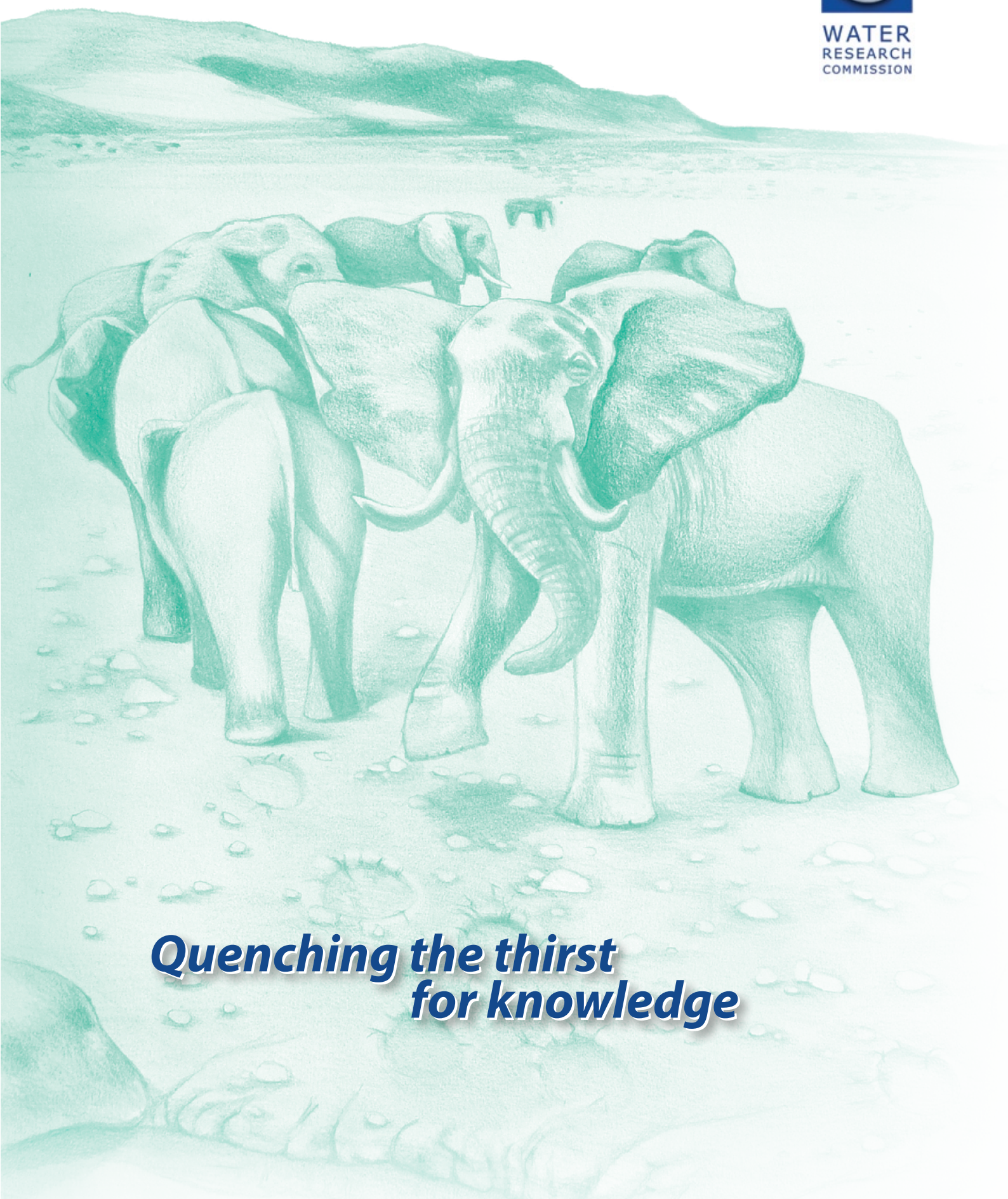


*Water Research Commission
Knowledge Review 2008/09*

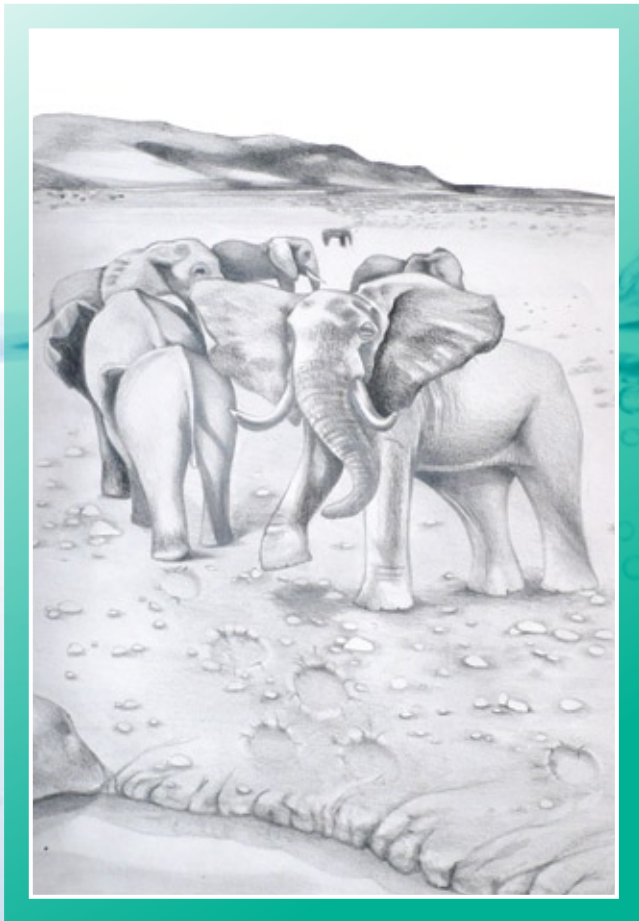


**WATER
RESEARCH
COMMISSION**



***Quenching the thirst
for knowledge***

Quenching the thirst for knowledge



On the cover

Despite its formidable size, the African elephant (*Loxodonta africana*) is among the most gentle and social of all animals. An elephant is only as good as its herd and communication is vital for survival. Elephants communicate mainly through sound, touch and body language. Over long distances messages are sent by producing and receiving low-frequency sound (infrasound), a subsonic rumbling, which can travel through the ground farther than sound travels through the air. This can be felt by the sensitive skin of an elephant's feet and trunk, which pick up the resonant vibrations much as the flat skin on the head of a drum. Elephants are a keystone species: they create and enlarge watering holes by trampling the mud and carry it away after wallowing. Their paths to waterholes channel the rains. In dry times, elephants dig holes using their trunks and feet to expose underground springs, creating much needed water supplies on which many other animals depend. They have great capacity for compassion and possess a significant sense of memory. In many African cultures the elephant is seen as a general symbol of physical power, leadership, longevity and wisdom.

Cover illustration by Vanessa Joubert

Vision

To be a globally recognised leader in providing innovative solutions for sustainable water management to meet the changing needs of society and of the environment.

Mission

The WRC is a dynamic hub for water-centred knowledge, innovation and intellectual capital.

We provide leadership for research and development through the support of knowledge creation, transfer and application.

We engage stakeholders and partners in solving water-related problems which are critical to South Africa's sustainable development and economic growth, and are committed to promoting a better quality of life for all.



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Introduction

Investing in the Creation and Sharing of Water-Centred Knowledge

During 2008/09, the WRC continued to support the water sector and all its relevant institutions and partners. This was achieved by providing them with knowledge aimed at informing their decision-making processes, improving their monitoring and assessment tools, and making available a range of new and improved technologies related to water resource management and the provision of water and sanitation services. The WRC continued to address the issue of climate change and the linked phenomena of extreme events. Research funded by the WRC will support the development of adaptive and mitigating strategies which will ensure the future sustainability of the country's water resources and services.

The research portfolio for 2008/09 was set on the basis of the WRC's strategic plan. The WRC continued to invest in the creation of knowledge via its 4 main key strategic areas (KSAs). These areas include **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management, and Water Utilisation in Agriculture**. In general, the portfolio as planned for the year under review was well-received by the various stakeholders. These KSAs are supported by the **Water-Centred Knowledge** KSA. This structure continued to form the core operating framework for WRC-funded research and development and was further consolidated during the year.

Water Resource Management – Research carried out by this KSA aimed at ensuring that the water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research aimed at developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment of the quantity and quality of water available for development in South Africa; building up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming

and human-induced impacts on water resources (including an understanding of the impact on human health); providing control measures for improving the prevention, mitigation and control of pollution of water resources and supporting and improving policy reforms for promoting equitable, efficient and sustainable conservation and allocation of water resources among competing needs. During 2008/09 the WRC invested in research projects in 4 research thrusts in this KSA including water resource assessment and planning; management of natural and human-induced impacts on water resources; water resource protection and water resource institutional arrangements.

Water-Linked Ecosystems – This KSA invested in the creation of knowledge aimed at enabling good environmental governance and ensuring the utilisation and sustainable management of water-linked ecosystems in our water-scarce country during a time of demographic and climate change. The research developed the understanding of the ecological processes underlying the delivery of goods and services and provided knowledge to sustainably manage, protect and utilise aquatic ecosystems. Three main research areas were addressed during 2008/09, including research on ecosystem processes, i.e., the biophysical processes, form and function of ecosystems; ecosystem management and utilisation, including issues such as the ecological Reserve; and ecosystem health and ecosystem rehabilitation (rivers and wetlands).

Water Use and Waste Management – This KSA focused mainly on research for the domestic, industrial and mining water sectors. The aim was to proactively and effectively lead and support the advancement of technology, science, management and policy relevant to water supply, waste and effluent management for these sectors. During the year under review, this KSA supported studies on appropriate technologies for improving the quality and quantity of our water supplies for domestic use, with a





**Dr Rivka Kfir, Chief Executive Officer,
Water Research Commission**

focus on water supply and treatment technology serving the urban, rural, large and small systems. Research was conducted on new ways to manage and enhance hygiene and sanitation practices, and on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Infrastructure for both water supply and sanitation was included. Waste and effluent were also addressed, as well as reuse technologies that can support and improve management in the municipal, mining and industrial sectors, and innovative as well as integrated solutions for water and waste management in the industrial and mining sectors were studied. The research areas included: water services (institutional and management issues); water supply and treatment technology; sustainable municipal wastewater and sanitation, industrial and mine-water management; and sanitation and hygiene education.

Water Utilisation in Agriculture – Research carried out in this KSA aimed at increasing household food security and improving the livelihoods of people at farming, community and regional levels through efficient and sustainable utilisation and development of water resources in agriculture. More specifically, the research focused on increased biological, technical and economic efficiency of water use, the reduction of poverty through water-based agricultural activities, the increases in profitability of water-based farming systems and the sustainable use of water resources. All agricultural sub-sectors were addressed including irrigated and dry-land agriculture; woodlands and forestry; grasslands and livestock watering and aquaculture. During 2008/09, research was conducted in 5 main areas including water utilisation for food and fibre production; fitness-for-use of water; water utilisation for fuel-wood and timber production; water for poverty reduction and wealth creation in agriculture; and reclamation and protection of water resources in agriculture. Research projects specifically addressed the needs and requirements of homestead food garden and smallholder crop production in rural communities.

Supporting research projects

During the year under review, the WRC supported 294 research projects, of which about 78% (230 projects) were active projects (ongoing and new) and about 22% (64 projects) were finalised. The active projects comprised 168 ongoing projects and 62 newly initiated projects that commenced during 2008/09. The various mechanisms of funding included both non-solicited projects, accommodating projects within the broad research strategy

of each KSA, and solicited projects, where research projects are developed in accordance with clear terms of reference, aimed at solving specific problems. The WRC supported 39 solicited projects, which translates to about 17% of active projects. During the year 22% of the projects (64 projects) were finalised.

There was a slight increase (3%) in the total number of projects due to an increase in the number of ongoing projects, which increased by about 6%. There was a decrease (7%) in the number of new projects initiated during the year as well as a reduction in the number of active solicited projects by about 48%. This is an indication of an active research cycle where multi-year projects are in progress and where many of the previously solicited studies have been concluded.

Total investment in the support of knowledge creation, sharing and dissemination amounted to R115.7 m. This represents an increase of 17% from the previous year (R99.2 m. total investment was reported in 2007/08). This investment includes about R4.5 m. for the Water Information Network (WIN-SA), R3.3 m. for the Framework for Education and Training in Water (FETWater), and other income leveraged for research projects during the year under review. Both the investments in research projects and in research support, expressed as a percentage of total expenditure, were close to the set budgeted ratios and almost identical to that of previous years. The ratio addressing funding of the creation of new knowledge (research projects only) is identical to that of the previous year but slightly better than the budgeted percentage of 63%. The ratio for research support is also similar to that of the previous year, with only a 1% decrease but in line with the budgeted percentage of 75%.

Leveraging income for the creation, sharing and dissemination of water-centred knowledge

During the year under review the WRC continued to leverage levy income by striving to obtain funds from other sources to support water research. During 2008/09, this drive has been highly successful. The WRC income originating from sources other than the levy for 2008/09 amounted to R16.1 m. Leveraged income included funds allocated to a number of KSAs for direct support of research projects and funds provided for capacity building, knowledge sharing and dissemination (e.g. WIN-SA and FETWater). Leveraged income was obtained from both local and international sources, where the main source of income was due to support by various government departments for specific research and other knowledge-sharing projects. Sources of income other than the levy for 2008/09 amounted to about 17% of the total income.



TABLE 1
Number of students involved in WRC projects

<i>Institution</i>	<i>No. of historically-disadvantaged (HD) students</i>	<i>Total No. of students</i>
Agricultural Research Council (ARC)	10	14
Althydro CC	3	3
Anchor Consulting	1	3
Aquagreen Consulting	2	5
Asset Research	4	12
Association for Water and Rural Development (AWARD)	2	4
Cape Peninsula University of Technology	10	12
Central University of Technology, Free State	1	2
Conningarth Economists	5	5
CPH Water	1	1
CSIR	25	35
DH Environmental Consulting	2	3
Durban University of Technology	8	9
Emanti Management	4	4
Geoscience	4	4
GEOSS	1	2
Golder Associates Africa	7	7
Groundwater Africa	0	1
Hlathi Development Services	5	5
Monash South Africa	2	5
Mvula Trust	1	1
Nelson Mandela Metropolitan University	5	9
Nemai Consulting	1	1
Ninham Shand	1	6
Partners in Development	3	5
Pegram & Associates	0	3
Process Optimization and Resource Management (PRO&RM)	2	2
Pulles, Howard & De Lange	2	2
Rhodes University	12	20
Rural Integrated Eng	9	12
Sarah Slabbert Associates	1	5
Sigma Beta	7	11
Source Strategic Focus	3	3
SRK	1	2
Sustento Development Services	0	2
The Impact Free Water Group	4	5
Tshwane University of Technology	14	14
Umgeni Water	3	3
Umlhlab Consulting Group	2	2
University of Cape Town	28	55
University of Fort Hare	13	13
University of Johannesburg	7	14
University of KwaZulu-Natal	48	89
University of Limpopo	2	2
University of Pretoria	34	62
University of Stellenbosch	18	51
University of the Free State	19	36
University of the North-West	4	8
University of the Western Cape	21	24
University of the Witwatersrand	7	18
University of Venda	9	9
UWC Consortium	3	3
Water for Africa	3	5
TOTAL	384	633

Building Capacity

The WRC aims at providing South Africa with future researchers as well as a source of skilled human capital for other institutions within the water sector. This is done by accommodating students conducting water research through the various projects supported by the WRC. During the year under review, the WRC continued to place strong emphasis on building research capacity in South Africa as well as supporting a number of related capacity building initiatives in Africa. In many areas of research supported by the WRC, it is evident that students who participated in earlier WRC projects are currently leading WRC-funded research projects and are serving as members of steering committees as well as reviewers of new proposals.

During the current year (2008/09) the WRC continued to excel in its support to students, with special emphasis on historically disadvantaged students. Currently about 633 students are supported by WRC projects, of whom about 61% are from disadvantaged backgrounds. This is a slight decrease (5%) in the number of students and also a slight reduction in the percentage of historically disadvantaged students as compared to the previous year. This indicates that although the WRC's strategy to improve capacity building through its research projects is successful, the difficult time facing the science and technology and higher education sectors is reflected in the slight decrease in student numbers. Of all the institutions supporting students, universities are clearly leading with 447 students, of whom 260 or 58% originate from historically disadvantaged backgrounds. Although all South African universities support students through WRC projects, the University of KwaZulu-Natal exceeded all with 89 students, followed by the University of Pretoria with 62 students, 55 students at the University of Cape Town, 51 at the University of Stellenbosch, 36 at the University of the Free State and 24 at the University of the Western Cape. Science councils supported 53 students, with the CSIR supporting 35 students, of whom 73% were from historically disadvantaged backgrounds.

There is also a clear pattern of an increased number of students involved in projects led by consultancy groups. Consultancies involved 131 students of which 64% were from historically disadvantaged backgrounds. The increase in the number of students in non-academic institutions is encouraging as these students represent on-the-job continuous development and/or new skilled human capital for the sector. The increase in the number of students is also a result of the WRC strategy of building research networks and research consortia.

Capacity building initiatives

In addition to its support for the training of students the WRC has initiated and supported a number of national capacity building initiatives:

The WRC is leading the establishment of a **Technical Assistance Centre (TAC)** to assist rural water service providers. The centre will provide technical support to water provision as well as sewage treatment. To date all preparatory work for the establishment of the structure, facilities and human resources has been completed and a number of positioning/marketing initiatives have been launched. These comprised presentation of the TAC during workshops and training sessions (e.g. workshops held at the Water Institute of Southern Africa (WISA) Biennial Conference 2008), development of information packages, provincial launches in the Eastern Cape and the Western Cape, as well as the compilation of an implementation plan for the TAC in these 2 pilot provinces for 2009/10.

The WRC continues to act as the Department of Water Affairs

and Forestry (DWAF) implementing agent for the **Framework for Education and Training in Water (FETWater)**, a joint UNESCO, Belgian and South African programme. This is a key national capacity-building initiative aimed at the development of competencies and capacity regarding water resource management. During 2008/09, Phase II of this programme has progressed well under the custodianship of the WRC. The annual conference took place in February 2009, where all 7 networks presented their reports and business plans. During the year a total of 84 people were trained by FETWater; 57 of these were historically disadvantaged individuals and 31 were women.

The WRC serves as the implementing agent for DWAF for the **Water Information Network (WIN-SA)**. During the period 2008/09 WIN-SA continued to generate knowledge targeted at building the capacity of local government. Partners such as the South African Local Government Association (SALGA) and the Department of Provincial and Local Government (DPLG) contributed to the generation of knowledge and strengthening of content by collaborating with WIN-SA on lessons such as the *DPLG Series* and the *Benchmarking Initiative*. A *Regulation Bulletin* was also released as a new product in collaboration with the DWAF regulation unit. The WIN-SA portal and mailing lists played a critical role in widening information exchange and dissemination. WIN-SA has established strong links with the Cities Network to support and strengthen its knowledge management strategies and interventions. During the year under review WIN-SA has undergone expert assessment and review. The assessment, which was positive overall, also came up with specific recommendations on how to strengthen WIN-SA as a network.

Through the dedicated activities of one of its research managers, Dr Burgess, the WRC is leading the establishment of a joint International Water Association (South Africa) and Water Institute of Southern Africa (**IWA-SA/WISA**) **Young Water Professionals Forum**. This forum will address the needs of the young water professional in terms of professional growth and building their track record.

Building capacity in Africa

The WRC's capacity-building activities continue to address support for Africa:

The **NEPAD Network of Centres of Excellence for Water Research in Africa** is an ongoing dedicated activity, where the WRC coordinated and led the process of establishing the network in cooperation with the French Institute of Research for Development (IRD). During the year under review a framework was developed to determine criteria to select those organisations that would act as centres of excellence, and the process of selection has since been completed.

The WRC continues to be involved in the **Water Research Fund of Southern Africa (WARFSA)**. WARFSA was established with the purpose of building research capacity among regional institutions and individuals as well as promoting the utilisation of research results in the planning and management of water resources in the sub-region. Currently one staff member serves as a Board Member of WARFSA.

The WRC is supporting the Academy of Science of South Africa (ASSAf) in the **Inter-Academy Programme (IAP) for Water** which aims to build capacity for water research. The WRC supports all IAP activities in Africa. During the year under review, the WRC organised and facilitated a workshop on *Regional Collaboration in Hydrology and Hydropower* (Pretoria, June 2008). Of the 30 participants, 11 were from other African countries (Uganda (2), Ghana, Tanzania, Zimbabwe, Kenya, Botswana, Namibia, Lesotho (2) and Mozambique).



Innovation and Knowledge Application

The WRC supports knowledge creation which in turn may lead to innovative methods and technologies. While many of these innovations are public goods and are readily available for use, some technologies, processes and products require commercial involvement in order to make them publicly available.

Currently, the WRC has licence agreements with reputable South African companies. These include one royalty-earning innovation, i.e. **The Secondary Metabolites**, a cluster of 13 patents, currently licensed to Synexa-Life Sciences; the WRC has been receiving royalties since 2006. Two other licensed innovations are currently undergoing further development: the **BioSURE™ Process**, a cluster of 36 patents which is licensed to ERWAT, and the **Ambient Temperature Ferrite Process (ATFP)** for removing iron from acid mine drainage, which is currently licensed to Environmental Technology Agencies (ETA). Further development is often required to allow the technology to function reliably at a large scale. Business related to another innovation that was licensed out last year is rapidly progressing. This is an invention that will allow the provision of clean water at a small scale and could effectively provide drinking water for small rural communities. The **Capillary Ultra-Filtration Membrane Technology (CUF)**, a cluster of 5 patents, was licensed to Ikusasa Chemicals in January 2008.

The WRC has launched patent applications for 2 new innovations:

- **Process for treating sulphate-containing effluent** – The object of this invention is to provide a process for treating sulphate-containing effluent in a bioreactor. The process involves introducing the sulphate-containing effluent into the bioreactor along with a metabolisable carbon energy source, such that the metabolisable carbon energy source is present in an amount in excess of that required for the biological reduction of the sulphate in the effluent to sulphide. This is followed by a step in which the sulphate in the effluent is biologically reduced to sulphide, simultaneously biologically producing methane from the carbon energy source, and removing the sulphide from the effluent.
- **Treatment of wastewaters using dual-stage membrane bioreactors** – This invention is a wastewater treatment process. The process includes steps providing a discrete acclimation bioreactor system for developing a desired micro-organism inoculum, with the system being in selectively interruptible fluid flow connection with an effluent hydrolysis system. This allows the flow of desired micro-organisms from the bioreactor system to the effluent hydrolysis system to be regulated independently from the effluent feed flow through the hydrolysis system, leading to greater flow-through and system efficiencies.

The WRC has 2 pending licences. ERWAT has expressed an interest in commercialising the patent entitled: 'Process for treating sulphate-containing effluent' whereas AtlHydro (Pty.) Ltd. has submitted a business plan for the commercialisation of the patent entitled: 'Treatment of wastewaters using dual stage membrane bioreactors'.

Examples of other innovations developed in 2008/09 include:

- **Innovative approaches to handle brine** – 'Dewvaporation' is a technology that extracts distilled

water from brine and generates a more concentrated brine stream. It is based on the natural cycle of humidification and de-humidification and may utilise waste heat or low energy steam to evaporate brine. Compared to traditional thermal evaporators, evaporation of water in 'dewvaporation' occurs from the surface of the liquid and not from a highly heated metal surface. As such, it is anticipated that scaling will be reduced. Compared to WAIV (wind-aided intensified evaporation), the technology is more complex, but offers the advantage of recovering high-quality water from brine streams.

- **The SHAPE (Sanitation and Housing Applied Priorities Enquiry) Model** – Every sanitation choice affects a consumer's disposable income; finding the right solution is therefore fundamental in the quest for sustainability. To enable informed choice, the WRC supported the development of a computer modelling tool to help determine the effective demand for services, with a specific focus on sanitation, for peri-urban residents. The result was the SHAPE Model. The Model allows the user to specify their preferences for, e.g., sanitation, within the context of a global cost for the housing solution.

Marketing local water innovation

Marketing the WRC's technologies remains a continuous process. Our technologies are now listed on one international IP-marketing website, *The Place to go for IP*, hosted by Technology Transfer Tactics, an American-based company. During the year under review the WRC has completed the development of the WRC IP booklet and developed the WRC IP Technology Transfer Office website (<http://www.wrcip.org/index.php>) which was launched on 6 March 2009.

Knowledge Review 2008/09

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2008/09 financial year. This reflects the organisation's strategic focus based on assessment and integration of the needs, opportunities and priorities presented by the current context and challenges facing the water sector in South Africa, and globally.

In 2008/09 the WRC placed heightened emphasis on improving the mechanisms for dissemination and uptake of water centred-knowledge, especially with regard to policy development and implementation. This was needed to support the current dynamic environment which is being experienced by the water sector, and was done in addition to and without any adverse effect on, the core business of the WRC, i.e. investment in the creation of water-centred knowledge. The WRC strived to support the South African Government with special reference to water issues and to provide the required knowledge to the water sector and other related sectors. Throughout the year under review the WRC has continued to focus on building strong formal relationships with DWAF and other departments within all spheres of Government. In the year that follows the WRC will continue in its quest to serve South Africa and support Africa as an effective and dynamic water-centred knowledge hub.



Ms Eiman Karar: Director

KSA 1: Water Resource Management

Scope

The **Water Resource Management** KSA will take account of pertinent developments taking place in the implementation of the National Water Act (NWA) of 1998. As such, the focus will continue to be guided by the Bill of Rights, the Constitution of South Africa Section 27 (1)(b) 'everyone has the right to have access to sufficient water' and by the principles and objectives of the NWA. The primary principle of the Act is that water resources should be managed to achieve optimum long-term social and economic benefits for all. This implies maintaining an optimum balance between protection of the environment and efficient water utilisation. The supporting principles are:

- The basic human needs of present and future generations
- The need to protect water resources
- The need to share some water resources with other countries
- The need to promote social and economic development through the use of water
- The need to establish suitable institutions

This KSA supports the implementation of the NWA by:

- Developing tools and technologies for overall water resource management
- Supporting decision making by reviewing existing policies and strategies
- Providing quick responses to immediate and specific research questions in support of national initiatives
- Providing platforms for debate
- Building capacity in project teams and steering committees
- Disseminating resultant information as widely as possible
- Encouraging partnerships through joint projects with key stakeholders

In recent years, the research focus in this KSA has been shifting from supporting policy-making to providing guidance for policy implementation and the development of policy instruments. The challenge for research in this KSA is to provide the necessary information systems, guidelines, decision-support systems, prediction tools and technologies/methodologies that support planning, development and protection of water resources. As the decentralisation of the management of water resources is in its infancy, information systems supporting local decision making have become critical. The NWA places emphasis on stakeholder participation in water resource management which forms a blend between the decentralisation and democratisation for decision making. The role of local government in the management of water resources needs to be better understood, as well as its responsibilities and inter-relatedness. Ground-

breaking research on pricing, value chain and service delivery in the water resource management arena is required for financial sustainability at a national level. Research in this KSA will highlight the emerging trends and reflections from the implementation of the NWA to date: what has worked and what has not. This can be achieved by exploring scenarios and by making future projections for policy review and bench-marking. Furthermore, a comprehensive and integrated monitoring and regulatory framework must be in place in order to achieve decentralisation and delegation of authority to local water management institutions. Compliance and enforcement of provisions in the Act exacerbate an already stretched sector whose absorptive capacity for research findings is limited. Internationally shared water remains a strategic focus with particular research needs, and with emphasis on defining the suitable pathways for engaging local management institutions without compromising the sovereignty rule.

Other key issues informing the research addressed by this KSA are issues related to climate change. Climate change and hydroclimatic variability can have serious implications on the triple bottom line (environmental sustainability, economic growth and social justice) and on sustainable development. The conjunctive use of surface water and groundwater should filter down to addressing seamless research needs for both social and economic development.

Objectives

The primary objective of research in this KSA is to ensure that the water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The secondary aims have been streamlined to reflect the needs analysis process. Thus, the revised aims to support the primary objective are to:

Develop a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa

Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (including the understanding of the impact on human health)

Provide control measures for improving the prevention, mitigation and control of pollution of water resources

Support and improve policy reforms for promoting equitable, efficient and sustainable conservation and allocation of water resources among competing needs.

In view of the above revised aims, the thrusts have been realigned as follows:

- Thrust 1: Water Resource Assessment and Planning
- Thrust 2: Management of Natural and Human-Induced Impacts on Water Resources
- Thrust 3: Water Resource Protection
- Thrust 4: Water Resource Institutional Arrangements

Thrusts and Programmes

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Scope: This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning. The thrust will promote better understanding of the variability of the quantity and quality of water available for use and further development in South Africa. Recent changes in national water resources infrastructure management, the awareness of the poor state of water resources infrastructure and increased knowledge of water resource planning needs are expected to receive attention, through the support of competent and sustainable solutions. Sound water resource assessment and planning can only be achieved with reasonably accurate and consistently recorded and processed data and information. The thrust will support the implementation and use of a national water resource information system.

- Catchment data and information systems
- Surface water / groundwater hydrology
- Water resource planning
- Water resource development
- Climate change and hydro-climatic variability
- Water resource quality management

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Scope: Research in this thrust focuses on developing appropriate understanding, tools and strategies for managing the impacts of climate variability and change as well as human interventions on the hydrological cycle and related water resources, with the aim of supporting the development of policy responses, at regional, national or catchment scale, to existing and emerging problems. This includes development of systems (e.g. river flow and inundation forecast models, drought-impact monitoring systems) for the management of floods and droughts.

- Developing mitigation and adaptive measures for global climate change
- Human-induced effects
- Integrated flood and drought management

THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow reduction processes as well as other physical processes such as sediment accumulation.

- Protection and management of surface water and groundwater quality

- Urban and rural water resource management
- Integrated river flow and catchment hydraulics

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders based on catchment and water management area boundaries. The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of integrated water resource management (IWRM). The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust supports research on tools and methodologies for IWRM decision support which aims to provide strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures for implementing IWRM through:

- Institutional governance and reforms
- Compliance and enforcement
- Pricing and financing of IWRM
- Transboundary water resources
- Future scenarios

Research Portfolio for 2008/09

From the needs analysis, the KSA will actively pursue the full articulation of the coming new challenges in water resource management. These challenges are not necessarily new but can be viewed in different combinations each year and with newly-defined priorities. The management of related hazards such as floods, droughts, erosion and various kinds of pollution should be factored into any integrated approach to water resource management and related policies. Competition over scarce or inequitably allocated resources can lead to tension and insecurities. Strategies for reducing demand, increasing efficiency, etc. will be important research topics fully aligned to the flagship programme of the Minister of Water Affairs and Forestry. Valuing water in the South African context can be complicated due to the prevalent inequities in distribution of the resource and the larger poorer population whose ability to pay for water is limited. In all of the above, the need to safeguard society and the economy through early warning systems has been identified. Research results need to be shared and communicated effectively to be optimally used for the benefit of South Africa and further afield. Finally water governance, which has received a lot of attention recently, continues to occupy centre stage in the DWAF-identified list of priorities and in the research portfolio for the coming years as well.

During the past funding cycle the research community was given an opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. This year's plan was informed by the recent external Institutional Review of the WRC and the needs expressed by the Minister of Water Affairs and Forestry as well as other consultations with government and various institutions and individuals. Continued consultation with stakeholders at local and regional levels is of vital importance to identify future research needs and priorities.

Budget for 2008/09

The approved funding of the research portfolio for 2008/09 led to a committed funding budget of R19 913 729. Funding of R7 758 500 in 2008/09 was requested to support new projects within the 4 thrusts. The proposed new projects will continue to develop tools, technologies and guidelines that are necessary to support sustainable water resource management.

Core Strategy

Strategic context

Nothing is more fundamental to life than water. Not only is water a basic need, but adequate safe water underpins the nation's health, economy, security, and ecology. The strategic challenge for the future is to ensure adequate quantity and quality of water to meet human and ecological needs in the face of growing competition among domestic, industrial-commercial, agricultural, and environmental uses. To address water resource challenges which are likely to emerge in the next 10 to 15 years, decision makers at all levels of government will need to make informed choices among often conflicting and uncertain alternative actions. These choices are best made with the full benefit of research and analysis. It is therefore of great importance that the nation will continue to invest not only in applied research but also in fundamental research that will form the basis for national implementation of water sector projects.

The management of water resources continues to be a high priority in South Africa. At a national level the recent momentum towards establishing economic growth and development as the main government driver has seen different sectors, including the water sector, articulating their roles in economic growth and development. In the water sector this is reflected in the DWAF strategic plan for the year 2008/09 where the main objective for water resource management is set to ensure that water resources are allocated for the promotion of social and economic development. In this KSA research has already begun, and will continue, to address the research issues that will contribute to this government driver of Water for Economic Growth and Development. The KSA's research will also continue to contribute to previously-supported ongoing research issues affecting all KSA stakeholders. The KSA will place special emphasis in the following areas as well as strengthening research that addresses issues in these areas:

- The support of institutional reforms: the water law compendium, which consists of some 350 water-related court cases that have been compiled from 1912 to 1998, has been a project targeted at improving the DWAF programmes on water allocation reform (WAR) – imperatives which are part of the initiative of Water for Economic Growth and Development. The compendium of water-related court cases is an instrument that is targeted at supporting water use verification for various purposes.
- Water resource accounting is expected to benefit from improvements in the accuracy and detail of measurements and how these are interpreted in water resource simulations and other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes can only suffice if real, reliable data are available at reasonable spatial and temporal resolutions for verifications. The KSA has invested vastly in enhancing the estimates for quantifying water use and water availability. This year, the KSA also contributed to

the streamlining and integration of existing water resource information systems. Research that sought to provide appropriate platforms for CMAs to collect, capture, process and utilise data in support of the national information systems was supported through the KSA's research.

- The imminent dangers posed by degraded water resource infrastructure will be investigated and solutions developed to ensure that the existing and new programmes on infrastructure reconstruction and maintenance at national level are comprehensive
- The deteriorating quality of water resources including water in some of the major rivers, dams and aquifers has continued to threaten the efficient and sustainable supply of reliable water to various sectors. Previous research has identified a number of water quality challenges. The KSA will seek to support research that addresses the challenges surrounding the provision of suitable and sustainable solutions for addressing water quality issues at the resource level.
- The evidence of global climate change, largely as a result of human activities, has now been documented. There is a growing consensus among global climate model projections regarding the nature and extent of the change. The main climate change consequences which are related to water resources have been identified as increases in temperature, shifts in precipitation patterns, increased frequency and intensity of floods and drought events, and sea-level rise.
- The KSA has initiated a comprehensive research programme on climate-change impacts on water resources with a view to gaining insight into the magnitude of the impacts and the consequential adaptation needs in the sector. Subsequently, the first steps to incorporate research on vulnerability, mitigation and adaptation have already been taken. The success of this research relies on the outcomes of considerable prior investment by the WRC in water-related climate, atmosphere and ocean-atmosphere research, as well as hydrological modelling research, done over a period of more than 15 years. The KSA will seek to drive further research on climate change to deal with regionalisation of climate change knowledge as well as improving the modelling processes to account for conditions that are consistent with the Southern African region.

In addressing existing and new research issues, the KSA will also attempt to deal with existing questions and other areas where solutions are pending:

- Can the reallocation reform (WAR) imperative satisfy the constitutional rights for clean water to all and meet the country's economic growth target of 6% per year?
- Will the rainfall-monitoring networks of 1 station in every 450 km² instead of every 25 km² provide adequate data to generate competent solutions for decision making that will satisfy the water quality and quantity needs of people, economy and the environment?
- What will the impact of climate change be on the people, economy and our society? How will the negative impacts be forecast, mitigated and reduced?

Thus, in line with WRC aims, this KSA aims at providing the country with applied knowledge and water-related innovation, by translating needs into research ideas and, in turn, by transferring research results and disseminating knowledge and new technology-based products and processes to end-users.



Needs analysis

The working approach for setting and overseeing the water resource research agenda is based on the following principles:

- An effective alliance with, and active participation of, water resource research stakeholders
- A systematic, strategic, and balanced agenda of both core and problem-driven research priorities set to meet short- and long-term needs
- The national water resource research effort should be coordinated to reduce needless duplication and to ensure that gaps do not occur
- Research should be multidisciplinary and interdisciplinary
- Research should be proactive and anticipate the nation's water needs and the environmental impacts of management options
- Research should be accountable to the public to assure that the water resource research investment has been appropriately utilised to meet the nation's needs

In the current situation where demand for water increases, the impact of climate change intensifies and storage sites reach capacity, South Africa is looking to new strategies that reduce demand, increase efficiency, provide for reuse of wastewater and allow for water trading. The knowledge emanating from research undertaken by this KSA aims to inform the decision process regarding where and how to best invest in these options and provide enabling technologies. The methodologies followed in this needs analysis process are varied and include:

- Stakeholder workshops
- Documents, e.g. National Water Resource Strategy
- Focal group and individual interviews
- Interpretation and reinterpretation of research outcomes
- International/regional forums
- Strategic studies

Some of the pertinent issues related to the development of the research portfolio are:

Managing risks

Water-related hazards, such as floods, droughts, tropical storms, erosion and various kinds of pollution should be factored into any integrated approach to water resource management and policy. Although it is the world's poor who suffer the most when exposed to such dangers, everyone's security is at stake. One way to minimise risk is to develop more capacity in the monitoring and forecasting of extreme events. With this information, appropriate early warning systems and infrastructure can be installed, and new planning strategies devised. It is also necessary to ensure that climate variability and change have their place in the total picture.

Sharing water resources

Competition over scarce or poorly-allocated resources can lead to tension and insecurity. Therefore decision-makers, communities, governments and regions must strive to develop policies that allow for sharing among all stakeholders. Many different interests are at stake and equitable solutions must be found: between cities and rural areas, rich and poor, arid lands and wet lands, public and private, infrastructure and natural environments, mainstream and marginal groups, local stakeholders and centralised authorities. At the regional and international level, many river basin and aquifer authorities are developing integrated approaches that stress cooperation of the shared resource.

Valuing water

This whole question is among the most controversial of all the challenges identified in the Ministerial Declaration emerging from the 2nd World Water Forum in The Hague. In many societies the whole notion of putting a price tag on something as intrinsically valuable as water is unacceptable. Yet services must be paid for. There is also much disagreement about how to balance the costs of provision and wastewater treatment with the goal of equity and finding ways to meet the needs of poor and vulnerable populations. Creative new partnerships between the public and private sectors should be developed, along with accounting and taxation systems that take full account of environmental and social factors.

Ensuring the knowledge base

This target takes account of the whole range of technical and non-technical information and knowledge, and seeks ways for all societies to benefit from their development, exchange and dissemination. National authorities and resource managers need sound scientific data on which to base their projections and decision-making. Stakeholders need access to other kinds of information and educational opportunities if they are to understand and participate in the process as responsible citizens. With the development of modern telecommunications and the global marketplace, it is more necessary than ever to ensure that every community and country play a role in building a more sustainable future.

Governing water wisely

This challenge area is particularly complex and sensitive. It moves the debate about sustainability beyond water management issues and into processes of political, social and institutional change. Many countries agree that good governance means allowing every sector of society to participate in the decision-making process and that the interests of all stakeholders should be taken into account. However, mechanisms for doing so are not always in place, even if decentralisation and the increasing involvement of civil society are worldwide trends. International cooperation and assistance may play a crucial role – particularly in developing countries – by helping to strengthen institutional capacity.

Research needs/issues

- Support the national information systems on water resources, improving the available water resource information, enabling better management of information and enhanced information dissemination to stakeholders, especially CMAs
- Integration of surface water and groundwater assessments, explorations, planning and management
- National infrastructure development and management needs to meet the national growth target of 6% of GDP per year
- Impacts of climate change on people, the economy and the environment
- Adequate forecasting for flood management and disaster mitigation and preparedness
- Water quality control, mitigation measures in support of municipalities
- Evaluation and mitigation of the health impacts from human activities on surface and groundwater
- Groundwater contamination impact on communities relying on groundwater resources for drinking water
- Challenges for sustainability of urban systems

- Institutional arrangements for regional water resource development to meet the Millennium Development Goals
- Decision support systems for CMAs
- Alignment of catchment management strategies, local economic development plans, IDPs, etc.
- Water use charges and the sustainability of water management institutions
- Benefit sharing in the management of transboundary waters

The National Water Resource Strategy (NWRS) is a guiding document to defining research requirements in this KSA. The NWRS is required by the NWA. The NWRS provides information about ways in which water resources will be managed, including the institutions to be established. It must also provide quantitative information about the present and future availability of, and requirements for, water in South Africa. This must be done for each of the water management areas, and propose interventions by which the two may be balanced ('reconciled'). This Strategy must also quantify the proportion of available water in each water management area which falls under the direct control of the Minister in terms of her or his national responsibilities. Research cannot provide management and immediate policy decisions. These have to be made on the basis of available information. However, the NWRS requires better information and improved information analysis tools that will allow detailed examination and evaluation of the consequences of the various policy and management options. This KSA will support the implementation of the NWRS in the following broad ways:

- Through integrated water resource assessment (developing knowledge of the different components of the resource in terms of quantity and quality and its condition in relation to reference conditions)
- By developing and refining tools and methods to support implementation of RDMs and SDCs
- By providing greater understanding of threatening processes to water resources such as global climate change, water resource degradation, over-commitment of the resource, and impacts of land use and water storage and diversion on the water resource
- By providing tools for the assessment of policy and management options (such as re-allocation of water between users, modelling, decision-support systems, and predictive tools)
- By providing data and tools for assessment of the progress of resource management programmes, and their successful refinement
- While providing research support to implement the NWA is crucial to the KSA's business, this KSA needs to support water resource management actions at global, regional and local level

The *United Nations World Water Development Report 2: Water, a Shared Responsibility* of 2006 describes the main priority water resource issues as presented below:

- 'The world is not running out of water, but many millions of its most vulnerable people live in areas subject to mounting water stress.
- Some 1.4 billion people live in river basins in which water use exceeds recharge rates.
- The symptoms of overuse are disturbingly clear; rivers are drying up; groundwater tables are falling and water-based ecosystems are being rapidly degraded.

- Far more also needs to be done in the face of the threats to human development posed by climate change. This is not a future threat; global warming is already happening and it has the potential in many countries to roll back human development gains achieved over generations.
- Reduced water supplies in areas already marked by chronic water stress, more extreme weather patterns and the melting of glaciers are part of the looming challenge.
- The competition over water will intensify in the decades ahead. Population growth, urbanisation, industrial development and the needs of agriculture are driving up the demand for a finite resource.
- Meanwhile, the recognition is growing that the needs of the environment must be factored in to future water use patterns.
- Two obvious changes emerge: as national competition for water intensifies, people with the weakest right, small farmers and women among them, will see their entitlements to water eroded by more powerful constituencies.
- Second, water is the ultimate fugitive resource, traversing borders through rivers, lakes and aquifers, a fact that points to the potential for cross-border tensions in water-stressed regions. Both dangers can be addressed and averted through public policies and international cooperation.'

It is clear that the outcomes of the above *Development Report* reinforce the locally-identified issues presented above. These outcomes will also assist in identifying future research projects and programmes (including priority-setting). The KSA aims to continue to be proactive and responsive to the water resource management needs in South Africa.

Overview of technological trends

Research on water resource management, especially water resource assessment studies, has been characterised by the general trend towards improving the levels of detail and accuracy in water resource observations and modelling techniques. A number of projects have been initiated to address knowledge gaps in water resource processes and how these can be simulated in areas that are deficient in data and information. Some current and potential research projects can identify technological advancements in the field of water resource management as a whole. Some of the areas that have been locally and internationally developed recently include the following:

Isotope hydrology

Isotope hydrology has evolved into a multidisciplinary field. As new approaches are developed, new applications and tools are being added to the isotope toolbox. For example:

- Boron isotopes can now be used to identify traces of sewage pollution in groundwater
- Chlorine isotopes can supply information about the origin of the salinity and the complexities of flow in large, slow-moving groundwater systems. They can estimate the age of water and may indicate the size of a reservoir.
- Methods are now further refined for the measurement of isotopes like krypton-85 and helium-3 for determining the age of young water and the origins of fluids
- Traces of now-banned chemical species such as freons can be employed as environmental tracers of surface pollutants in shallow groundwater



Among the key challenges in future isotope applications are:

- Developing approaches to address the water problems of mega-cities
- Responding to the complex and deepening crisis of environmental pollution
- Contributing to understanding global climatic change
- Advancing professional sophistication in the practical application of isotope techniques
- Raising awareness of the role of isotope techniques in water resource management and geothermal energy resources

Nanotechnology

The use of nanotechnology could play a large role in averting the potential future water crisis. But hoping that the 'magic' of nanotechnology will solve all water problems is naive – the basic problems of accessibility to technologies, affordability, and fair distribution still need to be solved. Nanotechnology can provide important opportunities for the South African water resources:

- Detection of chemical and biological substances: metals (e.g. cadmium, copper, lead, mercury, nickel, zinc); nutrients (e.g. phosphate, ammonia, nitrate, nitrite); cyanide; organics; algae (e.g. cyanobacterial toxins); viruses; bacteria; parasites; antibiotics; biological agents; etc.
- Decontamination of the above-listed substances. For example, nanoparticles of gold coated with palladium are very effective catalysts for removing TCE from groundwater – 2 200 times better than palladium alone, and photocatalytic nano-materials allow ultraviolet light to destroy pesticides, industrial solvents and germs
- Purification and filtration of water for drinking purposes, such as through nano-scale membranes or using nano-scale polymer 'brushes' coated with molecules that can capture and remove poisonous metals, proteins and germs
- Desalination to remove dissolved salts from seawater, brackish water and wastewater

Nanotechnology can be applied to instrumentation that will have the following attributes: rapid response time, real-time measurements, high sample throughput, portability – for on-site analysis, multi-parameter, simple design, easy to use, low detection levels and large working range. Interest is rapidly increasing for the use and application of nanotechnology within the water industry.

Remote sensing

Data monitoring using remote sensing is undergoing a revolution in terms of technical monitoring capabilities through the advances in spatial and spectral resolution of new sensors. The continuing improvements to the analysis are also expanding the level of detail that can be extracted from imagery. One of our research projects is now applying hyperspectral imagery to accurately estimate evapotranspiration, plant water content, water stress and plant- or soil-water availability. Unlike low spectral resolution imagery which covers only selected regions of the electromagnetic spectrum, thus giving more generalised products, high spectral resolution imagery covers a wide region of the electromagnetic spectrum (approximately 400 to 2 500 nm). This gives more spectral bands with finer bandwidths (generally less than 10 nm). The finer spectral resolution allows for detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

Satellite radar tools and applications

Satellite radar has become more widely available and used in

evapotranspiration and water use monitoring. Our research has continued to improve and investigate new techniques for improving measurements and estimates of evapotranspiration and other variables in the water balance. Most of our users are, however, still stuck in the use of outdated and less reliable sources of information such as open water evaporation data. Our research on evapotranspiration is now looking at how the knowledge gained can be incorporated in some of the commonly-used water management tools. Water legislation and management guidelines are clearly showing that spatial processes such as those in water catchments and in land-use management practices will be driven by remotely-sensed data in the future. In July 2006 the South African cabinet approved the establishment of South Africa's first space agency, an initiative that heralds the wider development of many local and new research activities around satellite development and satellite data applications.

Scenario building as a tool in water management

Scenarios are a way of developing alternative futures based on different combinations of assumptions, facts and trends, and expose areas where more understanding is needed for your particular scenario project. They are called 'scenarios' because they are like 'scenes' in the theatre – a series of differing views or presentations of the same general topic. Once several scenarios are produced at the same time, one can better understand the available options or possibilities for informed decision making in the management of water resources.

Key stakeholders

The major stakeholders remain as follows:

- The Minister of Water Affairs and Forestry as the shareholder
- Government departments representing a major group that has a large stake in the research conducted, especially DWAF which represents the water resource managers and planners, i.e. all those entrusted with developing and allocating water resources to meet the needs of the environment and various users
- Other government departments such as the Department of Minerals and Energy (DME), the Department of Science and Technology (DST), the Department of Provincial and Local Government (DPLG), the National Department of Agriculture (NDA), the Department of Health (DoH), the Department of Education (DoE), the Department of Environmental Affairs and Tourism (DEAT) and the Portfolio Committee on Water represent the other stakeholder group.
- Major water users including farmers, mines, industries, water service providers and civil society
- South Africa shares many rivers with its neighbouring countries, therefore, the governments and major water-user groups from these countries constitute the 4th group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.

Providers of research

Most of the research supported and funded by this KSA is conducted by universities, science councils and consulting firms. These role-players either contribute to the execution of the research and/or represent the private research institutions such as the petroleum industry, paper industry, energy, sugarcane, forestry and the information technology industry, such as Siemens.

Strategic Initiatives

National initiatives

Staff members continue to undertake various leadership positions (many positions are ongoing or set for a term of a number of years). Climate change as a strategic focus point had a fair share of local initiatives. The following are contributions made by the KSA:

- The KSA participated in the National Climate Change Committee which is a non-statutory stakeholder body that advises the Minister of Environmental Affairs and Tourism on climate change issues at national and regional level. WRC participation will ensure contextualisation of WRC activities within the broader national climate change agenda.
- The KSA supported the DST with the water aspects of the climate change component as part of the Global Change programme that was initiated in 2008
- The KSA is a member of the DWAF Climate Change Think Tank under the chairmanship of the Director-General of DWAF
- The KSA prepared the document in preparation of a high level Dialogue (that was markedly on adaptation to climate change at regional level, e.g. SADC) on behalf of the DWAF Director-General prior to the 5th World Water Forum
- The KSA participated in the *Climate Change Summit* held on 3-6 March 2008 in Johannesburg; the WRC had a stand displaying knowledge relevant to climate change
- Inputs were made by the KSA to the climate change section of the 7th edition of *Water for Growth and Development* presented at the Summit on 26-27 March 2009

In other areas of research interest, the KSA made contributions that have national significance, such as:

- Cyanonet initiative to collaborate with DWAF on cyanobacteria blooms and to establish a web-based identification system
- The KSA initiated research into the problem of cyanobacterial blooms and animal deaths in the KNP (Kruger National Park) through its project with the Agricultural Research Council (ARC) – Veterinary Institute
- The KSA participated in the development of a cyanobacterial management and monitoring plan for KNP, as well as the identification of the cyanobacteria strains
- Member of DWAF project steering committee for the 'Vaal River System: Development of an Integrated Water Quality Management Plan Study'
- Member of DWAF project steering committee for the 'National Eutrophication Monitoring Programme'
- Member of DWAF project study team for the 'Development of SA Risk-Based Water Resource Quality Guidelines'
- Member of DWAF project steering committee for the 'National Radioactivity Monitoring Programme'
- Member of the DWAF's flagship project on 'Water Allocation Reform'
- Steering committee member on the drafting of a 'National Groundwater Strategy' (DWAF)

Leadership positions

- Council member of the Water Institute of Southern Africa (WISA).
- Interim Chair of the Groundwater Division of the Geological Society of South Africa (GSSA)
- Board member of Monash University
- Board member of EcoLink NGO

- Chair of TIGER initiative on the use of earth observation satellite tools
- Secretariat for UNESCO IHP (International Hydrological Programme)
- Steering committee member of NIP (National Implementation Programme) of the Stockholm Convention on the POPs (Persistent Organic pesticides)
- Awarded Senior Fellow status by WISA, 21 May 2008

The WRC continued its involvement in a number of existing national initiatives and has spearheaded new initiatives where the WRC plays key roles.

Public appreciation

An impact study on the WRC's role in building capacity in the groundwater sector commenced during 2008/09 and is intended to be finalised in the following year. This investigation will be part of a series of studies that will assess the impact of this KSA's research investment in the South African water sector.

Other activities included:

- Launching of the coffee table book *Rivers and Wetlands of Cape Town: Caring for Our Rich Aquatic Heritage*
- A lecture was presented on South Africa's water quality and emerging issues to students enrolled for an M.Sc. in integrated water management at the University of Pretoria, thereby helping to ensure that the future generation of water resource managers is sensitive to water quality issues and WRC activities
- A presentation was made on the impact of climate change on groundwater at the University of the Western Cape during an IWRM course in March 2008

African leadership

- The KSA co-organised a workshop on hydropower and water resources together with the South African Academy of Sciences and other African Academies of Sciences
- Based on a strategic agreement with IWMI (International Water Management Institute), the KSA managed the financials for WaterNet
- Participated in the Colloquy on Sustainable Mining organised by the German Embassy with a view to remain informed about German research initiatives and potential WRC participation
- The WRC publication **Protocol for the Assessment of the Status of Sustainable Utilisation and Management of Groundwater Resources with Special Reference to Southern Africa (WRC Report No. TT 318/08)** is now being used as a base for several SADC, African and AMCOW initiatives
- The UNEP Africa Water Assessment of vulnerability due to climate change, a study/publication initiated and endorsed by AMCOW and other African leader groupings
- The South African Academy of Sciences through the support of the WRC has been identified to act as the coordinator/facilitator to strengthen other African Academies participation in the Inter Academy Panel: Water Programme
- The project African Water funded by the EU has been finalised which entailed a number of workshops introducing Framework Programme 7 to African countries

International player

- The WRC continues to support SAFeWater (the French-South African cooperation for research on water). A mid-term review was held in March 2009 where plans and future ideas for a follow-on phase were discussed with DST and the French Embassy in South Africa.
- Collaboration with the North-South Centre, ETH, Zurich, Switzerland. This collaboration was established during 2007 and included a number of visits and meetings with the Director of the Centre as well as other academic and other Swiss research organisations such as Swiss Federal Institute of Aquatic Science and Technology (EAWAG).
- EU-South Africa Side-Event: The KSA was part of the WRC delegation which supported the DST in the development and facilitation of a Side Event on Water Research for Sustainable Development, during the South Africa – European Union Summit, Bordeaux, France.
- Participation in Water Expo – Zaragoza, Spain and related activities; The KSA, by invitation, delivered a talk on the South Africa case study in the Federal and Federal-Like Systems for Water Management held in Zaragoza, Spain and hosted by the University of Zaragoza. The papers will be published in English and Spanish.
- The collaboration and participation with the Global Water Research Coalition (GWRC) in the development of a method to detect BMAA, a neurotoxin associated with algae in water sources, has again positioned South Africa as a leader in algae research, and the researcher was invited by several international specialists to their laboratories after a paper on the method (developed at Nelson Mandela Metropolitan University) was presented at an international conference in the USA
- Participated in the development of the GWRC International Cyanobacteria guideline by writing two of the five chapters
- The KSA made 3 presentations during the 5th World Water Forum (a paper on development of a toolbox for climate change adaptation action at local/community level; a presentation at the invitation of Prof. Jochen Froebrich from the Centre for Water and Climate of the Wageningen University from The Netherlands; a paper on the institutional aspects of water as a human right on the invitation of UNESCO)
- South Africa – Germany cooperation on water in the environment with specific emphasis on mining impacts on groundwater. Key partners on the South African side are the WRC, Council for Geoscience, CSIR and Tshwane University of Technology.
- Organised and facilitated the *UNESCO Capacity Building Africa Regional Workshop* in Port Elizabeth as part of the UNESCO IHE (International Hydrological Programme) Secretariat activities. The workshop was co-hosted with the DWAF and in tandem with the *Implementing Environmental Water Allocations* (IEWA) held and hosted by the WRC and numerous other partners.

Growing the Knowledge Base

Capacity building initiatives

Table 1 illustrates the number of postgraduate students who benefited from WRC-funded research in this KSA in 2008/09. This is in line with the set targets.

TABLE 1
Capacity building through student involvement in KSA 1 projects in 2008/09

Organisation/institution	No. of historically-disadvantaged (HD) students	Total No. of students
Agricultural Research Council (ARC)	0	1
Central University of Technology, Free State	1	2
Conningarth Economists	5	5
CSIR	6	10
Geoscience	4	4
GEOSS	1	2
Groundwater Africa	0	1
Monash South Africa	2	5
Ninham Shand	1	6
North-West University (NWU) (Potchefstroom campus)	0	1
Pegram and Associates	0	3
Rhodes University (RU)	3	3
Source Strategic Focus (Pty.) Ltd.	3	3
SRK	1	2
University of Cape Town (UCT)	6	11
University of the Free State (UFS)	10	16
University of KwaZulu-Natal (UKZN)	15	28
University of Pretoria (UP)	14	19
University of Stellenbosch (US)	9	20
University of the Western Cape (UWC)	6	8
University of Venda (UV)	4	4
TOTAL	91	154

In total 25 project leaders are women (in 07/08 the total was 16) and 9 project leaders are Black males (9 in 07/08). This figure represents approximately 35% and 13%, respectively, of total projects (24% and 15%, respectively, in 2007/08).

The KSA participated in a number of initiatives contributing to the water-centred knowledge base in South Africa. The following **technology transfer workshops** were held in support of research outcomes:

- *Knowledge Cafés* were conducted in tandem to create platforms for dialogue between civil society, researchers and policy makers
- Workshop on the *Lowest Appropriate Level for Governance* was held in partnership with the University of the Western Cape
- Workshop on the *Criteria for the Success of Women in the Water Sector*, held at the WRC, Pretoria
- Workshop on climate change research agenda for the next 10 years
- Workshop on the *EDC Bio-Assay Toolkit* developed in collaboration with the GWRC, University of Pretoria
- Workshops held at *WISA 2008*, Sun City, included the EDC research programme and project awareness campaign and the presentation and discussion of 'Development of a Conceptual Framework for Integrated Water Quality', another WRC-funded project
- Inception workshop for Project No. 1843: 'An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments' to clarify tasks, methodology and initial catchment selection
- Workshop to discuss a WRC project dealing with water quality and quantity of the Waterberg coal reserves
- Workshop to finalise workplan and interaction between participants of Project No. 1849 'Management of human-induced salinisation in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity'
- Half-day workshop followed by the Reference Group Meeting on the *South African Handbook on Hydraulics*, Stellenbosch University
- Workshop on a *Methodology for Near-Real Time Spatial Estimation of Evaporation*, University of KwaZulu-Natal
- The KSA organised 3 workshops on *Light Non-Aqueous Phase Liquids* with the Institute for Groundwater Studies, which were held at the WRC (Pretoria), Durban and Cape Town
- A training course on *Modular Modelling Systems* presented by Dr G Levesley (United States Geological Survey)

Knowledge dissemination

This KSA has put great effort into the dissemination of WRC-related knowledge. Knowledge dissemination has successfully taken place through the publication of scientific articles, software, guidelines and 32 technical reports, and the presentation of at least 15 conference papers, 7 training courses and at least 15 workshops.

Conference presentations, publications and other activities by staff members

During the course of 2008/09, staff participated in both the WRC Open Days. Other activities included:

- 'National Water Act review', presentation made to parliament.
- 'Human capital development in the water sector', presentation made at the *Knowledge Week* organised by the DBSA

- 'The role of the WRC in capacity building', a presentation made at the UNESCO regional workshop
- 'Water as a human right', presentation made at the *5th World Water Forum*
- 'Knowledge and Capacity Development for Growth and Development: The role of the Water Research Commission' – opening address at the *EnviroWater Conference*
- Another presentation was made at the *EnviroWater Conference* in Stellenbosch on the research on water quality
- 'Capacity-building for IWRM in Africa' at the IWRM training course, Cape Town
- 'The Water Research Commission: A suitable model?' Presented at the SADC *Groundwater in IWRM* initiative
- 'Groundwater exploration' lecture given as part of a Groundwater Division course.
- 'The South African water reforms and their contested implementation', a presentation made to SaciWATERs (South Asian Consortium for Interdisciplinary Water Resources Studies), Sri Lanka
- Keynote presentation at Pan African Environmental Mutagen Society (PAEMS) international conference in Cape Town, on the WRC research programme on toxins and EDCs
- A poster was presented at the *International Water Association (IWA) World Water Conference*, Vienna, on the EDC research outcomes and the precautionary principle
- A 2-week seminar in Rome, Italy, at the International Development Law Organisation (IDLO) on climate change and law
- Reviewer for *Hydrogeology Journal*
- *Water SA* Special Issue – Guest Editor and Guest Editor-in-Chief for a special KSA1 issue based on the IWRM conference held in March 2008
- 'The role of the WRC in development in South Africa', presentation made to the African Academies of Science
- The KSA acts as an external reviewer for UNESCO IHE Partnership Research Fund (UPaRF)
- External examiner for the University of KwaZulu-Natal and the University of Pretoria
- Regular biannual lectures are delivered to the North-West University (Potchefstroom campus) on IWRM and Introductory Geohydrology as an outreach service

Implementation Plan

Research portfolio for 2008/09

The primary objective of the research in this KSA for 2008/09 remains largely the same as developed in the business plan for the previous year, which is to ensure that water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research portfolio for 2008/09 addressed this primary objective, as reflected by the following secondary aims to:

- Improve water resource information systems and access to data
- Achieve integration between surface and groundwater research. A programmatic approach will be designed addressing the need for joint studies.
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impacts on humans)



- Broaden the scope for policy and institutional studies to deal holistically with the legal, economic, compliance and implementation aspects

The research portfolio for 2008/09 is presented in Table 2, which provides an overview and description of research thrusts and programmes.

TABLE 2
Overview and description of thrusts and programmes

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Scope: This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning. The thrust will promote better understanding of the variability of the quantity and quality of water available for use and development in South Africa. Recent changes in national water resource infrastructure management, the awareness of the poor state of water resource infrastructure and increased knowledge of water resource planning needs are expected to receive attention, through the support of competent and sustainable solutions. Sound water resource assessment and planning can only be achieved with reasonably accurate and consistently recorded and processed data and information. The thrust will support the implementation and use of a national water resource information system.

Programme 1:
Catchment data and information systems

Scope: This programme will support the provisions of Chapter 14 of the National Water Act, especially Part 2: National Information Systems on Water Resources. This programme is focused on supporting the national initiative for improving the available water resource information, better management of the information and improved information dissemination to stakeholders. It will establish direct linkages to the national information systems as well as identifying and resolving water resource information gaps. In this programme researched water resource information will be integrated into the national information system that is being established by DWAF. The programme will also support the process of decentralising identified water resource data and information from broader national perspectives to detailed and highly resolved local and catchment scales.

Programme 2:
Surface water / groundwater hydrology

Scope: This programme focuses on developing and utilising integrated hydrological approaches in surface water and groundwater assessments, water resource explorations, planning and management. It will take advantage of gains made in improved understanding of groundwater and surface water hydrological processes as well as the availability of better hydrological data, especially the various forms of more accurate remotely-sensed data with better coverage. Through this programme, strategic partnerships with international expertise in both groundwater and surface water hydrological research will be encouraged to flourish. Hydrological tools that have been developed in the past are expected to be upgraded, redeveloped or replaced by tools that are more suited to the current data availability, the improved knowledge and the recent technological advances in hydrological modelling.

Programme 3:
Water resource planning

Scope: This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities, and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps, such as the absence of reliable information in ungauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water systems plans that will benefit from real time, historic and stochastic data on a countrywide basis. Impacts of climate change on water resources and the planning processes will be accounted for so as to ensure a proactive approach and allowing for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs which have to account for other factors such as national strategic importance, poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals.

Programme 4:
Water resource development

Scope: This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges and economic growth target of 6% of GDP per year will require thorough understanding and assessments of alternative sources of water. Such sources could be built into future projections for new water, virtual water, water transfers – be they national or international, desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. Effort will be applied to the development of solutions for supporting and complementing the processes and strategies pursued by the Water Infrastructure Agency.

Programme 5:
Climate change and hydro-climatic variability

Scope: The goal of this programme is to better forecast the variability of rainfall, flow and groundwater recharge. The ability to forecast at very short time scales (48 hours down to a few hours ahead) would greatly benefit flood management and disaster mitigation activities. At longer time scales (e.g. inter-annual or seasonal scales) the ability would greatly assist decisions concerning seasonal water allocation to various users and the environment. Forecasting models range from the empirical (based on statistical relationships which use various oceanic and atmospheric predictors) to the mechanistic (based on the use of dynamic models encapsulating best understanding of influential atmospheric and oceanic processes). This programme will also seek to improve the understanding of climate change for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and mitigation. Through this programme support will be provided for weather and climate disaster mitigation programmes at various levels which will include regional, national, provincial as well as other more localised scales.

Programme 6:
Water resource quality management

Scope: The quality of water is an important factor in determining the quantity of water that is potentially available for productive use. Determining the amount of water available for different uses is further complicated by the considerable variation that exists in quality requirements between and within different user groups. This programme is aimed at developing and refining fitness-for-use criteria, developing the means to monitor and assess water quality at regional and national levels, improving the manner in which water quality information is conveyed and the identification of emerging water quality issues. The programme also seeks to investigate and apply water quality control and mitigation measures.



THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Scope: Research in this thrust focuses on developing appropriate quantitative understanding, tools and strategies for managing the impacts of climate variability and change as well as human interventions on the hydrological cycle and related water resources, with the aim of supporting the development of policy responses, at regional, national or catchment scale, to existing and emerging problems. This includes development of systems (e.g. river flow and inundation forecast models, drought impact monitoring systems) for managing floods and droughts. The focus in this thrust is on the prediction of climate change consequences, the mitigation of floods and droughts and the effects of those on the resources and the people who rely on these resources, with special emphasis on the health impacts from microbial contaminants.

Programme 1: Developing predictive tools and adaptive measures to global climate change

Scope: The need to prepare the country to cope with global climate change is of paramount and strategic importance. Taking the view that water is South Africa's key resource implies the need to adapt water resource management progressively as global climate change progresses, in order to maintain optimal levels of both resource protection and beneficial use of water for society. The development of coping strategies will require the development of informed, quantitative scenarios of potential impacts at regional and catchment level on rainfall regimes and rainfall variability, hydrological and geohydrological regimes, water availability and reliability, water quality, ecosystem structure and functions and ecological processes. The following key questions thus need to be considered and addressed in this programme: What confidence can be placed in current General Circulation Model-generated scenarios of global climate change? How reliable are current techniques for the downscaling of scenarios from global to regional and catchment scales? At which point will anthropogenic climate change in the Southern Africa context become detectable and distinguishable from natural climate variability and which monitoring systems need to be in place in this regard? How will the frequency and magnitude of extreme rainfall and flow events be affected? Can existing conceptual and numerical models utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely inter-related land use, ecosystem, hydrological (including geohydrological), water yield and water quality changes at regional/catchment level? How will existing management strategies and tools need to be adapted? What are the main socio-economic impacts likely to be, given the structure of society in Southern Africa, and what are appropriate technological, social and political coping strategies?

Programme 2: Human-induced impacts

Scope: Various kinds of human activities can influence the quantity, quality, reliability and ecological health of water resources, including activities which take place in other environmental compartments within the hydrological cycle. This programme includes research to improve our ability to assess, evaluate and predict the effects on surface and groundwater resources of human activities and human-induced impacts, with a view to developing strategies for management and mitigation of health impacts.

Programme 3: Integrated flood and drought management

Scope: The need to prepare the country to cope with global climate change is of paramount importance. Flooding and drought are major natural hazards to human society and have important influences on social and economic development. This programme focuses on research that will result in the development and implementation of integrated institutional frameworks and technological tools to reduce and combat floods and their negative effects while enhancing positive flooding patterns that are important to the natural ecosystem. Research related to drought management will focus on integrated tools and strategies for early identification and mitigation of the social and economic impacts of drought, with the aim of supporting collaborative, multi-institutional processes and programmes.

THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation.

Programme 1: Protection and management of surface water and groundwater quality

Scope: Urban and industrial activities expose groundwater and surface water resources to a range of chemical and microbiological pollutants. This programme investigates the natural and anthropogenic occurrences of hazardous constituents with the aim of developing strategies to minimise the negative impacts on groundwater and surface water resources. The development of improved pollution prevention, control, detection and remediation strategies is essential for the effective management of the water resources. The programme addresses both point and non-point sources of pollution, resulting from activities in the subsurface and/or on the surface. More than 90% of South Africa's aquifers occur in fractured rock. An improved understanding of the fate and transport of pollutants in these fractured-rock environments will be one of the main outcomes. Sampling protocols will be developed for radiogenic elements and non-aqueous phase liquids (NAPLs) in these fractured-rock environments.

Programme 2: Urban and rural water resource management

Scope: An integrated approach to water resource planning and management is essential to the sustainability of urban and rural water resources. In many urban and rural areas, water shortages stem from improper use and degradation of the available water by pollution. The outcomes of this programme will enhance the capabilities of local authorities to protect their resources in a sustainable manner through the development of, among others, groundwater protection zones and improved land-use planning. Specific tools will be developed to facilitate the management of these resources.

Programme 3: Integrated river flow and catchment hydraulics

Scope: Research in this programme is focused on establishing and maintaining high-quality river flows, reduction and mitigation of river degradation which is caused by river hydraulic processes such as damaging flow regimes, sediment transportation and deposition. The programme will also integrate improved catchment management as part of a holistic strategy for the protection of groundwater and surface water resources. The programme will seek to establish processes and practices that will ensure minimum disruptions to natural water flow regimes, especially low flows which usually result in periods of critical water constraints in river systems. The groundwater and surface water processes which are associated with the critical flow regimes are also investigated in this programme.



THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders based on catchment and water management area boundaries. The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of IWRM. The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust will support the suitable implementation of IWRM in South Africa. The further articulation of the NWA for the benefit of all South Africans and the fulfilment of the developmental role of the state within the water resource limitations will be investigated. Lessons learnt and evaluations of the IWRM applications in South Africa to date will be part of this portfolio focusing on home-grown approaches and experiences in water resource management. The thrust supports research on tools and methodologies for decision support in IWRM which aims at providing strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures. These structures are for implementing IWRM, through:

- Future projections based on scenario building
- Bridging the gap between WRM and better services
- More emphasis on enforcement and compliance
- Addressing financial provisions and institutional sustainability challenges
- Better understanding of internationally shared water resources in support of NEPAD

Programme 1: Institutional governance and reforms

Scope: The principle of subsidiarity, or as is sometimes referred to as democratisation of water resource management, has brought about challenging concepts, both conceptually and in terms of application. Although current reforms in South Africa are based on sound IWRM principles, to date the implementation thereof continues to break new ground, proving that institutional engineering cannot provide a one-size-fits-all solution to the new management paradigm. Further understanding and research are hence needed to learn and decide on best practice as defined in the South African or similar socio-economic settings.

Programme 2: Compliance and enforcement

Scope: For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Bench-marking and best-practice are crucial here to learn from lessons.

Programme 3: Pricing and financing WRM

Scope: The issues of financial sustainability, affordability of charges to users, transparency and corporate governance aspects are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good ground-breaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources? Does pricing water and introducing the water resource charges exclude the poor and will it further cripple local government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.

Programme 4: Transboundary water resources

Scope: This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.

Programme 5: Future scenarios

Scope: This activity has been warranted a separate programme to ensure that local South African expertise is qualified to explore future scenarios and answer the 'what if' questions in support of reflection and evaluation of national policy applications. Projecting the water resource management and development institutional arrangements landscape 10 or 15 years from now would be of interest to decision makers to define policy reviews and enhance decision making. Further complexity can be added on through the introduction of the water services institutions. Mapping of the processes for tariff setting between both water resources and water services could allow further investigation into service delivery affordability and efficacy. This programme is likely to have a phased programmatic approach to adding more and more layers to the scenarios and for them to be customised for localised aspects that need not be of national interest.

KSA alignment with DWAF's objectives

Due to the fact that this KSA interacts regularly with DWAF, the research programmes are in alignment with the DWAF Strategic Plan for 2007/08- 2009/10 (see Table 3). Hence, the KSA project distribution reflects good synergies and considerable alignment with the DWAF strategic programmes.

- **Equitable and sustainable supply** covers the policy, planning and regulatory functions required to ensure the reliable and equitable supply of water for sustainable economic and social development, including the eradication of poverty. This includes assessing available water in a particular area and developing strategies to enable supply to meet demand. Sustainable supply supports the provision of a reliable and equitable supply of water as well as the bulk of the *Working for Water* and *Working for Fire* programmes for sustainable economic and social development, including the eradication of poverty.
- **Protection policies and measures** which cover the policy, planning and regulatory functions required to ensure the protection of water resources, such as developing a system for classifying water resources as required by the National Water Act (1998). Protection measures initiate and support the implementation of measures to protect water resources, such as pollution protection measures or ensuring sufficient water for the aquatic ecosystem to function properly.
- Institutional regulation and development. Institutional regulation provides policy and strategy support for developing and establishing effective water management institutions and includes revenue collection from water use charges. Institutional development ensures that effective water management institutions are developed in the regions.
- **Strategic alignment and stakeholder empowerment**
Strategic alignment ensures that policies and strategies are internally consistent and aligned with relevant external policies and legislation, develops and maintains monitoring and information systems, and promotes capacity building among water resource management practitioners and stakeholders. Stakeholder empowerment develops empowered, skilled and representative staff and capacitates stakeholders and the general public to achieve integrated water resource management.
- **Infrastructure development and rehabilitation** provides for the augmentation of the water-trading account to undertake the design, construction and commissioning of new water resource infrastructure as well as the rehabilitation of existing infrastructure to ensure the safety and functionality of departmental dams and related structures. Operations of water resource infrastructure provide for the augmentation of the water-trading account to ensure the effective management of water resources and the sustainable operation and management of bulk water infrastructure.
- **African and international cooperation**
African cooperation promotes integrated water resource management globally, particularly in Africa in support of NEPAD. The participation in the establishment and support of new shared watercourse institutions is one of the outputs, as well as improved multilateral and bilateral regional cooperation in Africa.

TABLE 3

KSA alignment with DWAF's objectives

DWAF objectives	WRC thrusts/programmes	WRC projects (examples)
Equitable and sustainable supply	• <i>Catchment data and information systems</i> • <i>Surface water/groundwater hydrology</i> • <i>Water resource planning</i> • <i>Water resource development</i> • <i>Climate change and climatic variability</i> • <i>Water resource quality management</i>	• An investigation of the potential use of ocean colour remote sensing to assess the influence of variations in freshwater inputs to coastal ecosystems: Phytoplankton and sediment dynamics of the Natal Bight • Identification, estimation, quantification and incorporation of risk and uncertainty in water resource management tools in South Africa • Integrating water resource and water services management tools • Optimised monitoring of groundwater – surface water – atmospheric parameters for enhanced decision making at a local scale • Development and application of global navigational satellite systems (GNSS) methodology for groundwater resource assessment
Protection policies and measures	• <i>Protection and management of surface water and groundwater quality</i> • <i>Urban and rural water resource management.</i> • <i>Integrated river flow and catchment hydraulics</i> • <i>Developing mitigation and adaptive measures for global climate change</i> • <i>Human-induced effects</i> • <i>Integrated flood and drought management</i>	• Nitrate removal for groundwater supply to rural communities • An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments • Management of human-induced salinisation in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity • A comparison of the costs associated with pollution prevention measures to that required to treat polluted water resources • Development of a risk indicator methodology to estimate the relative risk of pesticide contamination in South African water resources • Quality control and assurance guideline for South African toxicity testing laboratories • Assessment of the toxicity of cyanobacteria in the Kruger National Park
Institutional regulation and development.	• <i>Institutional governance and reforms</i> • <i>Compliance and enforcement</i> • <i>Pricing and financing of IWRM</i> • <i>Transboundary water resources</i> • <i>Future scenarios</i>	• The water sector institutional landscape by 2025 • An investigation into the water infrastructure development financial allocation pathways in municipalities • Towards regulation of water resource management in South Africa • The impact of IWRM on the lives of women and the poor in South Africa • Water allocation reform, instruments and processes for achieving equity and gender balance

Research Projects for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Refining tools for evaporation monitoring in support of water resource management

CSIR

No. 1567

In the hydrological cycle evaporation is generally a large component of the hydrological cycle which is only second to precipitation. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the transpiration of plants. The accurate measurement of water use as prescribed in the National Water Act of 1998 calls for more accurate assessment of the water balance. Most variables in the water balance have been measured or estimated to a reasonably more accurate level when compared to evaporation. The evaporation measurement/estimation techniques that are currently applied for most water use calculations have been around since the late 1940s. New methods have started to come out in the last 20 years or so as technology (micro-electronics and computer hardware/software) enabled innovative developments such as scintillometry to be available for various uses. At the same time new opportunities for improved measurement, such as through the complementary use of ground-based and remote-sensing techniques (especially for larger-scale water-resource related applications), also need to be explored. In this project the researchers used a variety of case studies and applied selected methods for evaporation monitoring. The research investigated accurate and precise requirements relating to evaporation measurement/estimation for various water-resource management applications. In this research the appropriateness of evaporation measurement/estimation techniques for addressing a range of key water-resource management needs was evaluated. The evaporation monitoring techniques were compared for various land uses and water resource management scenarios which included various land-cover canopies and open water in Midmar Dam. This research resulted in the development and testing of an electronic guideline for the complementary use of measurement and estimation techniques in evaporation monitoring. The research produced guidelines to aid users in the selection of a suitable technique for estimating total evaporation from a specific surface. The guidelines also provide users with basic information on the selected technique(s). A simple electronic Decision Support System (DSS), in the Visual Mind™ software programme, supports interaction with the guidelines. With the tools developed in this project water managers and foresters are equipped to account for evaporation more accurately than in the past.

Cost: R1 600 000
Term: 2005 - 2008

Programme 2: Surface water / groundwater hydrology

Definition and upscaling of key hydrological processes affecting critical perturbations to water resources for application in models

University of KwaZulu-Natal

No. 1320

The implementation of the National Water Act (1998) requires an understanding and quantification of dominant hydrological processes in order to faithfully manage water resources. This understanding is particularly important in quantifying low flows and the sources thereof; in assessing the impacts of land use change; in quantifying the hydrological perturbations resulting from climate change and in assessing impacts of non-point source pollution, especially where the source of the impact is to be identified. Accurate quantification of dominant hydrological processes requires clear definition and quantification of the sources and pathways of stream flow components. The key objective in this project was to define key hydrological processes at a range of scales by observation and experimentation at these scales in order to improve deterministic, physically based simulation tools. The project focused on applying the better understanding of hydrological processes in the ACRU model where representation of these processes at a range of scales was made. The project investigated the hydrological processes at various scales and how these processes link land use changes, stream flow reduction activities (SFRAs), surface and groundwater interactions and topological runoff-generating mechanisms.

In this study the dominant hill-slope mechanisms were examined using hydrometric observations of climate variables, soil water capillary pressure head (or tension), hill-slope and deep groundwater levels and stream discharge. In addition, geophysical observations were made to define the distribution of subsurface water, both in the soil and in groundwater. Finally, various components of discharge are sampled and analysed for the stable isotopes of water and other elements in various water samples. The combination of these observations leads to the estimation of the contributing fluxes of the stream runoff. The dominant mechanisms that regulate the different components of flow were included in the development of the ACRU agrohydrological modelling system.

In the research the streamflow generation mechanisms and their occurrence in the case study catchment were defined. The project fieldwork quantified and integrated the mechanisms into a simple catchment model. The groundwater and soil water response after rainfall events were continuously monitored. The hydrograph separation using isotopes revealed that hill-slope groundwater contributed significantly to the stream flow, estimated at 70% of the discharge. Near-surface groundwater contributed some 16% in most events other than 2 low discharge events where near-surface groundwater was estimated to contribute between 1 and 4%. Specific response dynamics resulting from the combinations of techniques in the catchment are:

- Overland flow. The tracer-based, 3-component hydrograph separation, using EC and Si as tracers, suggests that the direct contribution to event-based stream flow from the event rainfall ranges between 14% and 26% of the event discharge.

- Near-surface soil water. Observations in shallow tensiometers and free water collection tubes have demonstrated the existence of a rapid response, near-surface discharge during rainfall events. These zones of near surface, lateral flow have been identified by hydrogeological investigations and have been estimated by tracer aided separation techniques to yield up to 16% of event discharge.
- Hill-slope groundwater water. During a series of event flows, this source of water has been estimated to yield 70% of the total discharge (EC and Si tracer based hydrograph separation). Using lumped isotope sample end member mixing analysis, this hill-slope contribution to flows is estimated at 60% of the stream discharge during the wet season. During the dry season, the soil profile continues to generate stream flow well into the middle of the winter.
- Fractured rock groundwater. Some proportion of the deep aquifer water contributes to the event flows but, without tracer samples from these deep sources the proportion could not be estimated. During the dry season the seepage water spilling over the outcrops is estimated to contribute 32%, and the subsurface seepage 68%, of the winter flows as late as August.

A model algorithm, comprising threshold-based subsurface responses and catena-based linking has been proposed as a direct emulation of observed stream flow generation dynamics. Future hydrological model performance would be enhanced by including functions which represent the travel times of the different components of flow which could be observed by continuous observations of the combination of techniques applied in this study.

Cost: R2 100 000
Term: 2002 - 2008

Water resources of South Africa, 2005 Study (WR2005)

SRK (CE) Inc.

No. 1491

The knowledge and processes involved in accounting for water resource availability continue to benefit from new insights, knowledge and data. The WRC has been instrumental in providing support and a platform for water practitioners to take part in regular research to develop water resource assessment techniques, collate the data and assess the nation's available water resources, at varying intervals since the late 1970s. The last water resource assessment research project was carried out in 1990. This old study addressed surface water availability assessments and used time-series data which ended in 1989. To date the outputs of this 1990 project are at the centre of national and regional water resource planning. This research project, which is commonly referred to as WR2005, is the best attempt to capture the latest available water assessment techniques, improved hydrological simulations, and to integrate water resource data which included data on groundwater, surface water, wetlands, water quality, soils, land use, improved catchment delineation, population, return flows, and several other variables that have a bearing on the quantification and assessment of the available water resources. This research is the most up-to-date assessment of available water resources.

Cost: R6 700 000
Term: 2004 - 2008

Towards improved estimates in water resources assessments using hyperspectral imagery to classify and map land-cover classes in Southern Africa (NS)

CSIR

No. 1684

Accurate assessments of vegetation water use, evapotranspiration and plant or soil water availability are important in water resource management decision-making processes. The accurate estimation of evapotranspiration, plant water content, water stress and plant or soil water availability could be improved through the use of hyperspectral imagery. This study investigated the local use of hyperspectral imagery through the application of advanced hand-held spectroradiometers, airborne and satellite sensors. The hyperspectral imagery was chosen to take advantage of its high spatial and spectral resolution. The vegetation types *Acacia mearnsii*, *Pinus patula*, *Eucalyptus macarthurii*, *Eucalyptus grandis* and *Saccharum* were considered in the study. Remote sensing imagery, ground-based spectral measurements and ancillary data were collected during winter and summer to account for the significant differences in vegetation over the dry and wet seasons. The data sources selected for this study included the ASD hand-held spectrometer and Hyperion and Proba Chris satellite sensors. In the statistical techniques applied, the maximum likelihood classifications achieved the highest overall accuracies above 98%. Four vegetation indices were selected from the training phase and these were best classified using the minimum distance method. The minimum distance method best classified the 6-year-old *A. mearnsii* and the 10- and 12-year-old *E. macarthurii* for all 4 vegetation indices. The research concluded that the accuracy of classifying and mapping different vegetation classes is strongly dependent upon a unique combination of spectral bands. Furthermore spectral variability is evident across different vegetation classes within a season and between dry and wet seasons. In general the Proba Chris multispectral imagery performed well for genus level classification whereas the Hyperion hyperspectral bands accurately classified both genera and species.

Cost: R634 700
Term: 2006 - 2008

Programme 3: Water resource planning

A synthesis and encapsulation of hydrological research findings into a DSS for application and operational/ planning level

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1490

The National Water Act (No. 36 of 1998) has provisions for DWAF to be the central unit in national water information and modelling/processing tools. The Hydrological Decision Support Framework (HDSF) is a research product where the hydrological data and modelling tools for decision making at water management area level were developed on the basis of the current state of knowledge, data and technological resources. The HDSF allows the integration of the models through a GIS user interface linked to a populated extensible database. This will enable rapid application of the model and the reporting of the simulations as well as easier validation of outputs from different modelling tools. In this project, the existing frameworks and possible new developments were investigated and compared. An existing framework, the SPATSIM, was selected

for enhancement and redeployment in a generic GIS platform which incorporated several other models. The main product of the project, the SPATSIM-HDSF modelling framework software, is expected to be used by DWAF, CMAs and various water managers, specialists and researchers in hydrological practice.

Cost: R2 597 000
Term: 2004 - 2008

Programme 5: Climate change and hydro-climatic variability

Model output statistics applied to multi-model ensemble long-range forecasts over South Africa

South African Weather Service
No. 1492

Improved seasonal weather forecasts can greatly assist managers in the fields of water resources and agriculture to adapt to climate variability and, more particularly, in preparing adequately for seasons characterised by climatic extremes. In this research a multi-model forecasting system for South Africa was developed to produce objective operational seasonal rainfall, streamflow and global sea-surface temperature forecasts. The forecasting systems developed for rainfall and streamflow comprise of a number of tiers including the generation of output from general circulation models and the statistical downscaling and translation of these outputs to station and catchment level (using the Model Output Statistics or MOS approach), as well as the combination of individual model forecasts using a selection of linear combination schemes of varying complexities.

Cost: R436 000
Term: 2004 - 2008

Using advanced knowledge of climate variability for the benefit of water resource management

University of Cape Town
No. 1566

Seasonal climate forecasts are available in South Africa, yet they are of little value to the water management sector if they are not accessible and understood. Currently these products, that address annual climate variability, do not yet appear to meet the needs and expectations of water resource managers. Water resources are significantly affected by climate variability, particularly through the impacts on run-off and seemingly even more so on groundwater recharge. In a climate-change context impacts of climate variability will be compounded and the ability to access and use relevant climate information may become key to successful coping and adaptation strategies. Even currently, seasonal forecasts and climate change projections could help to manage the impacts of climate variability on water resources so that managers do not 'miss out' on realisable benefits purely because of lack of awareness of useful products or because the products have not been tailored to suit their needs. This research improved the understanding of how water resource managers use weather and climate information and especially seasonal forecasts, and the potential for better use of information and forecasts both through capacity-strengthening initiatives and the provision of information more appropriate to the needs of managers.

Cost: R1 478 000
Term: 2005 - 2008

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

A multi-tracer study of the origins, systematics and hydrological linkages of high nitrate concentrations in Bochum District, Limpopo Province

University of the Witwatersrand (Schonland Research Centre)
No. 1328

The Bochum project was aimed at investigating the sources of high nitrate levels in the Taaibosch area, Bochum, Limpopo Province. It was found that high nitrate levels, ubiquitous in Limpopo Province, are not necessarily associated with anthropogenic sources in the Taaibosch study area. Various hydrogeological, hydrochemical and environmental isotope linkages gave rise to a model of nitrate production involving phreatophyte roots. This is probably also associated with hydrological, hydrochemical and biological processes in the conditions peculiar to the basalt aquifer. An area around the settlement of Bochum, to the south of the Blouberg, was selected for the extension of this study. The study area is underlain by two contrasting hydrogeological regimes: metamorphic granites and sandstones. This study has shown that a combination of hydrochemistry and environmental isotope analysis can contribute significantly to an understanding of the genesis of nitrate in groundwater in the context of its hydrology and hydrochemistry. The very limited number of nitrogen isotope analyses that could be produced has demonstrated that ^{15}N data are fundamental to this, when interpreted in the framework of the overall hydrological and hydrochemical information.

Cost: R300 000
Term: 2002 - 2008

Nitrogen dynamics in catchment landscapes cleared of alien vegetation and impacts on water quality

CSIR
No. 1696

The hypothesis of this study was that clearing invasive alien vegetation might disturb the alien vegetation-microorganism-soil N cycling system by producing a large episodic input of fresh litter rich in N and by eliminating a large N sink. In addition, changes to the local microclimate and the soil chemistry and physics may result in increased net N mineralisation beyond the N requirements of the remaining biota. Both field measurements of soil and groundwater quality as well as modelled spatial distribution of N concentration in groundwater were investigated in order to test this hypothesis. The main outcomes of the research were:

- Nitrogen levels in soil and groundwater were higher in alien-invaded areas compared to fynbos areas
- A quick release of NO_3^- into groundwater occurred after clearing land of alien-invasive legumes. Higher N concentrations were recorded in soils of the uncleared compared to the cleared treatment, and in groundwater for the cleared compared to the uncleared treatment.
- The long term effect of clearing alien invasive legumes is the reduction of N concentrations in groundwater in the absence of N fixation

Cost: R845 000
Term: 2006 - 2008

Programme 2: Urban and rural water resource management

The history of Cape Town's river systems: Using hindsight to guide the management of urban river systems in South Africa

Southern Waters Ecological Research and Consulting
No. 1691

The documented lengthy and rich history of Cape Town's rivers and wetlands is presented in this report. Several authors unpacked the history of the waterways and water bodies of Cape Town which have played a pivotal role in the history of their area. The report is set in the period 2006 to 2008, where the past is examined from several perspectives that included catchment hydrology, ecology, urban developments, state and municipal legislation, societal well being, environmental degradation and the remediation of damage to rivers and water bodies. The analysis of the past management of Cape Town's rivers provides a platform for developing sustainable and enhanced integrated urban catchments. This report presents a comprehensive review of the management of rivers in Cape Town in the 20th century. As part of the historical outlook, the various options selected in the past that had influences in the river systems were evaluated in terms of their social, ecological and economic costs and benefits. This report is a result of various stakeholders who worked tirelessly to come up with an informative book that educates, entertains and provides guidance to various role-players and practitioners in Cape Town and the water sector in general.

Cost: R642 200
Term: 2006 - 2008

Programme 3: Integrated river flow and catchment hydraulics

Ecological and environmental impacts of large-scale groundwater development in TMG aquifer systems

CSIR; Umvoto Africa
No. 1327

The evidence from the Kogelberg field study indicates that TMG (Table Mountain Group) aquifer discharge directly contributes to flow in the Oudebos tributary and cryptic discharge from the mid-slope 'wetland' on a fault. It also indicates that indirect TMG discharge contributes to the valley bottom wetland (via surface water) and to the coastal wetland (via the surficial unconsolidated wetland). All the fynbos species tested showed very high vulnerability to xylem embolism formation, i.e. they were vulnerable to reduced water availability. However, they showed relatively low levels of experienced midday water stress even in terrestrial off-seep settings, particularly the deep-rooted *Proteas* which are known to have root systems up to 10 m deep (within the maximum known depth of soil formation in the TMG terrain). Shallow-rooted *restios* showed the greatest degree of moisture stress. The *Proteaceae* appear to be tapping water in the deep soil horizons, the colluvium and weathered TMG. At the Kogelberg site the following ecosystems linked to TMG discharge were identified:

- Slope wetlands linked to TMG faults and fractures and lithological contacts
- A coastal wetland linked indirectly to TMG fractures
- Perennial river and riparian zone linked to TMG fractures and lithological structures

- Terrestrial fynbos and perched high wetlands linked to (non-aquifer) TMG jointing and micro-fractures

The field study in Purgatory revealed that seeps on the eastern slope of the catchment occur where permeability interfaces (lithological contacts in particular the shale band and Peninsula formation) are transected by the Purgatory fault. These systems constitute a combination of lithologically-controlled and fault-controlled wetlands where groundwater contribution from the confined Peninsula Aquifer via the fault structure is possible. Seepzones at or just below the Goudini – Cedarberg Shale contact appear to be lithological contact systems and not connected to the confined TMG aquifer. Groundwater discharge into the eastern tributary is clearly evident along the deeply incised gorges. This inflow maintains the perennial character of the eastern tributary. The groundwater contribution most probably originates from the Peninsula Aquifer and discharges along the cross faults. The 2 wetlands in the non-perennial drainage line of the western tributary show strong seasonality in water level fluctuation. However, it appears that the stream flow in the dry months slightly increases below the second instream wetland suggesting some groundwater inflow, contributing to maintaining the ecosystem but not sufficient to create a perennial stream. At the Purgatory field site the following groundwater-linked ecosystems were identified:

- Slope wetlands linked to lithological contact and TMG fracture discharge
- Riparian zone indirectly linked to TMG fault and fracture discharge
- Seasonal and perennial rivers linked to TMG faults and fractures

The key findings of the research carried out on the project can be summarised as follows:

- It was shown that monitoring boreholes can be drilled in ecologically-sensitive areas without significant disturbance, using an appropriate EMP and site supervision.
- It was confirmed that it is imperative to collect good quality, hard physical data, such as groundwater-level data in correctly-sited boreholes and piezometers located at groundwater discharge-linked ecosystems, to monitor the changing availability of groundwater.
- It was shown that Si, DOC and Rn radioactivity are useful tracers of groundwater discharge into the aquatic environment. SiO₂ and DOC are more conservative tracers with respect to changes once discharged, whereas Rn (with a half-life of 3.8 days) could be used to indicate points of discharge. Macro-ions did not prove useful tracers in this study.
- Temperature is a useful indicator of groundwater flow and is indicative of the depth of groundwater flow.
- Stable isotopes are useful to distinguish between different plant water sources, although the differences might be more distinct along gradients where the effect of altitude is more significant.
- Aquatic and terrestrial species indicators for groundwater dependency were not evident at the 2 study sites. Assemblages of plant, invertebrate and diatom communities were very diverse and could not be linked statistically to areas of groundwater discharge.
- The study did not encounter any species (threatened or not threatened) that are solely dependent on groundwater discharge.
- Wood-anatomy based measures indicate that on- and off-seep fynbos plants are highly vulnerable to moisture stress.

However, there is no marked difference in the degree of xylem embolism vulnerability shown by on-seep species and their analogues off-seep, showing that the plants are adapted to the currently available moist conditions, i.e. precipitation and mist. The monitoring period covered 1 slightly wet year (2004/2005) and 2 dry years (2005/2006 and 2006/2007), compared to long-term average data.

- Deep-rooted plants, such as the Proteaceae, did not exhibit moisture stress, while shallow-rooted plants, such as restios, showed some degree of moisture stress during dry periods. The Proteaceae appear to be tapping water in the deep soil horizons, the colluvium and weathered TMG, which is generally found in the top 10 to maximum 20 m below ground. In general, most plant species access multiple sources of water, with groundwater as a dominant source during drier periods.
- Remote sensing can be a useful tool to identify perennial wetland ecosystems and can be utilised for long-term and routine monitoring over a wide area of interest, provided the algorithm is adapted to the study area based on field verification and the spatial scale of the imagery is sufficiently small to detect ecosystems of interest.
- Subsurface flow in TMG mountainous catchments follows multiple geologically-controlled flow paths. Groundwater discharge from the TMG aquifers occurs at springs or seepage zones that are usually linked to predictable structural, lithological and topographic hydrogeological settings that can be mapped with high degrees of certainty.

Cost: R2 320 000
Term: 2002 - 2008

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Towards the establishment of water market institutions for effective and efficient water allocation

CPH Water
No. 1569

A regulated water market enables the transfer of water-use rights between water users in a manner that ensures that the transactions do not bear with them undesired third-party effects. The transfer takes place on a voluntary basis between buyers and sellers for their mutual benefit. Implicit in the discussions on water markets is that the laws, rules and regulations are in place to permit it to happen. The National Water Policy sets the scene and the National Water Act (NWA) of 1998 provides the conditions for water management to move from the previous legislative framework, largely based on 'command and control' methods, to a new system which is more decentralised and market-driven (while being regulated to minimise undesired third-party effects). In the case of water management, all the actors (such as water users, water management agencies and government entities) are influenced by incentives. These incentives are provided by the institutional arrangements applicable such as the conditions attached to water-use rights. The different parts of the institutional framework interact to achieve the stated objective, such as the efficient use of water that can be achieved by the transfer of water-use rights to higher value uses through a regulated water market. For such transfers

to take place the appropriate institutional arrangements need to be in place. On the technical side, water use (i.e. abstraction or diversion) and/or discharge needs to be measured and monitored, and water users must be informed of water-saving techniques and have the financial means to implement them. Water-use rights need to be well defined and transfer mechanisms need to be in place to allow water-use rights to move within and between sectors at acceptable costs of transacting. In addition water-use rights need to be appropriately priced to incentivise more efficient use.

Cost: R1 500 000
Term: 2005 - 2008

Programme 3: Pricing and financing WRM

The development of a framework for the involvement of local government in water resource management linked to water service provision

Rhodes University
No. 1688

The main aim is to investigate the possibility and abilities for IWRM at local government level in a small-to-medium Category B municipality using Makana Municipality as a case study. The next aim was to develop a framework of recommendations for action in order to achieve IWRM at local government level by defining the links between (Integrated) Water Resource Management and Water Services Provision. As a Water Service Authority (WSA) and Water Service Provider (WSP), Makana Municipality has to incorporate water resource protection into their planning, development and maintenance of services including the effects of land use. It is in this area where the integrative aspects of IWRM are so valuable. The third aim is also part of the IWRM protocols, namely, increased community awareness of water supply issues through a dedicated programme aimed at school learners within Grahamstown.

Cost: R550 000
Term: 2006 - 2008

Current Projects

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

A synthesis of the hydrogeology of basement aquifers in Southern Africa: Research needs and priorities

Council for Geoscience
No. 1418

Basement aquifers are found extensively in sub-Saharan Africa. The only viable water supply to many rural communities is located in these aquifer systems. To contribute to sustainable resource development, all knowledge about the attributes and dynamics of groundwater occurrence in basement aquifers needs to be consolidated. This is necessary to identify the research needs, gaps and priorities. This project aims to synthesise current knowledge relating to basement aquifers in Southern Africa. The output of the synthesis will lead to a research strategy that will address

shortcomings in our knowledge base. This is a necessary project to guide future research in the hydrogeological domain.

Estimated cost: R564 430
Expected term: 2003 - 2009

A catchment management strategy for the Kat River

Kat River Valley Water Users Association

No. 1496

For the past 6 years, a process of community education and capacity building has been pursued by the communities in the catchment, aided by the Geography Department at Rhodes University. This process has resulted in the establishment of a Water Users Association (the Kat River Valley Water Users Association – KRVWUA). It therefore offers the opportunity on a pilot scale to develop and apply methods of establishing a co-operative catchment management strategy, including water allocations, the Reserve requirements and Resource Quality Objectives (RQOs), and a monitoring programme.

The objectives are to:

- Continue to develop the socioeconomic capacity of the community of the Kat River valley
- Establish cooperative governance of the resources of the Kat River between DWA, the KRVWUA and the communities of the catchment, within the context of the Fish Keiskamma Water Management Area
- Establish the criteria for acceptance by DWAF of the allocation schedule and the catchment management strategy
- Undertake a yield analysis to establish the water yield that can be reliably provided by the Kat River
- Assess the Reserve for the Kat River
- Develop RQOs for the Kat River
- Establish existing lawful use of the water resources of the Kat River
- Reach agreement among the WUA members on a water allocation schedule for licence applications
- Establish strategic and contingency water requirements for the Kat River
- Establish the downstream water requirements of the users of the Great Fish River, into which the Kat River flows
- Design and initiate a monitoring programme that will assess the various water uses, Reserve flows and water quality, and the resulting state of the river

Estimated cost: R2 100 000
Expected term: 2004 - 2009

Remote sensing as a tool to determine the legal compliance of surface and groundwater users in catchments

Council for Geoscience; University of Cape Town; GEOSS

No. 1690

Since South Africa is such a water-scarce country, it is important for managers to have accurate information on all aspects of water resource management. This includes knowledge of the level of compliance of water users to water use licence legislation. In the Berg River catchment for example, compliance to water use legislation is checked by DWAF on a case by case basis. This is a tedious and time-consuming procedure. Remote sensing can be used to detect and map past and current water use. This can be compared to current water use licenses in the WARMS database. The aims of the project are therefore to:

- Use remote sensing to identify small dams in catchment areas of South Africa
- Establish the volume of water stored in small dams in selected catchments
- Use remote sensing and GIS to identify the illegal extraction of water from rivers
- Use remote sensing to identify potential groundwater resources
- Identify if groundwater is being used as a resource rather than dams within the same area
- Quantify groundwater use based on identifiable agriculture
- Use remote sensing and GIS to identify legal compliance of groundwater users in selected catchments
- Develop a methodology whereby water use compliance can be ascertained for any catchment in South Africa whether groundwater- or surface water-driven.

Estimated cost: R1 259 600
Expected term: 2006 - 2009

A methodology for near-real time spatial estimation of evaporation

CSIR

No. 1751

Evaporation is the second-largest variable of the water balance after rainfall. However, its quantification is handled at relatively lower levels of accuracy and reliability when compared to other variables such as runoff and storage. The evaporation estimation methods based on remote-sensing data hold great potential. Whilst a number of developed countries have already made advances in this emerging field of research, in South Africa the application of remote sensing to interpret and to generate near-real time evaporation estimates is a very new technique that still has to be customised and applied in local catchments. This study will investigate and review existing technology in evaporation estimation using remotely-sensed data, and will work with at least 2 international developers of satellite data interpretation software and apply customised software to selected catchments.

Estimated cost: R468 000
Expected term: 2007 - 2009

Land-water linkages: Agent-based modelling of land-use change and its impact on water resources in the Modder River basin

Central University of Technology

No. 1753

Changes in land use have profound impacts on water resources. This study applies agent-based modelling to investigate land-use changes and how these have impacted on water resources in the Modder River basin. While previous studies of land-use changes have addressed simplistic representations of 2 or 3 driving forces, the agent-based modelling technique will involve several situation-specific interactions among a large number of factors at different spatial and temporal scales. The main objective of this research project is to analyse land-use changes and highlight the dynamic nature of coupled human-environment systems using agent-based modelling in relation to land-use change and its impact on water resources.

Estimated cost: R357 000
Expected term: 2007 - 2010



Programme 2: Surface water / groundwater hydrology

Development of a user-friendly model for assessing the impact of waste discharge applications on downstream water quality

Stewart Scott (CE) (Water Quality)

No. 1212

Successful catchment management from a water quality perspective requires, inter alia, an intelligent representation (modelling system) of the catchment which describes present water quality and which can be used to predict the effect that proposed new or modified impacts will have on water quality at specific points. Options that need to be incorporated in such a modelling system include applications for new discharge points, increased discharges or altered permit conditions. It is also necessary to assess the impact of current and projected water use and alternatives for managing water quality. This points to the need for a simple but robust technology that can be used to rapidly assess the impacts of applications to discharge waste and the effect of proposed management options. The purpose of this project is to develop such a tool that will not replace the more complex models, but could rather be used to sift options to determine if more complex models need to be applied. The proposed tool could also serve to standardise the approach taken by CMAs in evaluating the initial results obtained by a large variety of organisations. It will be developed in co-operation with DWAF's Directorate of Water Quality Management and its Gauteng Region.

Estimated cost: R494 890
Expected term: 2001 - 2009

Flow conceptualisation and storage determination in TMG aquifer systems

University of the Western Cape (Department of Earth Sciences)

No. 1419

The TMG aquifer system is a regional aquifer considered to have potential to be a major resource for future water supply in the Western and Eastern Cape. This project addresses 2 key aspects, which are essential in order to manage TMG aquifers, i.e. conceptualisation of the groundwater flow system and determination of aquifer storage. The project will utilise a blend of fracture analysis/remote sensing, field testing, hydrochemical/isotopic tracers and numerical modelling to address the research questions.

Estimated cost: R3 500 000
Expected term: 2003 - 2009

Protocols assessing the sustainability of springs

Maluti Water

No. 1488

This project intends to develop a protocol for defining a spring-flow sustainability index. The development of a sustainability index would assist with water resource planning and result in security of water supplies to communities. The successful outcome of this project can result in innovative approaches

to protect and manage springs (both from a water supply and protection perspective). The objectives are:

- The development of a protocol for defining a spring-flow sustainability index (i.e. a tool for assessing the sustainability of springs)
- Review all the factors that affect spring-flow
- Assess the value of isotopes in characterising the sustainability of springs, including testing the correlation of perennial and seasonal springs with the isotopic signature
- Develop a weighting system to assess the sustainability of spring-flow

Estimated cost: R734 100
Expected term: 2004 - 2009

Flow conceptualisation, recharge and storativity determination in Karoo aquifers (with special emphasis on the Eastern Cape (Mzimvubu to Keiskamma Water Management Area)

SRK (CE) Inc.

No. 1565

The Karoo rocks outcrop over almost three-quarters of South Africa and act as a host for important groundwater resources. Hundreds of villages in the rural areas of the Eastern Cape and KwaZulu-Natal Provinces obtain their water supplies from boreholes adjacent to or within the area of influence of dolerite dykes and sills which have intruded the Karoo sediments. These conditions produce unique and complex hydrogeological systems, which complicates the development of groundwater resources. This project aims to:

- Conceptualise flow dynamics and groundwater flow paths
- Determine recharge-discharge and storativity and generate target maps for groundwater exploitation

Estimated cost: R3 400 000
Expected term: 2005 - 2009

The use of ^{222}Rn as a hydrological tracer in natural and polluted environments (NS)

CSIR

No. 1685

^{222}Rn is a very soluble noble gas and because of its conservative nature has application as a hydrological tracer in fractured rock environments, providing insight into aquifer flow rates and groundwater residence times. Consequently, the aims of the study are to test whether ^{222}Rn :

- Is justified as a tool for use during baseflow studies in South Africa when compared to existing geochemical and isotopic parameters
- Concentrations vary with groundwater age, chemistry, depth or flow rate
- Concentrations vary with seasons
- Can be used to distinguish between different geological features or point sources of pollution
- Has application as a tool to optimise the positioning of passive treatment works, assess risk, or calculate financial liability at mine sites

Estimated cost: R1 367 745
Expected term: 2006 - 2009

Basement aquifers in support of rural communities in Limpopo, North-West and Mpumalanga Provinces (with special emphasis on transboundary aquifer systems)

University of Pretoria

No. 1693

The primary intent of this project is to develop an understanding of groundwater resources in crystalline metamorphic and igneous terrains. The focus areas are the basement aquifers occurring in the Limpopo and Mpumalanga Provinces, specifically the Limpopo and Luvuvhu/Letaba Water Management Areas. The main objectives of this project are:

- Based on stakeholder involvement (e.g. DWAF, etc.) and previous studies (including areas that are experiencing water stress), identify regionally-significant water-bearing structural features and geological domains for further detailed groundwater reconnaissance and exploration (to be based on utilising integrated groundwater exploration approaches viz. hydrocensus, tectonics and geodynamics analysis, strain analysis for field structural mapping, remote sensing, etc.)
- Conceptualize flow dynamics (interconnectivity, regional directional permeability and transmissivity) and flow paths (including dating and tracing of deep water) in the identified water-bearing structural features and geological domains
- Determine storage capacity and storage coefficients (and sustainability yield constraints) of the various geological domains and its reliability during droughts using appropriate investigative techniques.

Estimated cost: R3 400 000

Expected term: 2006 - 2010

Hydro-pedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models

University of the Free State

No. 1748

In catchment hydrology, water and soils have a very intricate relationship which is reflected in the soil water regime of specific soil horizons, the quality of released water and the catchment water balance. Hydrologists are usually restricted by a number of uncertainties in soil-related processes and other limitations where expert soils knowledge is required. This study is expected to improve data, knowledge and models in a way that provides better interaction of soils and water. In particular the study will investigate, recommend and test appropriate soil-survey procedures and the interpretation of the soil-survey data with the aim of making this information suitable for use by hydrologists at all key water management scales that are used in South Africa. The study will also provide a quantitative characterization of the annual and seasonal soil water regimes in a range of representative local soils. The study will also seek to optimise the intensity of soil-survey information that contributes effectively to hydrological modelling.

Estimated cost: R1 873 500

Expected term: 2007 - 2011

Influence of catchment development on peak urban runoff

University of Pretoria

No. 1752

Developments in urban and informal areas are regulated with regard to potential flooding by the National Water Act

(No. 36 of 1998). The 1:100 year flood line is used to define the extent of the development. Furthermore it is required by the municipal authorities that all developers should create temporary storage if the development contributes to an increase in flood peaks. This study will provide a quantification of the influence of a catchment development on the flow rate and volume of runoff. The study will contribute to an effective stormwater drainage design and optimisation of costs for the upgrade of hydraulic infrastructures in targeted urban areas.

Estimated cost: R665 000

Expected term: 2007 - 2010

Measurement of the bulk flow and transport characteristics of selected fractured-rock aquifer systems in South Africa

University of the Free State

No. 1760

In South Africa, more than 90% of the aquifers are of a fractured nature. The physical properties of geological materials exert a significant influence on the storage and ability of fluids to move through them. The existing theory of flow cannot fully account for flow through fractured rocks. Field-scale studies and direct observations/measurements are the most robust means of developing and calibrating models of flow and transport in fractured-rock aquifers. As a result these fractured-aquifer systems can be better exploited and managed through:

- Developing appropriate innovative methodologies/approaches to measure bulk flow and transport characteristics of fractured-rock aquifers and of up-scaling those to appropriate scales and resolution; and
- Developing guidelines for future well-field developments in fractured aquifers

Estimated cost: R3 353 940

Expected term: 2007 - 2011

The identification and delineation of high-yielding well-field areas in Karoo aquifers as future water supply options to local authorities

Groundwater Africa

No. 1763

There have been a number of recent initiatives to quantify and delineate high-groundwater-potential areas, but they have either been based on inadequate data, or have fallen short in providing the necessary information that can be readily used by planners. This project will address 2 main issues:

- Identify and quantify usable high-groundwater-potential areas in the Main Karoo Basin (through specific case studies)
- Develop the framework for incorporating the high-potential areas into the municipal, catchment and national planning models. This will allow for water resource planning at all levels to properly take into account groundwater as a bulk water source. The project will focus on the Main Karoo Basin, but the methodologies developed will be applicable to all Karoo aquifers.

Estimated cost: R3 499 200

Expected term: 2008 - 2011



Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater

University of the Free State

No. 1766

The programme outputs will establish an improved understanding of the origin of pollutants, the pathways of these pollutants into the environment and the ultimate fate of these pollutants (LNAPLs). This project will produce tested techniques and guidelines for application in the industry. Available approaches are usually based on international case studies dealing mostly with porous aquifers. South African-specific case studies will enable a better understanding of the behaviour of LNAPLs in the subsurface with a specific emphasis on the fractured-rock environments.

Estimated cost: R3 500 357

Expected term: 2007 - 2011

Programme 4: Water resource development

Review and update of the SANCOLD guidelines for the design of freeboard of dams

University of Stellenbosch

No. 1759

A DWAF survey has estimated that as many as 37% of dams in South Africa have inadequately-sized spillways with a high likelihood of spillway failure. The lack of sufficient freeboard at dams also contributes to dam failures. The existing interim freeboard design guidelines *Freeboard for Dams* was published as a draft guideline in 1988 by SANCOLD. This document is still being used in the design of new dams, but a number of aspects of the document have become outdated. This project will review and update the existing guidelines for the design of dam freeboards. The project will improve the design provisions for wind, wave and surge effects on dam freeboards.

Estimated cost: R320 000

Expected term: 2008 - 2009

The development and calibration of South Africa's National Standards for water-retaining structures

University of Stellenbosch

No. 1764

The design of water-retaining structures in South Africa is often based on the British Standards for the reason that a local national code of standards does not exist. The British Standards which are currently in use in South Africa will soon be superseded by the Euro-codes, thus leaving the local practitioners with the dilemma of having to adopt yet another new foreign standard with no reference to South Africa or to develop new regionalised standards for the country. This research project will firstly exploit the extensive international and national research aimed at deriving rational design rules for civil engineering infrastructure and buildings. The research will ultimately lead to the development of the South African National Standards for water-retaining structures including the rainwater-harvesting storage facilities.

Estimated cost: R1 100 000

Expected term: 2007 - 2010

Programme 5: Climate change and hydro-climatic variability

A guideline for the selection of toxicity tests in support of the information requirements of the National Water Act

CSIR (Natural Resources and the Environment)

No. 1211

An important implication of the National Water Act (NWA) is that the introduction of both source-directed controls and resource-directed measures aimed at improving water quality will be based on the effect of these measures on the resource. Biological toxicity tests are ideally suited to assess these effects for stressors. Toxicity assessments can be used to set the standards used in source-directed controls, or to elicit a site or situation-specific response to a stressor. A large number and variety of biological tests are available internationally for aquatic toxicity assessment. A range of toxicity tests has also been established for South African use. Most of the local tests are presently applied in hazard assessments to establish toxicity at the source level. However, in order to implement the requirements of the NWA, methodologies appropriate for resource-directed measures and source-directed controls are required, as well as knowledge on how methodologies for one application relate to the other. The purpose of this project is, therefore, to establish a guideline for the selection of toxicity tests that would support the information requirements of the NWA. This will be compiled in a user-friendly document that will facilitate the application of toxicity assessment in water resource management.

Estimated cost: R450 000

Expected term: 2001 - 2009

The role of antecedent conditions in determining rainfall characteristics during the early part of the rainfall season

University of Cape Town

No. 1681

The early part of the rainfall season is a critical period for water resources in South Africa. Initial rainfall and its characteristics (frequency and intensity) determine the saturation of soils, contribution to runoff and associated reservoir storage levels as well as farmers' preparations for planting. It is the character of the climate and how it interacts with local and regional conditions such as vegetation, soils and the topography that largely determines soil moisture levels. This project will aim to:

- Understand the interactions of vegetation and soil moisture with the large-scale atmospheric circulation during the early part of the rainfall season
- Identify regions where characteristics of early seasonal rainfall may be influenced by vegetation and soil moisture and understand the implications of land-use change for the early season climate of the region.

Estimated cost: R1 642 600

Expected term: 2006 - 2010

Multidisciplinary analysis of hydro-climatic variability at the catchment scale

University of Cape Town

No. 1747

Climate research has made major advances in improving the understanding of large-scale climate variability, with emphasis on global and in some cases regional scales. Local climate

research has hardly touched on the conceptual understanding of ocean-atmosphere linkages to hydro-climatic variability at catchment scales. These are the scales that are more relevant to local water resource management and planning. The research will improve and refine our knowledge of how the large-scale climatic variations impact on smaller and localised hydrological scales. The research will lead to a better understanding of the mechanisms responsible for droughts, wet spells, floods and the variability of rainfall in Southern Africa at the catchment scale.

Estimated cost: R1 743 955
Expected term: 2007 - 2010

Programme 6: Water resource quality management

GIS-based assessment of non-point source pollution in Kuils-Eerste River catchments, Cape Town
University of the Western Cape
No. 1692

The water quality and hydrological character of the Kuils River and Eerste River in the Western Cape, which discharge into False Bay, have been changed drastically by land use in the catchment area. Major sources of pollution are the continuous effluent dischargers from the Macassar Sewage Works as well as non-point source (NPS) pollution due to the present land-use practices in the Kuils-Eerste River Catchment. The assessment and quantification of NPS pollutants in this area and others has always been a major challenge. This study will aim to provide techniques for assessing and quantifying NPS pollutants and developing intervention measures for the Kuils-Eerste River catchment. In addition, this project will also assess runoff-water quality over different land-use types, extend the existing data on stream flow measurements and water chemistry of stream flow and other surface runoff water in the area, generate a GIS-based water quality hydrologic model (catchment-loading model) and provide guidance for the mitigation of water resource pollution in the Kuils-Eerste River system.

Estimated cost: R713 000
Expected term: 2006 - 2009

An investigation into the effects of atmospheric pollutants on surface water quality in the eastern regions of South Africa
University of KwaZulu-Natal
No. 1697

South Africa possesses abundant sources of coal, found chiefly in Mpumalanga Province. This region therefore houses power-generation facilities which supply the majority of the country's electricity needs. The process of combustion of coal leads to the production of wastes which are discharged to the atmosphere, whence they are transported across the region by atmospheric circulation before being re-deposited on the land surface. Amongst the pollutants emitted by the burning of fossil fuels are oxides of nitrogen and sulphur (NO_x and SO_x). These compounds have for decades been associated with large-scale environmental degradation (chiefly acidification of soils and water) in the First World. More recently their deleterious effects have been recognised as potential threats to ecosystems in other parts of the world, including the eastern regions of South Africa. The project therefore aims to:

- Investigate the deterioration of surface water quality in selected catchments of the eastern regions of South Africa over the past few decades, due to the effects of atmospheric pollution
- Investigate deterioration of soil quality in selected catchments of the eastern regions of South Africa over the past decade and a half, due to the effects of atmospheric pollution
- Project, by means of modelling, future deterioration of soil and water quality in selected catchments of the eastern regions of South Africa under various management scenarios
- Illustrate the cost-benefit dynamics of managing pollution from atmospheric sources
- Ascertain the reliability of available estimates of atmospheric deposition

Estimated cost: R1 435 300
Expected term: 2006 - 2009

Water quality monitoring data and target users: Maximising value
CSIR
No. 1755

DWAF operates a vast water quality monitoring network. The information transfer which should form an integral part of the design of such networks is not functioning optimally at present. Much of the value of water quality information is lost if it is not effectively conveyed to users. This project will aim to maximise the value of water quality monitoring programmes by optimising the way in which information is transferred to users. This could have a knock-on effect regarding the appreciation of water quality management by politicians and the man in the street.

Estimated cost: R488 960
Expected term: 2007 - 2009

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 1: Developing predictive tools and adaptive measures to global climate change

Secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change
University of Cape Town
No. 1562

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality, water quality and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function,



with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R2 500 000
Expected term: 2005 - 2009

Programme 2: Human-induced impacts

An investigation into the impact of landfill leachate on the physical, chemical and microbiological quality of the Soutpan Stream and its immediate surroundings

Tshwane University of Technology

No. 1341

The Soutpan Stream runs past a very poorly-managed landfill site which serves the local Soshanguve community. The landfill is used for dumping of domestic and industrial wastes. Visible leachate is observed on a regular basis running into the Soutpan Stream. The Soutpan Stream serves a huge informal settlement as sole water source and thus presents a health hazard. The community uses the water for household practices, gardening and for animals to drink. This project aims to improve the situation and make the water and the landfill practices acceptable according to set guidelines. This will serve as an upliftment project for the community as we will make use of their experience and knowledge. The research aims to:

- Conduct an environmental inventory and audit of the study area
- Obtain information on how the landfill site is managed, the hydrogeological conditions, attenuating factors, weather patterns, volume and type of waste dumped, the volume and characteristics of leachate produced
- Investigate the direct and indirect physical, chemical and microbiological impacts and consequences, over a defined range of temporal and spatial scales, of the leachate generated at the poorly-managed landfill site on the Soutpan Stream and its immediate surroundings
- Suggest measures which will help to minimise any adverse impacts on the environment and human health

Estimated cost: R386 000
Expected term: 2002 - 2009

Persistent organic pollutants (POPs) in the environment

North-West University

No. 1561

South Africa is a signatory to the Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research now needs to be taken further in order to:

- Assess with higher confidence the scale and significance of the occurrence of POPs in the water environment in South Africa, the potential short-term and long-term impacts on water resources and water-linked ecosystems and the associated threats to sustainability of water resources and water use

- Better identify and quantify the fate and effect of selected POPs in the water environment
- Guide and inform the development of appropriate policy and regulatory measures that will:
 - Support implementation of the requirements of the Stockholm Convention
 - Substantially contribute to the protection of water resources and water-linked ecosystems with regard to POPs.

Estimated cost: R1 500 000
Expected term: 2005 - 2009

Development of a model to assess the cost associated with eutrophication

The Institute of Natural Resources

No. 1568

Eutrophication and its accompanying effects is one of the intractable symptoms of water pollution associated with modern society. It diminishes the quality of our water resources for many uses and costly treatment is often required to overcome its negative effects. In the prevention vs. cure debate, it is important to not only know the cost of prevention, but also the cost associated with eutrophication when it occurs at various levels, in order to justify often expensive preventative measures. Knowledge of the cost associated with eutrophication will also help in determining and justifying the introduction of waste discharge charges. Similarly to a study that assessed the cost to users that can be associated with water salinity, a multidisciplinary team will conduct this project to determine the costs associated with eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000
Expected term: 2005 - 2009

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface- and groundwater

University of Pretoria

No. 1686

The adverse effects of endocrine disrupting chemicals (EDCs) in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In South Africa no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal. In this study the presence/absence of veterinary drugs in the environment will be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources screened for oestrogenic and anti-androgenic activity, using a battery of bio-assays

Estimated cost: R1 900 000
Expected term: 2006 - 2009

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water

CSIR

No. 1749

DWAF is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles were used in the *1996 South African Water Quality Guidelines (Vol 6: Aquatic Environment)* the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in characterizing the biotic effect of various endocrinal active substances at various levels of biological organisation, critical interpretational gaps remain. In its commonly used paradigm, health-risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water. The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500
Expected term: 2007 - 2009

A national survey of mercury levels in South African resources

CSIR

No. 1754

Recent estimates indicate that Hg emissions from sources in South Africa, mostly coal combustion and gold mining, contribute more than 10% to the global Hg emissions, thereby ranking the country second after China on the list of major Hg polluters globally. Mercury (Hg) pollution is a world-wide problem that should be addressed at global, regional and national levels. Mercury is released into the atmosphere from anthropogenic sources both as elemental Hg (Hg₀) and in the ionic oxidized form (HgII). The major concern with Hg₀ is that once released into the atmosphere it is oxidized, contributing to the oxidized Hg pool. This HgII is very water-soluble, and is removed from the atmosphere by both wet and dry deposition and enters freshwater and marine resources, where it is rapidly converted into the more toxic methyl-mercury (CH₃Hg) form. This more toxic form bio-accumulates in the aquatic food chain and poses a serious health risk to humans who consume fish or other aquatic organisms that are contaminated with CH₃Hg. Anthropogenic activities, such as artisan gold-mining activities, industrial and small-scale coal combustion, as sources of Hg in the atmosphere, the deposit thereof into water resources, and its effects on water quality, are not well characterized in South Africa. Accordingly, as one important step towards such characterization, this project aims to carry out a national survey of Hg levels in South African water resources. This should provide a sound basis for establishing the extent to which Hg is currently a problem in South Africa. The aims of the study are to survey the levels and speciation of mercury in water, sediments and biota

in priority South African water resources; to assess the degree of compliance of the measured mercury levels with national and international guidelines; to assess the degree to which mercury may be a problematic pollutant in South Africa; and to create local capacity relating to mercury sampling and analysis.

Estimated cost: R918 850
Expected term: 2007 - 2009

Investigation into the effects of water quality (organic vs. inorganic) on the immune systems of humans

University of the Western Cape

No. 1756

This will be a comprehensive study of the effects of water quality on the immune system of humans. The quality of potable and raw water could vary considerably from place to place and this depends on the microbiological and chemical constituents of the water. Several of the physiological systems (e.g. immune, thyroid-hypothalamus, reproductive and the neuro-physiological system) can be impacted on by the quality of the water. The complexity of mixtures is that different constituents (depending on the concentration of each) could have synergistic or antagonistic or no effects in the particular mixture on the human body. Some man-made chemicals affect the function of one or more immune pathways and this can have adverse effects on the health of man and animals. The objective of the study will be to develop and validate analytical tools to evaluate the impact of aquatic pollutants on the immune system. Water extracts obtained from various areas will be evaluated for its immunotoxicity and analytical procedures will be verified to measure the different effects on the human immune system.

Estimated cost: R1 500 000
Expected term: 2007 - 2010

Programme 3: Integrated flood and drought management

Soil moisture from satellites: Daily rainfall maps over RSA, for flash flood forecasting, drought monitoring, catchment management and agriculture

Pegram & Associates

No. 1683

The amount of water in the soil acts as a vital switch between the atmosphere and the ground, governing many earth-bound water processes: infiltration, evapotranspiration, interflow and groundwater recharge. If accurate spatial estimates of soil moisture (SM) over large areas were available, they would be useful in many applications in hydrology, meteorology and agriculture. A number of satellites launched in the recent past have capabilities to measure variables for calculating countrywide SM at fairly high resolution. This project is expected to develop, and put in place, the scientific capacity to exploit the hardware, software and skills that exist in different international satellite agents. Other key project aims include:

- Developing a daily soil moisture map over Southern Africa at a resolution of 1 minute of arc and loading it onto the Internet
- Ground validation for remote sensing using soil moisture estimates at probes deployed by SAWS
- Interpolation over Southern Africa of meteorological variables near ground level: temperature, pressure, humidity, wind speed and energy

Estimated cost: R2 483 200
Expected term: 2006 - 2010

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

Importance of groundwater in the hydrological cycle and the relationship to surface water bodies

University of Zululand (Department of Hydrology)
No. 1168

Understanding the processes involved in groundwater-surface water interactions is becoming increasingly important for protecting the integrity of ecosystems. This project aims to develop models of typical groundwater-surface water processes in South Africa and also to establish compatible methods for estimating time series of surface and groundwater rates for comparative analyses.

Estimated cost: R770 000
Expected term: 2000 - 2009

Land-use impacts on salinity in Western Cape waters

University of Stellenbosch (Department of Soil Science)
No. 1503

The importance of dry-land salinity on water resources has been recognised for quite some time. Its importance is especially visible in the dryer parts of the country and in Western Cape rivers. Earlier research attributed the mobilisation of salt to ploughing of land, which increases infiltration and accelerates the mobilisation of salts contained in the underlying geologic strata. Another potential mechanism is that changes in land use from extensive pastoral use to intensive cropping over the last century or more may have triggered the same process of salt decantation being experienced in Australia. As the salinisation of some Western Cape dams is intimately linked to salinity releases from agricultural land it is important to gain a better understanding of the mechanisms that are operative. The central aim of this project is to develop a thorough understanding of soil water and salinity dynamics, salt sources and salt storage in dry-land profile and hill-slope transects, as well as corresponding groundwater salinity dynamics. This understanding should inform future large-scale modelling and enable the development of land-use practices that would reduce/prevent degradation of land and water resources.

The central objective of this project is to develop a thorough understanding of water and salinity dynamics in the regolith (soil plus vadose zone) of a small dry-land catchment representative of semi-arid conditions in the Berg River basin. The perspective will include both salt sources and storage, and groundwater fluxes and catchment runoff, in order to inform future large-scale modelling and to guide the development of land-use practices that would reduce the degradation of land and water resources. Subsidiary objectives include the following:

- Determine and map the spatial distribution of salts across the whole Berg River catchment
- Spatially relate salt distribution to salinity-generating factors (soils and soil-forming processes, geology, climate, topography, vegetation and land use) across the whole Berg River catchment
- Develop an improved understanding of how local tillage and other dry-land farming practices augment or reduce the mobilisation of salts

- Conduct mechanistic modelling of salinity dynamics
- Use the model to create small catchment-scale salt flux scenarios for various land use and water management practices that will serve to inform modelling of salt fluxes on a regional scale

Estimated cost: R2 347 068
Expected term: 2004 - 2009

Novel silicone rubber integrative passive field sampler

University of Venda (School of Environmental Sciences/
Department of Ecology and Resource Management)
No. 1504

Time-weighted average (TWA) passive field samplers provide vital information in ecological risk assessment of chemical pollutants. The passive field samplers quantify the freely-dissolved pollutant in water that approximates the bio-available fraction in longer exposure times. They therefore also give vital information on changes in pollutant level over time. However, not many passive field samplers are available and those that are available are mostly not very selective. They furthermore require additional clean-up steps before analysing the extracted samples. This project aims to develop, construct and test a simple and cheap TWA passive field sampler that will require no mechanical device and can be used in remote sites. The sampler will utilise silicone rubber in the form of a hollow fibre as absorbing medium. The inside of the hollow fibre will serve as the receiving phase and the outside as the donor phase. The pH of the solution in the receiving phase will be set such that target analytes are ionised and trapped. It is anticipated that this will result in very high enrichment factors over longer exposure periods. The developed sampler will be evaluated under laboratory conditions for its trapping efficiency for a range of pollutant groups as well as potential synergism and antagonism associated with trapping combinations of pollutant groups. The objectives are to:

- Develop a time-integrated sampling device based on silicone rubber for measurements of pesticide concentrations at environmental levels under field conditions
- Evaluate the efficiency of the sampling device for trapping representative examples of pesticides and other pollutant groups
- Determine the synergism and antagonism associated with trapping combinations of pollutant groups
- Evaluate the release of high concentrations during subsequent exposure to lower environmental concentrations.

Estimated cost: R250 000
Expected term: 2004 - 2009

Sampling and monitoring protocol for radioactive elements

University of the Western Cape
No. 1694

The presence of radioactive constituents (uranium, thorium and associated daughter elements) in groundwater poses a health risk. Weathering and leaching of trace element-rich geological formations and also mining wastes result in high concentrations of these constituents in groundwater. The National Radioactive Monitoring Programme (NRMP) of DWAF aims to monitor radioactive elements on a national scale. The focus of this study

is to support the NRMP by implementing investigations around impacted sites for local monitoring programmes. Specific objectives are:

- Re-evaluate the results of earlier research findings on uranium speciation and the associated anomalies (i.e. anomalies in the aqueous environment) at the selected study area
- Applying recent advances to characterize flow regimes in fractured-rock aquifer systems, with reference to 'tracing' the distribution of radioactive elements in fractured media
- Development of local-scale sampling and monitoring protocol for radioactive elements in fractured rock formations
- Delineating a groundwater protection zone around a selected study area with respect to an unstressed system taking into account the hydraulics, behaviour of selected radioactive elements, relevant policy documents, etc.

Estimated cost: R1 500 000

Expected term: 2006 - 2009

Investigation of the positive and negative consequences associated with the introduction of low-P detergents

University of KwaZulu-Natal (Pietermaritzburg)

No. 1768

Eutrophication is rated as one of the major water quality problems being experienced by South Africa. Eutrophication, specifically the accumulation of phosphorus (P), gives rise to serious problems with the water quality management of South African dams. It is estimated that up to 50% of P in South African sewage comes from detergents. This project will investigate the positive and negative consequences that the introduction of detergents with lower P contents would have on the eutrophication of dams, users of detergents, water and wastewater treatment works and the waste discharge charges system.

Estimated cost: R689 200

Expected term: 2007 - 2009

Development of a conceptual framework for the regulation of water quality within the context of an integrated, preventative management approach

Golder Associates Africa (Pty.) Ltd.

No. 1769

The implementation of the integrated preventive management approach that guides the *DWAF Drinking Water Quality Management Framework for South Africa* (2005) and *WHO Water Quality Guidelines* (2004) requires a well co-ordinated regulatory system for the management of the entire water supply system from the catchment to the consumer and the quality of effluents discharged into the water resources. Currently, the linkages between water resource management and drinking water quality management are not strongly followed nor addressed within the regulatory framework. Therefore, this project aims to develop a conceptual framework for integrating the regulation of the quality of water resources with that of drinking water quality in order to support the implementation of the integrated, preventative management approach.

Estimated cost: R600 000

Expected term: 2007 - 2009

Programme 3: Integrated river flow and catchment hydraulics

An investigation and formulation of methods and guidelines for the licensing of SFRA's with particular reference to low flows

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1428

Section 36 of the National Water Act, Act 36 of 1998 (NWA) gives the Minister of Water Affairs and Forestry the powers to declare a land-based activity as a streamflow reduction activity (SFRA), if that activity is likely to significantly reduce the availability of water in a watercourse to the Reserve, to meet international obligations, or to other water users. While afforestation has so far been declared a SFR activity, scarcity of knowledge has been identified as a major constraint in this regulatory process. The available licensing methods have been noted to be too coarse and, besides spatial scales, have also failed to handle issues such as soil textures and varying temporal scales. Questions surrounding the licensing process, the basis of the methods in use, the future of SFRA licensing and the need to evaluate other land uses continue to build up. This study seeks to develop scientifically-robust (and generic) and legally-defensible methods of assessing low flow reductions and ultimately to develop guidelines for the licensing of SFRA's. The objectives are:

- To re-analyse, and improve upon, conceptual modelling methods and input data utilised in WRC **Project No. 1110 (Estimation of streamflow reductions resulting from commercial afforestation in SA)** and to reconsider methods used for the derivation of confidence limits from the above project, and incorporate these into the proposed guidelines
- Analyses of different flow components (quickflow, interflow, baseflow and groundwater discharge) to determine how these are affected by afforestation and by dry and wet cycles as well as the determination of the relative importance of the flow components between catchments and the impacts of afforestation on the flow components
- Through these analyses, and with input from related process study research, to improve the simulation of low flows in the ACRU Agrohydrological Modelling System through improved conceptualisation of low-flow generation processes and the translation of these into model code
- To devise and implement a process whereby research and management needs are pursued in parallel in order to ensure optimal applicability and usability of the products of SFRA-related research
- To provide a link between researchers involved in hydrological process studies of the effects of land-use change on low flows, e.g. WRC **Project Nos. K8/577 (Weatherley catchment: Soil organic carbon and vegetation baseline study)** and **K5/1317 (The relationship between soil water regime and soil profile morphology in the Weatherley catchment, an afforestation area in the North-Eastern Cape)**, and managers and other interested and affected parties involved in this field
- To refine the guidelines for dealing with scale and resolution in the quantification of SFRs developed by Ninham Shand and the University of Stellenbosch
- To provide guidelines for the declaration of additional SFRA's that may be declared in the context of recent DWAF discussions and their authorisation in the context of the above guidelines

- To develop and implement in DWAF national and regional offices, and existing CMAs, a decision support system and associated guidelines, to assist in hydrological assessments for the consideration of water use authorisations. These will form an SFRA component of the planned Water Allocation Toolkit, the components of which can be applied consistently across regions, are transparent in approach, and are adaptable in that they can be upgraded or amended with minimum disruption.
- To ensure the compatibility of Reserve determination methodologies and the results thereof with SFRA and other water-use estimates and available hydrological information through consideration of specific months and daily flow records for various assurance of supply levels
- To test these products through the application of the guidelines in at least 4 catchment case studies
- To improve the research capacity in South Africa in the field of land-use hydrology and integrated water resource management and the skills of water resource managers involved in water-use licensing, particularly SFRA's

Estimated cost: R3 800 000
Expected term: 2004 - 2009

The impact of deep-rooted trees on the hydrological balance of a small catchment in the KwaZulu-Natal midlands
CSIR

No. 1682

Recent WRC studies and modelling of forestry water use have shown that our best estimates of tree water use, and in particular dry season water use, are not within acceptable error margins. One of the main reasons for this is the inability of hydrological models to accurately simulate the deeper soil water processes. This project, which will rely on field-based experimental work and computer modelling, is expected to:

- Quantify the long-term effects of commercial forestry species on deep soil water profiles, streamflow and evaporation
- To investigate and describe environmental and soil water processes which allow for total evaporation to exceed the annual rainfall
- To provide a modelling framework for the catchment water balance to improve streamflow predictions and specifically low flows
- To extend and test the database of catchment hydrological variables, including data on tree root behaviour and its effect on soil water in deeper soil layers, in modelling studies

Estimated cost: R639 200
Expected term: 2006 - 2009

Sedimentation and sediment yield maps for South Africa
University of Stellenbosch

No. 1765

Loss of storage capacity in dams due to sedimentation is a major strategic threat to our country's available water resources. Soil erosion, and therefore sediment yield and reservoir sedimentation, is accelerated by human activities such as clearing of vegetation and poor farming practices. In order to regulate and manage these negative actions, it is important to have accurate national maps of eroded areas and sediment yield. The sediment yield maps to be developed in this project are expected to assist DWAF in mitigating sedimentation

impacts and making adequate provisions for sedimentation in dam developments. The better understanding of localised sedimentation processes from this research will feed into the land and soils conservation and management practices which are major concerns in farming communities and the National Department of Agriculture.

Estimated cost: R1 400 000
Expected term: 2007 - 2010

South African Handbook on Environmental Hydraulics
Ninham Shand

No. 1767

A great deal of river hydraulics knowledge has been gained through WRC projects. In the past, research projects have addressed a number of subjects which have included flow hydraulics, sediment transport and deposition, which are cornerstones of environmental studies. The knowledge gained from WRC research has been accumulated into a number of research reports, some of which are no longer available for distribution. This project will seek to collate available knowledge and experiences and integrate these into a user-friendly handbook of river hydraulics. The project will engage several experts to contribute on their specific research areas.

Estimated cost: R920 000
Expected term: 2007 - 2009

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Water resource management in rainwater harvesting (RwH): An integrated system

Source Strategic Focus (Pty.) Ltd.

No. 1563

Rainwater harvesting (RwH), an old technology that dates back thousands of years, is gaining popularity in a new way. The global trend towards cheap and less ecologically-disruptive water supply systems has tended to favour the development and application of cheap, environmentally-friendly and readily-available techniques that are decentralized as opposed to huge centralized water infrastructure. RwH, one of the cheaper and decentralized water provision techniques, is set to expand nationally to cater for South Africa's unserved population in rural and agricultural communities, which currently exceeds half the population. Larger-scale implementation of RwH will require improved management to enhance benefits and mitigate negative impacts. Increased understanding and a better synthesis of RwH techniques to be achieved in this project will lead to the development of a model-based decision support tool as well as a policy document on the RwH practice. The RwH decision support tool and the policy document are set to guide and direct the RwH practice within the boundaries of integrated water resource management in accordance with the provisions of the National Water Act and other related legislation such as the Environmental Conservation Act. As part of the RwH decision support tools, methodologies for quantifying socio-economic, hydrological, ecological and environmental impacts of RwH are expected to be developed and refined for packaging as

standalone applications or for incorporation into existing water resource management and water systems analysis models.

Estimated cost: R2 800 000
Expected term: 2005 - 2008

A philosophy and strategy enabling learning for good ecosystem governance

CSIR

No. 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users and to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. In addition, the aim is also to develop a strategy and implement it using the above principles in pilot areas. As a new, emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200
Expected term: 2006 - 2009

Institutional dimensions of water resource management in South Africa: Socio-cultural perspectives

University of Cape Town

No. 1698

This project seeks to analyse, monitor and evaluate the new water management institutional arrangements by focusing on the role of socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices in determining water management outcomes. Some of the long-term benefits of the research include enhancing public participation in water management and the voices of local people, and alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400
Expected term: 2006 - 2009

The criteria necessary for the success of women in the water sector

Palmer Development Group

No. 1762

A number of successful women can be found in the political, corporate and business worlds in South Africa. Whether their success can be attributed to positive family endowments such as well-defined gender roles at the home and/or community level, the enabling legislation in support of gender parity, etc., or a combination of all the above, might explain why still only few women manage to make it to the top echelons. The project will seek to personalise the success by investigating real-life examples to draw out the criteria necessary for the success of women in the water sector. The intention is to uplift those feeling disempowered and to identify gaps if any hindering the progress of women in the water arena.

Estimated cost: R712 320
Expected term: 2007 - 2010

Development of the AWARE model for the Inkomati CMA

University of KwaZulu-Natal

No. 1935

RISKOMAN, a joint project with UNESCO-IHE, aims to develop a policy tool that: (a) can optimise water allocation in multi-purpose multi-reservoir systems in water scarce environments, based on economic values and socio-political preferences; that (b) can continuously adjust these allocation policies based on seasonal flow forecasts and knowledge of their uncertainties; and that (c) can hedge against inflow risks using adaptive, risk dynamic, management and operation strategies. This project adds 2 extra components to the RISKOMAN research: i.e. (a) The development of an interactive multi-level information system in which information will be provided to different levels of basin water resources stakeholders, with an emphasis on providing the integrated information from RISKOMAN to the level of CMA Board members; (b) improved understanding of the hydrological functioning of the Inkomati Basin through focused research on the spatial and temporal variability of hydrological drivers in the catchment with the use of remote-sensing methodologies and the application of these within the RISKOMAN project as a whole.

Estimated cost: R1 800 000
Expected term: 2007 - 2013

Programme 3: Pricing and financing WRM

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development

Conningarth Economist

No. 1570

Water being a limited resource, it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000
Expected term: 2005 - 2009

Programme 4: Transboundary water resources

Review of the involvements of national water institutions and civil society in international agreements in South Africa

Pegasys Strategic Management

No. 1758

Water management institutional reform is taking place within most of the SADC countries, and new local catchment councils and/or agencies are already in existence in the respective countries. At higher interstate levels, Shared River Commissions are established in accordance with the SADC protocol on shared rivers. To date, little or no attention has been paid to the interaction and integration of local actors vs. international bodies

and the quest to separate the governance and implementation/management dimensions in internationally shared rivers for effective management and long-term sustainable use of such resources. This project could look at some examples such as the Inko-Maputo Agreement and the roles and responsibilities of the different local and international role players to ensure effective implementation. Other examples can also be considered.

Estimated cost: R3 000 000
Expected term: 2007 - 2010

New Projects

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Optimised monitoring of groundwater – surface water – atmospheric parameters for enhanced decision making at a local scale

CSIR; University of the Western Cape; University of Stellenbosch; GEOSS; University of KwaZulu-Natal

No. 1846

The primary objective of this research will be to develop a framework for optimised monitoring of the most important variables required to manage groundwater resources and understand the fluxes between atmosphere – soil – groundwater – surface water systems at a local level. The secondary objectives of the project are to understanding the institutional and legal interactions of different agencies responsible for various monitoring programmes, develop guidelines for monitoring best practices applicable to South(ern) African conditions and further develop a framework for the monitoring of the different fluxes so that they are closely measured in time and space, where applicable.

Estimated cost: R1 300 000
Expected term: 2008 - 2011

Development and application of global navigational satellite systems (GNSS) methodology for groundwater resource assessment

Umvoto Africa (Pty.) Ltd.; Purdue University; Department of Land Affairs; Overstrand Municipality

No. 1851

The aim of this project is to demonstrate the use of high-precision global navigation satellite systems (GNSS) technology as a tool for groundwater resource monitoring and assessment; develop a methodology for relating GNSS measurements of natural or abstraction-induced surface deformation and conjunctive hydrogeological data in order to derive the *in situ*, bulk elastic properties of an underlying confined fractured-rock aquifer; and build South African capacity to establish the technical infrastructure and implement the data-processing methods required for pilot GNSS – for a groundwater scheme at the Gateway well field, Hermanus.

Estimated cost: R1 000 000
Expected term: 2008 - 2011

Programme 3: Water resource planning

Integrating water resource and water service management tools

WRP Consulting Engineers; DMM Software Services
No. 1840

Integrated water resource management (IWRM) is a concept that has been used to refer to a system where all aspects of human interaction with water resources are considered as potentially inter-related and are therefore addressed together rather than separately. While this definition of IWRM readily accommodates water services provision, narrower definitions that exclude water services are usually preferred and pursued. Among other objectives, this research will develop a framework for the integration of water resource and service management tools. The framework to be developed will present the best solution which takes account of the present state of needs, available resources, existing commitments and institutional frameworks. As part of demonstrating how easily the research findings are packaged for application, this project will develop and present a case study solution that integrates water service and resource tools for a specific complex water use area such as a large municipal area.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

Programme 4: Water resource development

Identification, estimation, quantification and incorporation of risk and uncertainty in water resource management tools in South Africa

Rhodes University; University of KwaZulu-Natal; Water for Africa
No. 1838

All estimation methods in natural resources are subject to uncertainty. Our failure to adequately account for uncertainty could lead to false 'security' in decision making. This research will investigate the links between risk and uncertainty in water resource management and develop an informed understanding of uncertainty and the associated risks in water resource management. Of importance is that the research will develop guidelines for incorporating uncertainty and the associated risk into water resource decision-making processes. Guidance on reducing uncertainty as well as mitigating the impact of uncertainty in water resource management is expected to be another key output of the research.

Estimated cost: R800 000
Expected term: 2008 - 2011

An investigation of the potential use of ocean colour remote sensing to assess the influence of variations in freshwater inputs to coastal ecosystems: Phytoplankton and sediment dynamics of the Natal Bight

CSIR; University of Cape Town
No. 1852

The freshwater flows into the estuarine systems and beyond, as well as the flow drivers, are of importance in cost-effective routine assessment of the productivity of riverine-influenced coastal ecosystems. Ocean colour remote sensing has been identified as a unique means of assessing the influence of

variations in freshwater inputs to coastal ecosystems. The study will improve understanding of the relationship between freshwater-derived fluxes into the marine environment and ecosystem response; in particular this study will distinguish between inflow (drivers) and the associated response of marine systems.

Estimated cost: R315 000
Expected term: 2008 - 2010

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 1: Developing predictive tools and adaptive measures to global climate change

An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments

University of KwaZulu-Natal (School of Agricultural Sciences and Agribusiness); University of Cape Town; Swedish Meteorological and Hydrological Institute (SMHI); DWAF; Government of Queensland; German Development Institute (GDI)

No. 1843

Much effort has been expended to improve predictions of how global change will impact on primary biophysical changes such as rainfall and temperature, and the secondary effects on crop production, water resources and ecosystems. However, to date practically no effort has been made to integrate the causal relationships of global change to determine or assess its higher level socio-economic impacts. These impacts can be disastrous on a regional scale and its knock-on effect may have serious implications for the national economy. Vulnerable communities may be most seriously affected. On the other hand, socio-economic activities mostly display remarkable adaptive ability and thus resilience to change. This project will be undertaken to assess how sensitive socio-economic activities are to expected climate change in 4 divergent areas of South Africa.

Estimated cost: R2 500 000
Expected term: 2008 - 2011

Tropical systems from the southwest Indian Ocean into Southern Africa: Impacts, dynamics and projected changes.

ARC; University of Pretoria

No. 1847

This project aims to determine from historical synoptic-scale weather data instances when tropical systems from the Indian Ocean have influenced rainfall over the Limpopo Province and Mozambique. The period that will be investigated is from 1948 to the present. During this time a sufficient network of rainfall stations allows for the investigation of the impact of these systems on rainfall over the province. The inclusion of rainfall data can enhance the analysis of these types of systems. Tropical depression track data from the Tropical Cyclone Centre, La Reunion, will also be used for this purpose.

Estimated cost: R680 200
Expected term: 2008 - 2011

Programme 2: Human-induced impacts

A comparison of the costs associated with pollution-prevention measures to that required to treat polluted water resources

CSIR; University of Cape Town

No. 1845

It is widely assumed that prevention is better than cure. This project will determine whether or not this assumption holds when applied to cleaner production technology costs (prevention) compared to the cost of treatment of pollution and the external costs borne by downstream users (cure). Four of the most important water quality contaminants will be covered: namely, salinity, eutrophication, microbial pollution and sediments. Because of the differences in the sources of the contaminants to be investigated and in the levels of information available for each, a differential approach will be followed in conducting this project. Specific catchments where the specified pollutants are of concern will be identified and the study will be undertaken in the identified catchment, e.g. salinisation in the Vaal catchment and eutrophication in the Crocodile catchment.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

THRUST 3: WATER RESOURCES PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

Management of human-induced salinisation in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity

University of Pretoria; University of the Western Cape; Western Cape Department of Agriculture

No. 1849

Salinisation is a major problem affecting Western Cape waters. The situation is exacerbated by an increasing demand for water. The recognition that dry-land agricultural practices (rather than only irrigation return flow) make a major contribution in this regard is of relatively recent origin (the current WRC **Project No. 1503** made a significant contribution in this regard). This follow-on project intends to continue with its small-scale process studies, expand their breadth by incorporating long-term studies of the Department of Agriculture and integrating the cumulative knowledge into predictive models to simulate the salt load and the contributions made by different land-use practices. The insights gained in this way will be used to develop guidelines for regulating land use in terms of salt-generating capacity.

Estimated cost: R2 964 000
Expected term: 2008 - 2012

Assessment of the toxicity of cyanobacteria in the Kruger National Park

ARC; SANParks Veterinary Wildlife Services; University of Pretoria; State Veterinary Services

No. 1850

Cyanobacteria (blue-green algae) are found throughout the world in freshwater and marine habitats. Cyanobacteria produce a variety of toxins known as cyanotoxins which have an adverse

effect on livestock, domestic animals and wildlife. There have been reports of deaths of wildlife suspected to have been caused by cyanobacteria in the Kruger National Park after exposure to water containing cyanobacteria. It is suspected that a large percentage of wildlife succumb to cyanobacterial poisoning every year as no normal data on mortality are recorded. The only time there is assessment of the surface water is when there are deaths of wildlife, and sometimes the cyanobacterial toxin content of the nearby rivers/dams, which the animals were exposed to, would have changed completely by the time of assessment of the water, thus not reflecting the toxin levels that caused mortality. The study aims to generate information (database) on the extent to which cyanobacteria and their toxins affect wildlife.

Estimated cost: R395 000
Expected term: 2008 - 2010

Quality control and assurance guideline for South African toxicity testing laboratories

CSIR; Golder & Associates Africa; Renaissance Environmental Hub; Umgeni Water; Rand Water; DWAF; SASOL; South African National Accreditation System (SANAS)

No. 1853

The South African National Water Act (Act 36 of 1998) (NWA) mandates the establishment of policies and approaches to reduce and prevent degradation; and to assess the quality of water resources. To comply with the above requirements the National Toxicity Monitoring Programme for Surface Waters (NTMP) (DWAF, 2005) and the Direct Estimation of Ecological Effect Potential (DEEEP) approach for waste discharge (DWAF, 2003) were introduced. Standard methods were documented for both of these approaches. The toxicity methods are presented in terms of the test environment; materials; equipment and reagents; test organism (breeding and maintenance); test procedure; data analysis and expression of results; test precision of results; test report format; as well as related issues such as sample collection; transport; and storage and waste disposal. Quality requirements pertaining to the above-mentioned sub-sections and training of new staff to comply with minimum requirements for accreditation purposes, will also be addressed.

Estimated cost: R600 000
Expected term: 2008 - 2010

Development of a risk indicator methodology to estimate the relative risk of pesticide contamination in South African water resources

CSIR; DWAF; University of Johannesburg; Università Cattolica del Sacro Cuore

No. 1854

Pesticides are among the most crucial non-point-source pollutants, because of their extremely high toxicity to many non-target aquatic organisms (fish and macroinvertebrates). The Department of Water Affairs and Forestry (DWAF) has recently designed and implemented the National Toxicity Monitoring Programme (NTMP), which monitors toxicity and a number of priority toxic chemicals, the majority of which are pesticides. The National Water Act (Act 36 of 1998) requires rivers to be classified according to a specific class and the establishment of resource quality objectives (RQOs) to protect the desired class of a specific river. Risk indicators can be regarded as lower-tier risk assessment tools that provide a relative assessment of the environmental

impact of pesticides through integration of ecotoxicological, environmental fate and pesticide use data. This study proposes to examine the application of pesticide risk indicators as a meaningful tool to predict the relative impacts of pesticides on the aquatic environment.

Estimated cost: R900 000
Expected term: 2008 - 2011

Programme 2: Protection and management of surface water and quality

Nitrate removal for groundwater supply to rural communities

CSIR; University of Stellenbosch; Biostream

No. 1848

This is a follow-up project whose main contribution will be the design criteria for a range of in situ and ex situ treatment of nitrates in groundwater. This provides alternatives for the specific needs of rural communities. The project investigates applicable identification systems in specific circumstances (i.e. rural communities, town water supply and stock watering, etc.).

Estimated cost: R600 000
Expected term: 2008 - 2010

THRUST 4: WATER RESOURCES INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Exploring the lowest appropriate level of water governance in South Africa

University of the Western Cape; University of Botswana

No. 1837

This project aims to develop an unambiguous conception of the management-governance relationship. Clarify the resource management responsibilities and concomitant governance responsibilities of each type of water organisation as intended by government and other stakeholders. Investigate the execution of the governance responsibility of each organisation type within a water management area and advise on possible reforms. The project aims to derive the most appropriate structure of water governance, particularly at local level, based on local experience in comparison with international practice.

Estimated cost: R1 000 000
Expected term: 2008 - 2010

The impact of IWRM on the lives of women and the poor in South Africa

Ninham Shand; University of the Western Cape; Groundwater Africa; North-West University; Rand Water; The Rural Action Committee; Mbumba Development Services; Umhlaba Consulting Group; FAO; Gavin Quibell (independent consultant); Roger Short (independent consultant); DANIDA/DWAF; PLAAS (Institute for Poverty, Land and Agrarian Studies, UWC)

No. 1839

This project aims to: conduct a comprehensive literature review of how IWRM has been conceived and applied both

in international literature and in selected national legislation and policy; to develop indicators for assessing how IWRM will impact on the lives of women and the poor and to apply these indicators to South African case studies; and to build research capacity locally and internationally on approaches to implement and monitor IWRM.

Estimated cost: R1 000 000
Expected term: 2008 - 2010

Water allocation reform, instruments and processes for achieving equity and gender balance

Sinelwati Scientific cc; Scientific and Technical Services Institution
No. 1855

This project aims to interrogate and derive lessons from international (regional) experiences with respect to sustainable use of water to meet the needs of historically-disadvantaged individuals and the poor; to evaluate immediate past interventions designed to achieve redress, establish reasons for success or failures and derive lessons; to evaluate each of the current processes and instruments for water allocation reform and investigate the conditions under which they can meaningfully redress race and gender inequities; to develop discussion documents and guidelines to inform and improve future implementation of the water allocation reform processes and instruments; to participate and share lessons with the department as the water allocation reform is implemented; and to develop a learning journey manual for the water allocation reform experience in South Africa

Estimated cost: R1 050 000
Expected term: 2008 - 2010

Programme 3: Pricing and financing WRM

An investigation into the water infrastructure development financial allocation pathways in municipalities

African Centre for Water Research; Pegasys Strategy and Development; Oscar Somers (independent consultant)
No. 1844

This project aims to describe and quantify the water and sanitation sector value chain; assess the impact of widely differing financial and institutional capacity of the sector actors on the financing of service delivery; describe and analyse financial decision-making in the value chain; identify constraints to financial effectiveness or to the use of any particular financial instruments in the pursuit of sector goals; and to develop scenarios and recommendations for improvements in the value chain.

Estimated cost: R2 000 000
Expected term: 2008 - 2010

Programme 5: Future scenarios

The water sector institutional landscape by 2025

CSIR; Barbara Heinzen (independent consultant); HSRC
No. 1841

The implementation of institutional reforms in South Africa is moving ahead despite a number of challenges and an environment that is changing constantly. The purpose of this investment is to project to the future and paint a

futuristic picture of the organisational landscape for both the management of water resources and for the provision of services. A good set of scenarios should leave the reader wondering which one is more likely or more probable. That forces the reader to think more, and that is the whole point of a scenario – to learn more about alternative futures, so that one can make better choices today. In this exercise, the scenario building must be conducted in a participatory and inclusive manner, and very systematically so that it could make a major contribution to refining the future outcomes in institutional rationing and to build new capacities in the country.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

Contact Persons

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Dr R Dube (until 31 December 2008)

Mr Wandile Nomqophu (from 1 July 2009)

E-mail: wandilen@wrc.org.za

Tel: +27 12 330 9069

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Mr Chris Moseki

E-mail: chrism@wrc.org.za

Tel: +27 12 330 9030

THRUST 3: WATER RESOURCE PROTECTION

Dr Shafick Adams

E-mail: shaficka@wrc.org.za

Tel: +27 12 330-9071

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Ms Eiman Karar

E-mail: eimank@wrc.org.za

Tel: +27 12 330 9029





Dr Steve Mitchell: Director

KSA 2: Water-Linked Ecosystems

Scope

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river) and water table-dependent (dependent on a water table, but not on surface water). This KSA focuses on the protection and sustainable utilisation of the aquatic environment and biota (instream, riparian and groundwater). This includes the research needs around the international conventions on environmental management (e.g. biodiversity) as well as human needs from the aquatic environment (e.g. sustainable management for equitable ecosystem resource utilisation, recreation and ecotourism).

The above will be achieved by developing technologies and methodologies, adaptive management processes and capacity to protect the resource and to sustain the flow of goods and services in a time of both demographic and climatic change in the Southern African context. Technologies and methodologies will be developed within this KSA to support the implementation of the national water policy to ensure sustainable resource use.

Objectives

In the light of international trends in research, the portfolio of research falling within the scope of, and addressing, this KSA has been adjusted. However, the main (primary) and secondary objectives of this KSA have been reviewed and found to appropriately address future research need scenarios. The main objective is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water; and to develop an understanding of the ecological processes underlying the delivery of goods and linked ecosystems in a water-scarce country during a time of demographic and climate change. This will be achieved through the following (secondary) objectives aiming to:

- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems
- Transfer the knowledge to the appropriate end-users, with special emphasis on decision makers and the community
- Build capacity in both research and management to sustainably manage aquatic ecosystems

Thrusts and Programmes

As indicated above, the research portfolio presented here does not deviate materially from that presented in the previous year. The thrust addressing Ecosystem Processes is progressing well.

A general description of thrust and programme structure is presented below. New initiatives and current projects have been grouped into strategic thrusts and programmes which directly address the above-mentioned objectives and are summarised as follows:

THRUST 1: ECOSYSTEM PROCESSES

Scope: This thrust includes research addressing the biophysical processes, form and function of ecosystems. This understanding will assist those managing the resource (water services, crop and aquaculture, biodiversity, etc.) to maximise socio-economic benefits in a sustainable manner. The aim is to generate knowledge to inform policy and management. Current programmes are:

- Estuarine processes
- Riverine processes
- Wetland processes
- Groundwater-dependent ecosystems
- Impoundments

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings. The following programmes are addressed:

- Ecological Reserve
- Estuary management
- Ecosystem health
- Environmental water quality
- Endocrine-disrupting compounds in water sources
- Socio-economic considerations
- Ecosystem governance

THRUST 3: ECOSYSTEM REHABILITATION

Scope: This thrust addresses the rehabilitation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities with the view to restoring, as far as possible, process, form and function in order to provide the stream of goods and services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where

possible. Capacity will be built to implement the research findings. Programmes include:

- Wetland rehabilitation
- River rehabilitation
- Influence of instream-constructed barriers

Research Portfolio for 2008/09

This KSA focuses on the protection and sustainable utilisation of the aquatic environment (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. It addresses national research needs (strategic and shorter-term) as well as those of international conventions on environmental management (e.g. wetland conservation [RAMSAR] and biodiversity). Work done within this KSA has contributed to the development of the National Water Act (NWA) and associated policies, an example being the ecological Reserve. This has meant that work within this field has not only addressed the strategic needs of the country, which have increased in line with the increased global recognition of the importance of the role of sustainable environmental management, but also has addressed some of the immediate research needs related to the NWA and its implementation. What people require of the environment is an area of increasing importance, and the building of capacity amongst the country's citizens (managers and the various user groups) to manage the environment sustainably is of cardinal importance.

Research was solicited in the following areas during 2008/09:

Development of DSS software for the determination of environmental water requirements (targeted solicited).

Existing methods determine scenarios for specified sites on a river and the flows there, which are extrapolated to apply to the remainder of the river. Stakeholders are then consulted to select the most applicable scenarios. This DSS will work the other way around, in that it will select the flows required for the various economic activities as well as the environment of a river basin, and then optimise flows to best suit the needs of all users. The method has worked well when presented by experts, and the DSS software will enable it to be more widely used.

Analysis of the ecological Reserve implementation scenarios with the intention to design an effective implementation approach / plan. The socio-economic differences among communities result in conflicting views with regard to the use and management of water resources, which has complicated the

implementation of the ecological Reserve in South Africa. In spite of all the challenges, there are situations where implementation of the ecological Reserve has been successfully executed and situations where implementation has not been successful. To have progress and effective implementation plans, there is a need to critique those 2 sets of case studies. The case studies should enable us to identify the strengths and weakness (gaps) of the implementation approaches and methods, and those of the policy itself. The results or output will be used to design 'a new way of doing things' as far as implementation is concerned. The output may also suggest refinement of the policy if need be.

A laboratory study to determine the effect of mixtures of pesticides in water on fish and small mammals (to support risk assessment). The risk associated with some of the more widely-used individual pesticides has been the subject of study, but what is not known is how these pesticides react with each other. Research done in this project will look for synergy or a synergy between pesticides, and so assess the relative risks associated with these pesticides in the environment.

Societal response/adaptation to the effects of climate change on water resource availability. The response of society to climate change is intricately linked with the environment, in that the environment underpins essential provisions for society. The project will be run in conjunction with the WWF-SA, who will be looking at the way in which society should adapt to climate change, and KSA 2 will look at the environmental response.

Hartbeespoort Dam recovery consortium. A substantial initiative to rehabilitate Hartbeespoort Dam is underway, and there will be research needed for this to be effective. Both KSA 2 and 1 are involved in this, and KSA 2 is already supporting some work within the initiative.

Non-solicited research. Projects researching ecosystem management will be given preference during the 2008-09 cycle, although effort will be made to stimulate research in ecosystem processes as well.

Budget for 2008/09

The approved funding of the research portfolio for 2008/09 leads to a committed funding budget of R11 698 847. For projects in 2008/09, R8 427 052 is committed to current projects, and R1 937 531 is requested for new projects in the 3 thrusts.



Core Strategy

The core strategy was fundamentally unchanged from 2007/08 and recommendations by the Institutional Review of July 2006 continued to be given special attention. Research funded from within this KSA will continue to address, within the mission and vision of the WRC, issues of sustainable use and the needs of the legislation and international conventions of South Africa. While addressing DWAF's priority areas and supporting the Minister of Water Affairs and Forestry's flagship projects through our research, the KSA furthermore internalised national strategies such as Water for Growth and Development, ASGISA (Accelerated and Shared Growth South Africa), JIPSA (**Joint Initiative on Priority Skills Acquisition**), and the 10-year plan of the Department of Science and Technology (DST). The Institutional Review panel and the board of the WRC made a number of recommendations, and these are being implemented.

Strategic context

The KSA for **Water-Linked Ecosystems** may be defined both by the physical boundaries of the area addressed by the KSA, as well as by the strategic role occupied by the WRC in the field, with relevance to organisations active in ecosystem research and management. Physically, the field includes aquatic and riparian ecosystems as well as those dependent on groundwater.

Research funded through this KSA not only provides knowledge for the protection of the resource and the biodiversity of aquatic ecosystems, but also supports sustainable utilisation of aquatic resources while ensuring equity between generations. The KSA 2 research further addresses the commitment of international conventions, the needs and implementation of policy as well as sustaining the capability of the environment to support the flow of benefits on which society depends.

The position of the WRC in funding research on ecosystems

Aquatic ecosystems comprise the resource in terms of the National Water Act of 1998. Even without this they are important for a number of reasons. They provide a barometer of ecosystem health, and hence environmental quality, which is responsive to change and easy to interpret. They also provide a number of goods and services which are used by all sectors of the population. Examples of these are water for domestic, agricultural and industrial use, polishing of effluents, basic food and fibre (fish, plants), traditional medicines and recreation opportunities, to name a few. A stable ecosystem provides the necessary resilience to cope with extreme events such as floods and droughts (natural) and pollution events (anthropogenic). In the past a proportion of the national cost for the treatment of wastes was externalised to the environment and although the environment was degraded by this, by and large the load did not exceed the capacity of the environment to cope with it. However, it is beneficial for all to maintain the resource in a good condition rather than to carry the costs associated with a poor-quality resource.

To this end, the WRC has funded research on ecosystems since the latter part of the 1980s. The work funded has been a balance between the generation of knowledge needed to understand ecosystem processes and ensuring that the knowledge generated supports sustainable management and utilisation of aquatic resources. Understanding established through the KSA's research is utilised to guide the direction of future resource management and planning. Some examples of this research funded during 2008/09 are the sustainable management of

estuaries aimed at empowering local authorities to better manage their natural resources, research on the development of cross-sectoral policy on biodiversity conservation aimed at providing all tiers of Government with the knowledge to protect South Africa's unique biodiversity without stifling development, and research on conservation planning.

The WRC, with its mandate to improve the national capability to sustainably manage water in the country, has a specific role which differs from that of other research funders. The WRC supports DWAF and other Government departments in their objectives to effectively manage the national water resource. Although in some cases there is an overlap, there is opportunity for synergy with other sources of funds, as the breadth of work funded by the WRC covers the short- to longer-term strategic needs of the country, and ranges from more fundamental to highly applied work within the area defined by the mandate. The number of collaborative initiatives and projects between this KSA and DWAF has increased substantially over the last few years and this has increased the alignment of the WRC with that of government.

Needs analysis

Identified in previous years is the urgent need for the generation of the ability to implement the new legislation such as the NWA. In this regard this KSA closely supports the Department of Water Affairs and Forestry (DWAF), Department of Environmental Affairs and Tourism (DEAT) and other Government departments and initiatives. However, the need also exists, possibly more than ever, for strategic research for innovation, the lead for which may come from global trends not necessarily yet reflected as needs in South Africa. The need to implement legislation tends to distract attention from this long-term need, although this is handled proactively as far as possible within this KSA so that anticipated research products are available when needed. The external Institutional Review also identified the support of research to address the longer-term needs of the country as requiring special attention. The capability to sustainably manage ecosystems is an overarching need which this KSA continues to address. In addition, involving both the decision makers and the community in the above is key to the successful implementation of the research findings.

At the higher level, it is necessary to improve the interface between scientists on the one hand and managers and the public, including rural communities, on the other. Without this, the concept of sustainable management will remain in the realm of theory. The external Institutional Review identified that the implementation of research findings required specific attention and this was addressed within the KSA through a WRC-wide initiative implemented during the year.

Research is needed to address the processes and functions of various components of aquatic ecosystems. It is becoming increasingly apparent that with the switch to largely addressing the needs of management over the past decade and a half, we are reaching the limits of current knowledge. More research needs to be initiated in selected areas in order to ensure that our knowledge remains ahead of the need to apply it.

At the operational level, in addition to the issues around the implementation of legislation, there is a need to provide knowledge on the mitigation of the effect of development on ecosystems.

Overview of technological trends

Several important recent trends in inland water research have been emerging internationally, and these are briefly discussed

below. These trends are being implemented in the medium- to long-term planning within the KSA where they are relevant to the country.

- **Climate change:** New knowledge further emphasises the importance of the phenomenon of climate change. There is an increasing body of knowledge on the effects of climate change from the temperate latitudes, but this deals largely with increasing temperature. More relevant to Southern Africa is the predicted change in rainfall, with the dry west becoming drier. The ramifications of this for management of the resource could be substantial.
- **Impoundment management:** Toxic blue-green algal blooms resulting from the eutrophication of impoundments continue to pose a problem world-wide. Locally, research work is addressing the possibility of managing the natural ecological processes within these impoundments in order to reduce the impact of these blooms. The ability to do this would not only protect the natural environment, but would also assist in keeping the cost of water treatment down.
- **Natural resources as a source for livelihoods:** Linking ecosystem utilisation to poverty alleviation, job creation and food security means the effective and sustainable management of ecosystems. Building capacity for sustainable utilisation in the context of sustainable development is a key intervention in this regard.
- Research on **wise use of wetlands** should accommodate the DST 10-year plan's focus area on 'Farmer to Pharma', which is aimed at developing pharmaceutical products from indigenous medicinal plants. Wetlands are sources of certain medicinal plants.
- **Conflict between water for food and water for the environment** is a key research initiative globally (led by the World Bank, CGIAR Challenge Programme). Furthermore, with the pressure upon local government to deliver on housing, clean water and other economic development, the misunderstanding regarding water for environment and water for growth and development should be managed using research outputs. Building the capacity amongst decision makers and other interested and affected parties is important for the success of this.
- It has become clear that research work is required on the **management of our shared rivers** to enable South Africa to be able to meet international commitments and conventions. This is possible by having collaborative initiatives with affected neighbouring countries. The KSA has initiated a project that will focus on management aspects of rivers that South Africa shares with her neighbours. A focus of this initiative is the implementation of the NWA as well as seeking to achieve congruence between the implementation of the NWA and related policies and legislation.
- Research on the **relationship between land care and water resource management** is planned and will be initiated in the near future when financial resources become available.
- The successful implementation of all of the above hinges on thorough knowledge of **ecosystem functions and processes** as well as the will to implement.

Portfolio planning

National research drivers in ecosystem research continue to be aligned with international trends, although the emphasis is on the local situation. The current research drivers do not deviate greatly from the previous year and include:

- **Ecosystem processes and functions.** Research into these aspects is important for the sustainable management of ecosystems and it is anticipated that this will remain a priority research driver for the foreseeable future. Research in this area provides the basic understanding on which management decisions may be based.
- **The ecological Reserve** provides a tool which enables managers to balance resource use with sustainability. *Version II* of the *Resource Directed Measures (RDM) Manual* is being developed, and it is anticipated that the process to determine the Reserve will become a lot more stable once this is available. As this happens, the need for new research in this field should decline sharply. However, action research on catchment governance structures is needed to facilitate the implementation of the Reserve in areas where it has already been determined. Projections for this research topic are that within 5 to 6 years it will require considerably less funding than it has at the moment, and in about 10 years it will be phased out. A possible exception to this may be wetlands and aquifers, as methods for determining the Reserve in these complex systems have not yet been finalised. It is seen that the need in this area will shift to building capacity, particularly at the level of the catchment management agency (CMA).
- **Co-operative environmental management** and governance is being developed within the context of research programmes addressing estuaries, wetlands, the ecological Reserve and other initiatives. This develops the capability to integrate ecosystem management with the social and economic requirements of the stakeholders.
- Within the current **estuaries research programme** much progress has been made in locating the management of estuaries within the institutional structures of the local authorities responsible for the estuaries. Courseware has been developed, and the implementation of this will depend on building capacity, particularly within the more poorly-resourced regions.
- The **wetlands programme** was run in 3 phases. The 3rd phase (wise use) will begin in 2010, and it is envisaged that the programme will be completed before 2012. The planning of the 3rd phase took into account recent advances in international research (e.g. Wetlands International and Ramsar) as well as changes in the South African institutional landscape (e.g. Grand Challenges in the DST 10-year plan).
- **Knowledge of ecosystem health and environmental water quality** provide the basis for balancing the use of the resource and the discharge of effluents with the ecological health and sustainability of the resource as well as human health related issues. Endocrine-disrupting compounds form a specific focus within the general topic of ecosystem health and environmental water quality. It is anticipated that research into this topic will continue into the foreseeable future.
- **Rehabilitation research** in its present form has a finite duration. It is becoming linked to wetland rehabilitation within the *Working for Water* programme as well as within DWAF, and will probably cease to exist as a research initiative within 10 years. However, international trends in impoundment management involve their rehabilitation through the manipulation of ecosystem processes, and research along these lines is currently being initiated through the WRC. This is a new research field globally, and is likely to continue for some time.
- Following the emphasis on the need for **communication, education and public awareness (CEPA)** which emerged



from the consultative workshops held in 2005 and which was also identified through the Institutional Review, increasing attention will be paid to this aspect of technology transfer. Some of the activities routinely taken within the KSA have proved successful, but it is necessary to hone these activities in order to ensure that this important link is managed as efficiently as possible. More efficient methods of transferring knowledge generated through research into the arena of implementation need to be embedded in the routine of research implementation, and this will require change of focus as well as a reallocation of funds to address this aspect.

A number of research initiatives have been identified, some of which are being piloted. It is anticipated that some of these will become large programmes which will run for longer than a decade. Resource constraints prevent all of these from being initiated simultaneously. These are discussed briefly below:

- Knowledge of the **socio-economic aspects of sustainable ecosystem management** lags behind knowledge of the ecosystem functions and processes, a WRC-wide shortcoming identified during the Institutional Review. Knowledge of this aspect needs to be improved if we are to ensure long-term sustainability of the resource. It is anticipated that research in this area will continue for the foreseeable future.
- Research initiated on the **Reserve determination for non-perennial rivers** is developing new understanding in the dynamics of rivers in the environment. Perennial rivers are largely limited to the well-watered east and the main stems in the arid west of South Africa. However, many of the tributaries, even in the well-watered east, are non-perennial. The initial programme is planned to be completed by 2011, but it is certain that a number of research questions will be raised during the research, and will require a decision as to which should be addressed in future research initiatives.
- South Africa has a very rich history of **diatomology**. Recently-developed indices using diatoms as indicators of water quality appear to be promising as present indicators of water quality which are both robust and easy to use, but will also be able to give insight into historical water quality for areas where early collections exist. It appears that these indices may be successfully applied to both historical collections and to recently-collected diatoms. WRC and DWAF are investigating the potential of using diatoms as an indicator for wetland health as the conventional indicators have not come up to expectations in this complex environment. A new phase of this research is being implemented which will embed diatoms into the suite of indicators used in monitoring environmental water quality
- Research into the **management of biodiversity** (in terms of the recent legislation) has started with a small project on fish biodiversity. It is likely that this field will expand substantially once the outcome of the conservation planning programme (above) becomes known. This initiative is being expanded to, *inter alia*, develop conservation.
- **Ecosystem governance** has been identified as an essential component of sustainable management as shown by the failure of some research programmes to achieve the results that the technology developed during these programmes promised. To this end greater emphasis will be placed on ensuring that this aspect is addressed during research providing technologies for implementation. Research is being initiated specifically to develop the necessary understanding to achieve this.

- **Action research** that has been conducted within this KSA has been largely focused on the communal management of wetlands for agriculture and natural resource harvesting. This research continues to be supported, and in addition, an initiative within the Eastern Cape Estuaries Research Programme will develop ways for the economic empowerment of rural communities based on naturally-available resources.

Research areas identified in 2007 remain important for the reasons given below. These are listed briefly:

- **Climate variability and change**. The effects of these on biota and the influence on long-term resource management need to be better understood if we are to plan successfully in the long term. Of particular importance to the Southern African situation is the predicted decrease in rainfall in the drier western parts of the country. The initial stage of addressing this is being undertaken by climatologists, and ecologists need to be included in this research initiative. The response of society and the effect of this on the environment need to be investigated.
- **Integrated water resource management**. There is a need to develop the ability to effectively manage the integration of ecological, economic and sociological knowledge to enable IWRM. This will synergistically add value to the knowledge available in each of the disciplines. The work planned for natural resource accounting will feed into this, as will research done within the ecosystem governance programme. This topic needs to be investigated in conjunction with the Reserve.

Key stakeholders

The key stakeholders remained largely unchanged for 2008/09. In addition to the Minister of Water Affairs and Forestry and DWAF, other government departments such as the DEAT are of importance. This KSA closely supports DWAF specifically at this time when they are implementing new legislation. Provincial and Local Government form another group of stakeholders, and the needs of CMAs which are currently being established influence research direction. Other end-users of the research are rural communities and others living on the land.

Donor funding is available in this field, usually for specific tasks which satisfy the donor's mandate. The largest funder is the Global Environment Facility (GEF), funded by the World Bank, which has been instrumental in establishing large biosphere reserves as well as the Cape Action Plan for the Environment (CAPE) in South Africa. Both the IUCN and Wetlands International (international NGOs) fund specific projects within their mandates in this field, and the latter is becoming increasingly active in Africa. Funding may also be available from industry for specific projects.

Other stakeholders

There are 2 main groups in this category nationally, funders and end-users of research. The National Research Foundation (NRF) has a thrust which overlaps to some extent with the field covered by this KSA. DWAF and DEAT give some funds for research, although this is largely for the purpose of consultancies aimed to address specific short-term needs. Some organisations, such as the science councils, fund research internally to increase their competitiveness in areas of opportunity. All of these offer the opportunity for leverage and synergy with WRC funds where the integration can be managed. Important international players are the International Water Management Institute (IWMI) (currently mainly through their Challenge Programme), WWF, UNEP and the World Bank.

There are a number of end-users of research such as South African National Parks (SANParks) and various consultants who have specific requirements and who also play, directly or indirectly, an important role in managing the aquatic environment. The needs of these groups are important as well.

Providers of research

There is basically no change in the providers of new knowledge in the field covered by this KSA. Researchers are located at the universities (Venda, North-West, Witwatersrand, Johannesburg, Free State, Zululand, KwaZulu-Natal, Transkei, Rhodes, Nelson Mandela Metropolitan, Stellenbosch, Western Cape and Cape Town), science councils (in this field predominantly the CSIR and the Agricultural Research Council (ARC)) and within various consultancy firms.

Within the above-mentioned universities the researchers are housed within specific research institutes or other units focused on specific aspects of research. The consultant firms which do work in the field of ecological research and management normally focus on the more applied aspects for rapid implementation. This is a good way of rapidly implementing research results and getting feedback into the research process at the same time.

Strategic Initiatives

National initiatives

- The River Health Programme. The WRC is one of three national custodians of this programme and a national steering committee was established.
- The KSA has assisted in the formation of a scientific support and coordinating committees of the Harties Metsi-a-me Project. This multi-faceted DWAF-funded project provides the vehicle to improve the water quality in Hartbeespoort Dam. While mainly aimed at implementation, the work needs to use relevant research results.
- The KSA, with SANParks, facilitated the formation of a Consortium for the Remediation of the Olifants Catchment (CROC) steering committee. CROC is a recently-constituted (12 October 2008) consortium of scientists concerned with the remediation of the Olifants River catchment, the state of which has recently been highlighted by the large number of crocodile deaths in the catchment.
- The KSA made specialist input into the external evaluation of the Centre for the Environment, Agriculture and Development (CEAD), University of KwaZulu-Natal
- Involved in the launch of the *Wetlands Rehabilitation* publications at the Wetlands Indaba

Leadership positions

- Board of the National Community Water and Sanitation Institute, University of the North (Chairperson)
- Member of the ARC Board
- Board of the Institute of Water Research, Rhodes University
- National Science and Technology Forum (NSTF) – Executive Committee representing the Science Council Sector and chairs the NSTF Science Councils sector meeting
- Member of the Board of Sci-Bono Discovery Centre
- Consortium for Estuarine Research and Management (CERM) – co-ordinated for the WRC.
- Member of the South African Mercury Association (SAMA)
- Working for Wetlands Steering Committee
- Wetland Inventory Advisory Committee – Working for Wetlands

- Co-chair of Framework Programme for Research Education and Training in Water (FETWater)
- Executive Committee of DWAF's 'Adopt-a-River' programme
- South African Environmental Observation Network (SAEON) – Technical Committee

Public appreciation

Two impact studies, aimed at evaluating the contribution that the WRC has made in advancing knowledge and skills in specific areas, were initiated and successfully completed:

- River Health Programme (RHP) (**Project No. K8/782**). The RHP has done extremely well in facilitating the transition from developing technical methods to establishing operational routines. The WRC has played an overwhelmingly positive role in enabling the kind and continuity of research that led to remarkable adoption by implementation agencies, capacity and awareness creation amongst diverse audiences, and an impact on water and research activities in a much broader sphere than that directly related to the RHP. This success is to a large degree the result of the community-of-practice style of participation that prevailed amongst RHP practitioners. The WRC has played a significant role in enabling this style. The RHP output resulted in DWAF initiating a National Aquatic Ecosystem Health Monitoring Programme (NAEHMP) which has an implementation manual and national steering committee (of which the WRC is a member).
- Environmental Water Requirements (EWR) (**Project No. K8/843**). The study showed that the WRC played and is still playing a critical role in the research and implementation of environmental water. Results and products from the WRC research were immensely used in the writing of the South African National Water Act (No.36 of 1998), especially the ecological Reserves and other environment-related policies in South Africa and other African countries such as Tanzania, Kenya, and Botswana. The study shows that the EWR knowledge and products have also positively affected South Africa economically and socially because EWR promotes sustainable use of aquatic ecosystems. The report entitled: **Environmental Flow Assessments for Rivers: Manual for the Building Block Methodology** (**Project No. 576/1/98** which was later updated as TT 354/08) was the first report in this field and is one of the most well-known and used WRC reports world-wide.

Other activities included:

- Watermark booklet: The School of Bioresources Engineering and Environmental Hydrology at the University of KwaZulu-Natal is using this as a text in their course on hydrology for engineering students, as it gives a concise and understandable overview of the complexities of the ecological Reserve
- Diatom collection: Workshop successfully facilitated to transfer ownership of the diatom collection from the CSIR to SAIAB (South African Institute for Aquatic Biodiversity), with the collection to be housed at the North-West University
- Lesson Plans: The school lesson plans developed by KSA 2 were demonstrated at a workshop in Abu Dhabi (UAE) and were a huge success and will be introduced into the school system there
- FETWater groundwater training manual: At the request of UNESCO and the United Nations University, copies of this manual have been sent to Pakistan for evaluation for use in the Pakistani situation



- Review of FETWater: An external review of Phase II of the Flanders UNESCO Science Trust Fund (FUST) for the period March 2004 to March 2007 included, *inter alia*, activities funded and covered by the FETWater project. FETWater, for which KSA 2 is the implementing agent, received a positive review

African leadership

NEPAD: the KSA provided leadership in the initiative on 'Establishing a Network of Centres of Excellence in Africa'. (In June 2008 this assignment was taken over by KSA 5.)

The research manager presented a paper in the IWRM conference in Cape Town on 'NEPAD Network of Centres of Excellence in Africa'

International player

- The KSA initiated and organised the international conference entitled *Implementing Environmental Water Allocations* (IEWA). This conference took place from 22 to 26 February 2009 and was attended by more than 400 delegates from more than 30 countries. Conference proceedings were covered by many major national media entities (television and newspapers). Issues raised during the conference that are relevant to South Africa have been noted and will be used in the future by the WRC (KSA 2) in collaboration with DWAF in planning and executing programmes. A KSA 2 research manager received an award for being the Chairman of the Best Run Conference, for his role as chairman of the IEWA Organising Committee.
- Reviewer of scientific papers for 5 Elsevier Journals (*Journal of Hazardous Waste*, *Chemosphere Journal*, *Environmental Pollution Journal*, *Archives of Environmental Contamination and Toxicology*, *Science of the Total Environment Journal*)
- A research manager co-authored a paper to be published in *Bioremediation, Biodiversity and Bioavailability Journal* 2009, Volume 3. The paper, entitled 'Partitioning and accumulation of heavy metals in sunflower grown at biosolids farm in EDTA-facilitated phytoremediation', was authored by Mmbofheni Stanley Liphadzi (WRC) and Mary Beth Kirkham (USA). www.globalsciencebooks.info/Journals/images/InPressList.pdf
- Presented a keynote address entitled 'The status of wetlands and the predicted effect of global climate change: the situation in Africa' at the 8th Intecol Conference, Cuiaba, Brazil, 20-25 July 2008
- Presented a paper entitled "Grasslands as natural water infrastructure in South Africa" at the 5th World Water Forum, Istanbul, Turkey, 19 March 2009
- Presented a joint keynote address with Mr Pienaar (DWAF-RDM) entitled 'Water resource protection in South Africa' at the 5th World Water Forum, Istanbul, Turkey, 19 March 2009
- A research manager was appointed by RAMSAR to represent the African Region as a member of RAMSAR's Science and Technical Review Panel (STRP) for 2009-2012. This has given the WRC a platform to influence wetlands research and technology transfer throughout the African continent through collaboration with RAMSAR focal points in each member country.
- Presented a paper at the *Ecohydrology Conference* in Lodz, Poland, 17-24 April 2008. As a follow-up, the concept of ecohydrology was presented to the WRC management

and other staff members as a way to advance knowledge-sharing and dissemination within the organisation. Talks to initiate a collaborative research or exchange programme between the WRC and UNESCO Centre of Ecohydrology have begun and this will benefit South African researchers and students.

Innovation

Project No. K5/1589 has successfully demonstrated a relationship between the ecological Reserve (environmental flows) and water-associated vectors or diseases such as malaria, liver fluke, and bilharzia.

Growing the Knowledge Base

Capacity building initiatives

Table 1 below illustrates the numbers of postgraduate students who benefited from WRC-funded research in this KSA in 2008/09. This met and exceeded the KSA's set targets.

KSA staff contributed to and attended the internal WRC Open Day and *Knowledge Review* launch. The KSA led, participated in and/or supported 19 **technical workshops** as follows:

- Workshop on mini-SASS
- Workshop to initiate the implementation of the Adopt-a-River programme
- Workshop to prepare terms of reference for a comparative study to determine the endocrine-disrupting effects of regional-specific agrochemical mixtures (pesticides, fungicides and herbicides) on aquatic wildlife (fish and amphibians) and mammals utilising affected water sources.
- Workshop on a *Case Study of the Olifants Rivers for a Framework and Manual for the Evaluation of Aquatic Ecosystems Services for the Resource Directed Measures*
- Workshop to discuss the way forward with the results obtained from studies on pesticides and DDT and communication strategies.
- Workshop on *Sustainable Peatland Management Guidelines*
- Workshop on strategic planning for Phase III research into non-perennial rivers
- Workshop on the *Effects of Stream Flow Regulation/ Manipulation on Invertebrate Hosts of Malaria, Bilharzia and Liver Fluke Disease*
- Workshop on *Food Web Manipulation*
- Workshop on *The Applicability of Modelling Techniques in the Aquatic Environment with Specific Respect to Algal Blooms*
- Workshop on adaption to the consequences of climate change on freshwater resources (co-funded with WWF)
- Workshop on the development of a biodiversity management plan for *Opsaridium peringueyi*
- Workshop on crocodile mortality in Mpumalanga and the KNP during 2008 (hosted for SANParks)
- Workshop for training in the identification of water beetles (Coleoptera)
- Workshop for *Sediment Quality Guidelines*
- Workshop on the *Housing and Curation of the South African Diatom Collection*
- Workshop on *Finalisation of the Estuarine Reserve methods: Version 2* on behalf of DWAF Resource Directed Measures (RDM)
- Workshop on *Eco-Classification: Expected Macro-Invertebrates Frequency under Reference Conditions*

TABLE 1
Capacity building through student involvement in KSA 2 projects in 2008/09

Organisation/institution	No. of historically-disadvantaged (HD) students	Total No. of students
Anchor Consulting	1	3
Agricultural Research Council (ARC)	1	3
Association for Water and Rural Development (AWARD)	2	4
CSIR	6	9
DH Environmental Consulting	2	3
Nelson Mandela Metropolitan University	2	3
Nort- West University	4	7
Rhodes University	7	13
University of Cape Town	4	12
University of the Free State	1	7
University of Johannesburg	0	7
University of KwaZulu-Natal	13	29
University of Limpopo	2	2
University of Pretoria	1	3
University of Stellenbosch	0	7
University of the Witwatersrand	6	12
Water for Africa	3	5
TOTAL	55	129

Knowledge dissemination

- The KSA has considered comments and suggestions from users of its *Watermark* book (universities, water managers, DWAF, etc.) and initiated a review of this book in order to publish its 2nd edition in 2009. The 2nd edition will include a new chapter on groundwater, which will add greater value to the book because the ecological Reserve determination for groundwater has also moved up in the priority list of the country (DWAF).
- Mini-SASS (**No. K8/733**): The mini-SASS was the development of a simplified method of biomonitoring based on the tried and tested SASS (South African Scoring System) technique. The mini-SASS tool has been used as a low-cost, low-technology environmental education and RHP tool for over 6 years. A critical audit of the current mini-SASS tool for perceived and real shortcomings was carried out to improve the programme. With help from WESSA, the mini-SASS tool is now being integrated into the National Curriculum Statement.
- A research manager was interviewed by PhalaPhala Radio station on environmental water and its link to food safety, 15 November 2008
- A research manager was interviewed by SABC TV international and SABC Radio on 5 February 2009. TV interview was aired live while the radio interview was broadcast a week before the IEWA conference.
- The director was interviewed by SABC TV and radio in Port Elizabeth during the IEWA conference
- The director's articles on Water Quality were published in *Pretoria News* of 26 February 2009, *News Africa* of 26 February 2009, *News Environment* of 26 February 2009

Conference presentations, publications and other activities by staff members

- The director presented a keynote address at the 8th *Intecol Conference*, Cuiaba, Brazil
- Implementing Environmental Water Requirements* (IEWA), Port Elizabeth, South Africa; a research manager was

Conference Chair and director was International Scientific Committee Chair

- 5th *World Water Forum*, Istanbul, Turkey; a research manager presented a paper on 'Grasslands as natural water infrastructure in South Africa'
- A research manager presented a paper at the *Ecohydrology Conference* in Lodz, Poland

Implementation Plan

Research portfolio for 2008/09

In essence, the implementation plan followed that of previous years in that the primary objective of this research portfolio is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country during a time of demographic and climate change. This will continue to be achieved through the following:

- Development of an understanding of the ecological processes underlying the delivery of goods and services
- Development of the knowledge to sustainably manage, protect, utilise and rehabilitate the aquatic ecosystem
- Transfer of the knowledge to appropriate end-users. A part of this will be the development of innovative tools and methods for effective knowledge dissemination.
- Strategically align research with WRC impact areas and government (DWAF) priority projects where relevant
- Building of capacity in both research and management to sustainably manage aquatic ecosystems

The research portfolio for 2008/09 is presented in Table 2. The programmes on socio-economic considerations and ecosystem governance, which were added to Thrust 2 in 2007, are expanding.

TABLE 2

Overview and description of thrusts and programmes

THRUST 1: ECOSYSTEM PROCESSES

Scope: This thrust includes research addressing the biophysical processes, form and function of ecosystems. This understanding will assist those managing the resource (water services, crops and aquaculture, biodiversity, etc.) to maximise socio-economic benefits in a sustainable manner. The aim is to generate knowledge to inform policy and management.

Programme 1: Estuarine processes	Scope: Estuaries are fragile and highly productive ecosystems and are highly sought after as places to live. Projects in this programme address the ecological processes occurring in estuaries.
Programme 2: Riverine processes	Scope: Programmes to investigate the ecosystem functioning and processes of riparian zones, rivers and impoundments will be developed. This is an area in which South Africa needs improved capability to manage, and in the case of riparian zones, this is a topic attracting international interest.
Programme 3: Wetland processes	Scope: Within this programme research will be conducted to develop understanding of the ecological processes and functioning of wetlands, and assessing their value to both the catchment and the people living adjacent to them.
Programme 4: Groundwater-dependent ecosystems	Scope: Within this programme the dynamics of groundwater-dependent ecosystems will be investigated in relation to the aquifers on which they depend. This will be related to exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.
Programme 5: Impoundments	Scope: Research within this programme will cover ecological functions and processes within impoundments with a view to improving our ability to manage these.

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings.

Programme 1: Ecological Reserve

Scope: Within this programme research will be conducted to develop and refine methods for determining and operationalising the ecological Reserve as required by the NWA. The programme will address the more strategic issues such as the development of new and improved methods as well as the shorter-term issues such as implementation of the Reserve. This programme is managed in close association with DWAF.

Programme 2: Estuary management

Scope: Within this programme research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage estuaries sustainability. This programme is managed in close association with Marine and Coastal Management, DEAT.

Programme 3: Ecosystem health

Scope: The River Health Programme (RHP: custodians are DWAF, WRC and DEAT) aims to implement nationally (at the level of Provincial Government and industry) a coherent bio-monitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and so are kept in the same programme. Research on the environmental health of wetlands, estuaries and impoundments is also included in this programme. This programme links with the impact area **Water and Health** and includes resource management actions which may affect human health.

Programme 4: Environmental water quality

Scope: Within this programme research will be conducted to develop bio-assays (both in the laboratory and the field) which will be employed to protect people and the environment from the effects of poor water quality. It will develop methods and competence to enable the use of toxicology in effluent discharge licences as well as its use in environmental water quality as required in the ecological Reserve. This programme addresses the longer-term development and refinement of methods and the competence to use them, as well as the shorter-term competence required to implement policy in terms of the NWA. This programme links to the endocrine-disrupter programme within the impact area **Water and Health**.

Programme 5: Endocrine-disrupting compounds

Scope: The overall objective is to characterise, and acquire information for assessing, the EDC effects of various chemicals and compounds in water (singly or in combination) both those occurring naturally and those resulting from pollution which have the potential to cause detrimental health effects in humans, animals and the aquatic environment as a guide to develop and implement cost-effective treatment and control strategies. Further emphasis is on the development of simple, rapid and cost-effective detection techniques. This programme will be implemented in 3 phases, of which the 1st phase is already completed.

Programme 6: Socio-economic considerations

Scope: The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with the ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment.

Programme 7: Ecosystem governance

Scope: The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this.



THRUST 3: ECOSYSTEM REHABILITATION

Scope: This thrust addresses the rehabilitation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities with the view to restoring, as far as possible, process, form and function in order to provide the stream of goods and services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Capacity will be built to implement the research findings.

Programme 1:
Wetland rehabilitation

Scope: Within this programme research will be conducted to develop methods to rehabilitate wetlands which will address both abiotic and biotic components, and seek to rehabilitate ecological processes and restore biodiversity as far as possible in degraded wetlands. This will be done in terms of both the international conventions to which South Africa is signatory as well as recent legislation from both DEAT and DWAF. The programme will also develop the competence to implement rehabilitation. Projects in this programme link closely with each other, and are managed as a unit.

Programme 2:
River rehabilitation

Scope: The research conducted within this programme aims to provide protocols for the rehabilitation of rivers, with the emphasis on urban rivers, that have been degraded as a result of anthropogenic activities or invasive biota.

Programme 3:
Influence of instream constructed barriers

Scope: This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems.

KSA alignment with DWAF's objectives

Most of the research addressing DWAF's objectives within KSA 2 falls under Thrust 2 (Ecosystem Management and Utilisation). Thrust 3 (Ecosystem Rehabilitation) addresses areas where anthropogenic influences have degraded the resource, developing methods for restoring of the resource to acceptable standards. However, Thrust 1 (Ecosystem Processes) is probably the most important of all, as the research falling within this thrust develops new knowledge which enables the development of effective management and rehabilitation methods. As an example, the 1999 methods for the ecological Reserve are all based on existing knowledge, but we are at a point now where we are not able to effectively take these further until new knowledge is developed in key areas. This is the sort of work addressed in Thrust 1. The alignment of KSA 2 research programmes with DWAF's objectives is presented in Table 3.

TABLE 3
KSA alignment with DWAF's objectives

DWAF objectives	WRC thrusts	WRC projects (examples)
Ecosystems for sustainable supply	• <i>Ecosystem management and utilisation</i> • <i>Ecosystem rehabilitation</i>	Research is aimed at sustaining resource water quality to ensure that the best quality water is available for growth and development. Examples of these projects are listed under the DWAF objective 'Ensure protection of water resources'.
Ensure protection of water sources	• <i>Ecosystem management and utilisation</i> • <i>Ecosystem rehabilitation</i>	• Environmental water requirements for non-perennial systems • Application and testing of a strategic adaptive management system for freshwater protection, associated with implementation of South Africa's national water policy • Testing a prototype methodology for environmental water assessments in non-perennial rivers • Development of methods for Reserve determination of wetlands - Phase I: Rapid Reserve • The freshwater requirements of temporarily open/closed estuaries on the South Eastern and South Western Cape coasts • CERM: East Kleinemonde Estuary modelling study • Estuaries and economic empowerment • Valuation of estuary services in South Africa • Framework and manual for the valuation of goods and services from aquatic ecosystems for the resource directed measures (RDM) • Development and testing of a coherent, integrated and practicable set of indicators for the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation • Guidelines for the determination and management of wetland buffer zones • Facilitating the free passage of migratory aquatic biota in South African rivers • Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment • Application of chronic (sub-lethal) toxicity endpoints to the development of resource quality objectives • The application of ecological informatics modelling approaches to South African conditions with preliminary testing on algal blooms • Development of a diatom-based biomonitoring protocol for South African rivers and streams • Phase III: Regional testing, method refinement & calibration; index formulation and River Health Programme accreditation • Assessment of environmental exposure & health risk in an area where ongoing DDT spraying occurs • Amphibian metamorphosis as a biological model to study the effect of endocrine contaminants on thyroid function • Environmental assessment in an area where ongoing DDT spraying occurs • The potential of food-web manipulation for the restoration of eutrophic South African impoundments
Stakeholder empowerment	• <i>Ecosystem management and utilisation</i> • <i>Ecosystem rehabilitation</i>	Covered in research into the environment in IDPs, economic empowerment, aspects of the reserve implementation, environmental governance and socio-economic aspects.



Research Projects for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

Habitat, use and movement of freshwater fish species

University of Cape Town (Freshwater Research Unit)

No. 1483

Fragmentation of rivers by dams, weirs and other human interventions is a major threat to aquatic biodiversity. Three of the nine species of yellowfish which occur in South Africa are endemic to the South-Western Cape, and all 3 are on the Red Data list as a result of human activities. The study was conducted on a tributary of the Doring River that supports populations of both Clanwilliam Yellowfish and Sawfins and demonstrated that detailed knowledge of habitat requirements of fauna is essential for the successful implementation of environmental water allocations (including dam-operating procedures), and that monitoring programmes should specifically address the response of key species to these allocations. Particular aspects that needed to be addressed were education and awareness of people such as landowners; protection and rehabilitation of river reaches, particularly the reaches critical to early life stages; fish sanctuaries; law enforcement; monitoring; and the eradication of alien fish species.

Cost: R688 000

Term: 2004 - 2008

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 2: Estuary management

A review of information on temporarily open/closed estuaries in the warm and cool temperate biogeographic regions of South Africa, with particular emphasis on the influence of river flow on these systems.

South African Institute for Aquatic Biodiversity; Nelson Mandela Metropolitan University; University of KwaZulu-Natal

No. 1581

The aim of this project was to answer generic questions posed during the DWAF RDM Reserve-determination process for temporarily open/closed estuaries (TOCEs). There are 2 publications from this project. The first is a review of knowledge on TOCEs, and the second a report on the findings of the East Kleinemonde Intermediate Ecological Reserve Determination Study.

Along the Eastern Cape coast there are more than 80 temporarily open/closed estuaries (TOCEs) that fall within the warm temperate biogeographical region, and 5 in the cool temperate region of the Western Cape. TOCEs are

predominantly regulated by the amount of river inflow received, the magnitude of which is governed primarily by catchment size and the regional climate that dictates rainfall patterns. The review focuses on the forces that govern hydrodynamic processes and mouth conditions in estuaries and to develop a conceptual model. The major forces that maintain open mouth conditions are river and tidal flow and the major closing forces are marine wave energy and sediment availability. In small and medium size estuaries (<150 ha) tidal flow can maintain open mouth conditions during spring tides but often closure occurs during neap tides. Within the coastal zone, there are a number of processes that can transport varying amounts of marine sediments to estuary mouths. River floods are the most important natural means of eroding and transporting sediments out of estuaries.

The Intermediate Ecological Reserve Determination Study was conducted on the East Kleinemonde Estuary, where a substantial increase in the town is being planned. Four development scenarios were investigated. The study concluded that the estuary can accommodate the reduction in river flow necessary to meet the requirements of future housing development. However, it will not be able to support the additional non-flow related human disturbance pressures that will be associated with the planned residential developments. Therefore the approval of any future residential developments should be conditional on the following mitigation measures being implemented:

- No consumptive use (e.g. fishing or bait collection) should be allowed in the East Kleinemonde Estuary
- No power boating on the East and West Kleinemonde estuaries (only canoes and electric motors to be allowed)
- All new urban developments will have to be connected to a wastewater treatment works to eliminate the risk of seepage from septic tanks entering the estuary
- Stormwater runoff from newly-developed areas will have to be captured and diverted from the system to prevent hydrocarbons and other pollutants from entering the system

Cost: R1 753 000

Term: 2005 - 2008

CERM: East Kleinemonde Estuary modelling study

Anchor Environmental Consultants; University of Cape Town (Zoology Department)

No. 1679

The 1st volume of this 2-volume series addresses issues around the resource economics of the East Kleinemonde Estuary, in the face of the planned development that will triple the size of the community living adjacent to the estuary and the additional stress that this will place on the estuary itself in terms of both water supply and waste disposal as well as recreational use. The 2nd volume details the development of an estuarine management model that will integrate both the ecological and the socio-economic factors that need to be considered in estuary management. This model is calibrated for the East Kleinemonde Estuary, but can be recalibrated for other estuaries where required.

Cost: R644 500

Term: 2006 - 2009

Programme 4: Environmental water quality

Development of a research programme on the application of aquatic ecotoxicology to water resource management

Ecosun

No. 1313B

This project was initiated in response to the recognition that neither government nor industry was proactively adopting ecotoxicology as a valuable technology in water resource management, particularly with regard to water resource protection. The research work has crystallised into the area of environmental water quality (EWQ), an integrated approach that advocates the use of water chemistry, biomonitoring and ecotoxicological data to achieve and understand the interactions between biota and their physicochemical habitat. A workshop was held to develop an objectives hierarchy that would enhance the likelihood of ecotoxicology being an integral part of approaches to and methods used in integrated water resource management. The long-term goal of the project was to ensure that aquatic ecotoxicology is developed, established and implemented, to contribute to effective and sustainable water resource use. The results and products of the project feed into the DWAF initiative for a National Toxicity Monitoring Programme and the development of guidelines for toxic organic substances, and the WRC initiative to link aquatic ecotoxicology with human health and endocrine-disrupting compounds.

Cost: R600 000

Term: 2002 - 2008

Programme 5: Endocrine-disrupting compounds

WRC research programme on endocrine-disrupting compounds (EDCs) Volume 2: Implementation of a research programme for investigating endocrine-disrupting contaminants in South African water systems

AEC Burger (independent consultant); University of Pretoria; University of Stellenbosch; CSIR; ARC; AMPATH; MEDUNSA; SABS; University of the Western Cape

No. 1402 (incorporating Nos. 1469, 1470, 1471, 1472, 1473, 1555, 1557)

Endocrine-disrupting compounds (EDCs) are defined as chemicals that interfere with the structure or function of hormone-receptor complexes. They can cause endocrine-disruptive effects at exposure levels up to a million times lower than carcinogen exposure levels of concern. Internationally, the negative impact of EDCs on health is evident and no longer an issue of dispute. Before 1999 only limited research was done on possible contamination of EDCs in South Africa. A need has been identified for a coordinated research program involving all researchers and stakeholders such as government departments and water suppliers. EDC research requires a multidisciplinary approach involving research in disciplines such as zoology, physiology, toxicology and analytical chemistry to be able to assess the risk to the human and wildlife populations and the state of contamination of the water resources. The main objective of the research programme is to develop the tools to be able to determine the risk to the population. In order to conduct risk assessments reliable data is needed on occurrence, magnitude and frequency of pollution.

In the strategic research report (Volume 1, KV 143/1/05) a survey was conducted on the state of the science in South Africa and existing data was evaluated. A list of priority compounds to be investigated was compiled, and analytical methods for determining EDC activity and levels of individual EDC components were evaluated and selected. A survey of laboratory capability and capacity was conducted. Recommendations on a protocol for a research programme were suggested. The 1st phase of the implementation of the programme (Volume 2) consisted of building capacity in research facilities for activity testing as well as chemical analysis. A workshop was held to select appropriate activity tests to be used in the study, because no single test could be used to determine the EDC activity. A limited surveillance study was conducted at 4 selected sites during 4 sampling events. The samples (water and sediment) were sent to the different laboratories for activity testing and chemical analysis. The results of the different laboratories participating in the study are summarized and presented in this report. Water and sediment samples were analysed for pesticides, minerals and industrial chemicals. Hormone analysis was only conducted on water samples. Analysis of minerals was done on both water and sediment samples. Although only few minerals have EDC properties it is known that some of them have a synergistic effect with some pesticides. EDC activity was detected at all the sites and the presence of EDCs was confirmed by chemical analysis. Hormones (estrone, ethinylestradiol and estriol) were found in water. Pesticides (endosulfan, terbutylazine, DDT and dieldrin) were found in low concentrations. Industrial compounds (p-nonyl phenol, phthalates and PCBs) were detected at some sites. No human health risk assessment was undertaken because there is not yet a model available for risk assessment of EDC pollution. The available risk-assessment models use the onset of cancer as an endpoint which could not be used for EDCs. Recommendations for future research needs and updating of the strategic research programme were also made.

Cost: R260 000

Term: 2003 - 2007

Programme 6: Socio-economic considerations

Enriching freshwater conservation

CSIR (Natural Resources and the Environment)

No. 1678

The project was aimed at advancing understanding of the relationships between freshwater conservation planning and the social, economic and political landscape within which freshwater conservation goals are being implemented. It is proposed that once this relationship is more deeply understood freshwater conservation goals and objectives will be more robust because they will reflect wider agreement about the desired and expected delivery of human benefits from freshwater ecosystems, and hence implementation of freshwater conservation will be more effective and successful. The project examined ways in which the systematic conservation process could be augmented by re-defining ecosystems as social-ecological systems, by promoting co-operation across overlapping mandates and an adaptive learning process, and by categorising societal groups and attitudes that can be targeted through different strategies to encourage freshwater conservation ideals and practices. A research strategy, which contextualises future research needs

in this field of research, was developed and a proposal to continue research in this field, based on the work undertaken in this project that was focused on how the conservation process is influenced by different categories of actor clusters (that do not know, care and/or act when it comes to freshwater conservation) was written and implemented.

Cost: R450 000
Term: 2006 - 2008

Current Projects

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Biochemical processes in a groundwater-fed inter-tidal ecosystem: Biogeochemical controls on the plant biodiversity within a salt-marsh ecosystem in the West Coast National Park: Impact of saltwater-groundwater interaction on pore water chemistry and vegetation

University of Cape Town (Department of Geological Sciences)
No. 1591

The relationship between groundwater and surface water is poorly understood and the relationship between groundwater and the marine environment is even less well understood. However, the impact of poorly managed groundwater exploitation on the latter would have a severe impact on the ecology of the system. The groundwater – seawater mixing process impacts the salinity, anoxia and water movement, bioturbation and nutrient availability in the sub-surface coastal environment thereby controlling the distribution of halophytes and freshwater loving plants and any change in this balance will reverberate through the ecosystem. Over-exploitation of the groundwater resource will have this effect.

This project aims to investigate this relationship in the West Coast National Park, an area of low rainfall and permeable geology where the Langebaan Lagoon which is primarily a groundwater-fed estuary. The area is undergoing development and so the demand for exploitation of the groundwater is increasing. This research will refine the understanding of the groundwater discharge around Langebaan, generate water quality maps, and identify any relationship between plant species and geohydrological characteristics. It will also identify specific characteristics which may be used in a monitoring programme and make recommendations on environmental water requirements of the area.

Estimated cost: R397 400
Expected term: 2006 - 2009

Programme 2: Riverine processes

Periphyton flow dynamics

University of Cape Town (Zoology Department)
No. 1676

Periphyton (benthic algae) in rivers is highly sensitive to changes in both water quality and flow. Periphyton forms the base of the riverine food chain and any change at this level will be reflected throughout the ecosystem. In addition, the growth of undesirable periphyton can have negative economic

consequences in several ways. Filamentous algae can clog irrigation and water purification equipment as well as render the habitat unfit for sensitive organisms, blue-green algae can cause toxin, taste or odour problems and any excessive algal growth will reduce the recreational value of the water body. Knowledge of the dynamics of the relationship between water quality and flow on the one hand, and the response of the periphyton on the other, will enable more accurate prediction of this response; this capability is required in the determination of the ecological Reserve. During this project understanding of the interrelationship between periphyton growth and water quality/flow will be developed to a point where preliminary predictions can be made, and this knowledge will be transferred to managers involved in determination and implementation of the Reserve

Estimated cost: R1 000 000
Expected term: 2006 - 2009

Programme 3: Wetland processes

National Wetland Rehabilitation Programme: Phase II - Wetland Health and Integrity

University of Cape Town (Freshwater Research Unit)
No. 1584

This is a solicited project, the second of three phases in the National Wetland Rehabilitation Programme, and focuses on the development of methods to assess the health and integrity of wetlands, as this assessment lags behind the assessment of rivers and estuaries, which poses a problem in the environmental water determination process. There is growing recognition of the important role of ecosystem services provided by wetlands. This project will develop a suite of assessment techniques, not only to assess the ecological condition of the wetland, but also the state of the services delivered, in addition to a protocol by which the loss of wetland function through degradation can be measured. Training courses and a communication programme will assist in the transfer of the technologies developed.

Estimated cost: R3 450 000
Expected term: 2005 - 2009

To investigate the capability of the Mfabeni Mire (St Lucia) to respond to climatic and land-use stresses and its role in sustaining discharge to downstream and adjacent ecosystems

University of KwaZulu-Natal (School of Environmental Sciences)
No. 1704

The relationship between ground- and surface water is important and not well understood. The Mfabeni Peatland (at 1 250 ha one of South Africa's largest, and at ~45 000 years before present one of South Africa's oldest peatlands) is situated on the east shore of Lake St Lucia within the Greater St Lucia Wetland National Park. The water from this wetland flows into Lake St Lucia where it provides freshwater refugia for biota in times of drought. During times of climate change wetlands such as this will potentially become more important for maintaining the biodiversity of Lake St Lucia and other similar systems. The research undertaken during this project will quantify the water balance of the peatland, the contribution of freshwater to Lake St Lucia, and evaluate the effects of climate change and land use on the water flux. Principles drawn from this work will increase

understanding of the relationship between ground- and surface water elsewhere and give guidance in managing this interface.

Estimated cost: R1 123 391
Expected term: 2007 - 2010

Programme 4: Groundwater-dependent ecosystems

Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa

North-West University (Zoology Department)
No. 1586

Groundwater ecosystems are virtually unknown in South Africa. However, in Australia recent research has shown them to be highly diverse. Fundamentally, they are of interest because there are certainly organisms which will be new to science, and the physiology and food chain dynamics of the organisms inhabiting these areas is of interest. In terms of the new legislation on biodiversity it is necessary to protect the ecosystems. However, the introduction of the concept of a groundwater Reserve in the national water policy means that if we are to implement the policy effectively we need knowledge of the ecosystem that is to be protected. The objective of this study is to broadly characterise the ecosystem in which stygobiont amphipods occur, develop a sampling method and conceptualise a biomonitoring protocol for groundwater using stygobionts.

Estimated cost: R1 350 000
Expected term: 2006 - 2009

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Environmental water requirements in non-perennial systems

University of the Free State (Centre for Environmental Management)
No. 1587

Methods for the determination of environmental flows for the Reserve have been developed and used for rivers with permanent flow. However, many rivers in the semi-arid west of the country are ephemeral. The NWA requires that the Reserve be determined before licences may be issued, and currently used methods have not been verified for ephemeral rivers. Verification needs to be done and, where necessary, new methods.

Estimated cost: R2 737 000
Expected term: 2005 - 2009

Programme 2: Estuary management

Valuation of estuary services in South Africa

Nelson Mandela Metropolitan University (Department of Economics)
No. 1413

Estuaries are delicate systems that are not only in high demand for development, but also deliver important

goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological processes and functions, but does not adequately account for the values placed on estuaries by people. This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 170 000
Expected term: 2004 - 2009

Estuaries and economic empowerment

University of KwaZulu-Natal (Centre for Environment, Agriculture & Development)
No. 1705

Earlier phases of the Eastern Cape Estuaries Management Programme researched the estuarine systems with the long-term aim of enabling communities living alongside the estuaries to generate income from the resource in a sustainable manner. Courseware was prepared and presented to local authorities (ranging from poorly- to well-resourced) on estuarine planning and management with a view to including the estuary in the Integrated Development Plan (IDP) of the local authority. This follow-up project will focus on subsistence livelihoods and will examine such issues as economic empowerment, institutional arrangements, participatory governance in the light of available opportunities, and will establish a framework where identified opportunities can be picked up in the IDP process. Principles developed during this suite of projects will be applicable to wetlands and other areas where natural resource-based enterprises may be developed.

Estimated cost: R1 500 000
Expected term: 2007 - 2010

Programme 3: Ecosystem health

Osmoregulation in freshwater invertebrates in response to salt pollution

Rhodes University (Institute for Water Research)
No. 1585

Salinisation is a major cause of water quality deterioration. Current methods for water quality assessment include boundary values for specific salts. Biological data is scarce for most of these salts, and what exists is based on acute toxicity data. This research aims to provide chronic toxicity test data, for selected indigenous stream organisms, which are biologically relevant for the country. This will be done through physiological experimental research (oxygen consumption and osmolarity), using samples generated during acute and chronic toxicity testing, and evaluating the salt boundary values in the setting of resource quality objectives.

Estimated cost: R201 160
Expected term: 2005 - 2009

The effects of streamflow manipulation on the intermediate hosts and vector populations of disease and the transmission of associated parasites

Institute of Natural Resources

No. 1589

Altering the flow of a water body will alter the environment. One of the effects of an altered environment is a change of the organisms that inhabit the environment. When making decisions on environmental flows, the status of disease vectors or intermediate hosts is not considered, and yet diseases such as malaria, bilharzia (in people) and fascioliasis (in livestock) have a substantial impact on the economy of areas where they prevail. The overall objective of this study is to assess the impact on the economy and to investigate ways in which it can be ameliorated, either through management actions or through altering the behaviour of the population groups at risk.

Estimated cost: R400 000
Expected term: 2006 - 2009

Conservation model for threatened fish species

University of Limpopo, (School of Agricultural and Environmental Sciences, Aquaculture Unit)

No. 1677

Freshwater ecosystems are recognised as the most threatened ecosystems world-wide, and in an inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of habitat, are generally more sensitive to disturbance than invertebrates. The 3 main threats are from habitat loss, impact of aliens and exploitation. The objective of this project is to develop a conservation model for threatened fish species using *Opsaridium peringueyi* as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170
Expected term: 2006 - 2009

Programme 4: Environmental water quality

Application of chronic (sub-lethal) toxicity endpoints to the development of resource quality objectives

Rhodes University (Centre for Aquatic Toxicology)

No. 1484

It is necessary to know the chronic levels of a toxicant for the process to determine water quality in the Reserve, so that safe levels may be prescribed. This project will refine work on acute toxicity of various stressors in order to verify extrapolations of chronic toxicity levels to acute levels.

Estimated cost: R1 340 000
Expected term: 2004 - 2009

Determine the applicability of ecological informatics modelling approaches for South African conditions with preliminary testing on algal blooms

North-West University (Potchefstroom, School for Environmental Sciences)

No. 1675

Ecological informatics was formalised as a discipline in 2004 and is defined as an interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing, at and between all levels of complexity of ecosystems, for use as a decision-making tool. Cyanobacterial blooms pose an ongoing problem in the water treatment industry, and there is currently no way of forecasting events, with planning being based on past experience. The ecological informatics approach is being developed, with some early success, for the forecasting of cyanobacterial blooms in Australia. The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use, based on the technologies used in Australia, for use by water resource managers and water treatment works.

Estimated cost: R225 000
Expected term: 2006 - 2009

Development of a diatom-based biomonitoring protocol for South African rivers and streams. Phase III: Regional testing, method refinement & calibration; index formulation and river health programme

DH Environmental Consulting

No. 1707

The study is an extension of 2 earlier phases (Phases 1 & 2) of the development of a diatom-based biomonitoring tool. The National Water Act ensures the protection of water resources, and therefore methods are needed to identify the health of aquatic systems. It is envisaged that the results from this study will be used in State of River reporting and will form part of the River Health Programme. The Diatom Assessment Protocol (DAP) as a biomonitoring tool can be used to test the water quality of various waterways, including the urban waterways. This study (Phase 3) will deal with the formulation and calibration of a Diatom Index for South Africa. Through testing of diatom species over a time period, the species that are most ecologically important will be determined for use in calculations. This study will determine those important diatom species in order to develop a South African Diatom Index. A diatom-based index will be accepted by DWAF and key stakeholders as a biomonitoring tool related to the 6 RDM water quality/condition classes (A-F). The objectives of the study are to:

- Formulate and validate a unique SA Diatom Index for rivers and streams related to the 6 RDM water quality/conditions classes
- Validate DAP methodology in close association with the ongoing development of the suite of aquatic ecosystem assessment models (VEGRAI, FRAI, GAI & MIRAI)
- Establish an inter-laboratory calibration and testing component for diatom identification
- Report on the modification of DAP for the rehabilitation of urban streams and canals with the inclusion of the DAP in the testing protocol
- Build capacity of scientists and DWAF personnel in the use of this tool in determining water quality and as a supplementary tool to determine the eco-status of rivers and wetlands
- Develop courseware for DAP for tertiary level education
- Report on river reference conditions based on historical diatom data

Estimated cost: R1 824 450
Expected term: 2007 - 2010

Programme 5: Endocrine-disrupting compounds (EDC) in water sources

The environmental exposure and health risk assessment in an area where ongoing DDT spraying occurs

University of Pretoria

No. 1674

The presence of DDT and metabolites in single pilot water, sediment and fish samples from the Vhembe district, Thohoyandou, Limpopo Province, is of concern. The concordant high prevalence of urogenital birth defects and the DDE concentrations in cord blood in babies born in a DDT-sprayed area should be regarded as a matter of extreme concern. The research question is whether environmental levels of DDT and DDE may contribute to adverse health effects in catfish and may pose a health risk for humans. The project will review the effects of EDCs on aquatic invertebrates and develop a comprehensive research programme to investigate the use of aquatic invertebrates as monitors of ecological health effects of endocrine disruptors. A further objective is to link possible health effects in biota from a DDT-sprayed area to adverse health effects in humans living in the Vhembe area. A scenario-based health risk analysis will be performed, EDC assessment techniques evaluated, and a toolkit of tests for wider application in other spraying areas will be developed.

Estimated cost: R1 985 000

Expected term: 2006 - 2009

Thyroid-disrupting activity in South African waters: Amphibian metamorphosis as biological model to study effects of endocrine contaminants on thyroid function

University of Stellenbosch (Department of Zoology)

No. 1680

Endocrine disruption of the control and functioning of the reproductive system is of global concern but there is also evidence that EDCs may interfere with the normal functioning of the thyroid system. Changes in thyroid function could adversely affect several physiological systems in humans and wildlife but the specific effects and toxicants involved are not well-known. This project aims to set up, validate and review protocols of the *Xenopus* metamorphosis assay (XEMA) for testing effects of water-borne chemicals on the thyroid endocrine system. A chemical and water serial diluter system and a flow-through water exposure system for EDC screening will be designed and tested.

Estimated cost: R400 000

Expected term: 2006 - 2009

Environmental assessment in an area where ongoing DDT spraying occurs

Rhodes University (Institute for Water Research)

No. 1706

Previous research at Rietvlei Dam, (WRC Project No. K5/1505) identified a number of possible endocrine disrupting compounds (EDCs). DDT was a major contributor in many of the samples analysed. In Limpopo Province and KwaZulu-Natal, DDT is used for malaria control, and higher

environmental levels were expected in studies there. This research will add value to the variables being investigated by **WRC Project No. K5/1674** in the Limpopo Province. The data will also contribute to the risk assessment to be undertaken in the same area. Several invertebrates and vertebrates will be examined for the effect of DDT:

- Snails have been identified as a promising endocrine-disruption biomarker
- *Xenopus laevis* and other frog species will be collected at small ponds, and investigated for indication of endocrine disturbance, possibly related to DDT
- Pied Kingfishers (*Ceryle rudis*), have been shown to be good indicators of aquatic pollution, and eggs will also be collected from other water birds as well from sparrows and this will provide an indication of the transfer of DDT from food and soil particles
- Small mammals (mice and rats as appropriate) will be collected and examined for EDC-induced abnormalities

This battery of vertebrate and invertebrate indicators, (snails, frogs, birds, rats and mice), collected *in situ*, could provide further evidence for endocrine-disrupting activity, and contribute towards risk assessment under locally-relevant conditions

Estimated cost: R398 330

Expected term: 2007 - 2009

Programme 6: Socio-economic considerations

Framework and manual for the valuation of goods and services of aquatic ecosystems for resource-directed measures

CIC International

No. 1644

The determination of the ecological Reserve for a particular catchment area requires the integration of the catchment area's management class, the related Reserve and the resource quality objectives. In addition, benefit trade-offs with other water users also have to be considered. The National Water Resource System (NWRS) recognises this by seeking to find a 'balance between protection and utilisation'. Therefore, in order to develop resource-directed measures (RDMs) that are technically sound, scientifically credible, practical and affordable, a framework and manual for the valuation of goods and services from aquatic ecosystems for the RDM are now required. The set of problems to be addressed here is therefore clear: in order to enable interpretation (and negotiation) of the likely consequences of changes in management class as embodied in the RDM procedures, the 'invaluable' aquatic ecosystem threshold must be determined, while trade-offs in ecological, social and economic benefits of the other management classes must be made transparent to users and other interested and affected parties. This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R750 000

Expected term: 2006 - 2009

Programme 7: Ecosystem governance

The development and testing of a coherent, integrated and practicable set of indicators for the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation

AWARD

No. 1709

Indicators provide a method for presenting information in a standard way that can be monitored and used to measure change. The wetlands in the communal areas are important resources which provide livelihoods for many of the poor people in the area. While the land tenure system in is not conducive to the exercise of close control of practices, these wetlands do form part of the national water resource and South Africa's IWRM policies require the integration of the many components of the water resource. Research done in this project will develop and test a coherent and practicable set of indicators for an integrated approach to the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation. Specifically, generic indicators for successful and sustainable wetland management with a particular focus on communal wetlands will be developed. In addition, international indicators (e.g. poverty) that do not fit the South African situation will be refined for use within the existing governance situation.

Estimated cost: R236 100
Expected term: 2007 - 2009

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity

CSIR (Natural Resources and the Environment)

No. 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision-making in a situation of varying levels of certainty and of potential conflict. Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820
Expected term: 2007 - 2009

The Shared Rivers Initiative Phase 1: Part A - Contextual profiles of the shared rivers of the Kruger National Park

AWARD; SANParks (Kruger National Park); University of the Witwatersrand; CSIR; Tlou & Mallory (Pty.) Ltd.

No. 1711

Research undertaken during this project will address a recently-identified gap in the governance process of water resources, in that a formal route of response to the red flag raised when a Threshold of Probable Concern is exceeded during the Strategic Adaptive Management process needs to be defined.

There is growing concern among scientists, managers and the general public in South Africa about the continuing decline in the integrity of the river systems of South Africa's north-east Lowveld in spite of an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management. The Lowveld river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland). Each has to achieve their own important resource management and water supply priorities within their portions of these basins. Each neighbour faces a similar set of needs and challenges in its attempts to balance social development imperatives with management for resource sustainability. There is a clear need to harmonize management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery.

This project aims to explore water policy implementation as a complex social-ecological process and initiate an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management. During this process, an understanding will be developed towards managing the Lowveld rivers following a cooperative, international and basin-wide approach.

Estimated cost: R1 500 000
Expected term: 2007 - 2009

THRUST 3: ECOSYSTEM REHABILITATION

Programme 2: River rehabilitation

Integrated management of water hyacinth in South Africa

University of the Witwatersrand (School of Animal, Plant & Environmental Sciences)

No. 1487

Water hyacinth is difficult to control and is a problem worldwide. Chemical control is expensive and ineffective in the long term. Biological control has provided a sustainable and cost-effective control in certain conditions, but the harsh South African winters are more detrimental to the control agents than the weed, allowing the weed to regenerate in the spring of each year. This project will refine earlier work (**WRC Project No. K5/915**) to control this problem weed by low-dose levels of certain herbicides without unduly damaging the populations of the control agents.

Estimated cost: R1 655 600
Expected term: 2004 - 2009

The potential of food-web manipulation for the restoration of eutrophic South African impoundments

DH Environmental Consultants

No. 1643

The project will address the challenge of eutrophication through the application of food-web manipulation as a cost-effective management option for South Africa's indubitably most limiting natural resource – freshwater. Many South African waters subsist in an advanced state of eutrophication, viz. a plagio-climatic condition dominated by a few taxa of coarse phytoplankton and fish. Such systems are resilient to remediation and require

shock treatments such as the rapid bulk removal of problematic fish to allow the system to reset. In South Africa, eradication of Common Carp was seen as the first step in rehabilitation of most dams with eutrophication problems because it is this alien fish that preys on zooplankton, feeds in open waters among macrophytes, and contributes to sediment disturbance and water column turbidity. The project will develop a scientific understanding regarding the storage vessels (dams) that largely supply all water user sectors (industry, agriculture, and domestic supply). The aims of this study are to:

- Determine fish assemblages at a suite of impacted and control dams in the same eco-region, coupled with identification of trophic state and eutrophication impact assessment
- Determine harvesting requirements to reset the fishery to a desirable assemblage
- Determine harvesting requirements to sustain the desired assemblage
- Collect data on specific abiotic and biotic components (stable isotopes, phytoplankton and zooplankton assemblage)
- Compare and contrast commonalities of ecosystem response and degree of system (site) specificity
- Assess in broad terms, economic and financial implications of the recommended approach
- Identify constraints to the proposed rehabilitation methodology
- Evaluate the findings in terms of the potential of this approach as a method for impoundment rehabilitation, as well as for commercial opportunities

Estimated cost: R1 727 760
Expected term: 2007 - 2009

New Projects

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

A framework for the classification of drainage networks in savannah landscapes

University of the Witwatersrand (Centre for Water in the Environment), SANParks (Kruger National Park); CSIR (Satellite Applications Centre)

No. 1790

The character of rivers depends on the nature of their catchment. However, catchments are also shaped by their rivers. The gravity-induced movement of water and sediment down and through hill-slopes is a major control on the distribution of soils and vegetation. However, hill-slopes and channels are still generally studied separately, within different disciplines that use different paradigms and methods of investigation. Even within river science, individual river reaches are generally studied in isolation, neglecting linkages, either upstream-downstream or within the river network. A holistic approach is needed, recognising the 4-dimensional character of river networks. This 4-dimensional character is often described using a hierarchical classification system. In this case, this will include patches of terrestrial landscape between channels, allowing the holistic study and management of river systems. In order to achieve this, the research seeks to describe the spatial organisation of savannah

landscapes in the Kruger National Park in terms of the patterns constrained by both the drainage networks and the hierarchy of interdependent soil, vegetation and hydrological systems.

Estimated cost: R570 000
Expected term: 2008 - 2011

Deriving conservation targets for freshwater systems

Ezemvelo KZN Wildlife; Albany Museum; ARC (Range and Forage Institute)

No. 1796

Systematic conservation planning provides a structured approach for identifying biologically significant areas which require conservation action. Conservation planners aim to protect biodiversity by planning for persistence and representivity. Rivers are complex, longitudinal systems showing continuous gradients, and conceptually, the application of the process to rivers (freshwaters) is at least a decade behind the application to terrestrial systems. Systematic conservation planning for terrestrial systems makes use of island biogeography theory and species-area curves to set defensible conservation targets. Rivers are characterised by length not area, and species persistence at one site is a function of upstream and downstream ecological processes. Therefore, the species-area method is not suitable in these situations. An approach with a theoretical grounding similar to the species-area curve is necessary for setting meaningful targets in freshwater conservation planning. The research seeks to develop such an approach.

Estimated cost: R404 015
Expected term: 2008 - 2011

THRUST 2: ECOSYSTEM MANAGEMENT & UTILISATION

Programme 1: Ecological Reserve

Development of methods for Reserve determination of wetlands. Phase 1: Rapid Reserve

Fluvius Environmental Consultants; Water for Africa; Golder Associates Africa; University of Cape Town; Wetland Consulting Services; Dr Patsy Sherman; North-West University (Potchefstroom); CSIR; University of KwaZulu-Natal

No. 1788

While satisfactory methods for determining environmental water requirements in permanent waters exist, wetlands have proved to be more complex. During the dry phase they provide a rich and productive flow of ecosystem services to the terrestrial system (e.g. grazing, agriculture) and during the flooded phase provide an equally important flow of ecosystem services to the aquatic system (e.g. water quality, flood attenuation, fish). The method developed needs to be able to cope with the alternate states of wetlands and their importance to the economies that they serve.

Estimated cost: R1 402 911
Expected term: 2008 - 2009

Application and testing of a Strategic Adaptive Management system for freshwater protection, associated with implementation of South Africa's national water policy

SANParks Scientific Services; University of the Witwatersrand;

Fluvius Environmental Consultants; Alexander & Llewellyn (Environmental Division); SAEON (Ndlovu Node)

No. 1797

River-based goods and services, with the explicit benefits to society, rely on healthy sustainable ecosystems. South Africa's water policy requires CMAs to manage the resource to achieve equity and social justice within ecological limits. These management practices are usually in conflict, but there is a growing body of research, geographically centred on South Africa's north-east Lowveld, on gaining coherence between these goals to achieve sustainable development. Strategic Adaptive Management (SAM) provides a proven vehicle for learning-by-doing by providing effective knowledge management. This project seeks to consolidate the SAM process developed within the Kruger National Park for wider and long-term implementation in water management areas (WMA) and to ensure that it is appropriately underpinned by the necessary knowledge, integration with the WMAs in the area and to support a wider enabling environment to ensure successful resource management

Estimated cost: R1 335 725

Expected term: 2008 - 2012

Testing a prototype methodology for environmental water assessments in non-perennial rivers

University of the Free State (Centre for Environmental Management); University of Cape Town; Rhodes University; Limpopo Province (Department of Economic Development, Environment and Tourism)

No. 1798

This proposal will extend an existing 3-year contract (**Project No.K5/1587**) on environmental water requirements for non-perennial rivers scheduled to end March 2008. The environmental Reserve must be determined for each significant water body before water-use licences may be issued, but methods are needed to determine environmental water requirements for non-perennial systems as non-perennial systems predominate in the arid west of the country. Standard hydrological models cannot predict along the whole hydrological spectrum from perennial to episodic systems, so water licensing will have to be based on a new understanding of the non-perennial hydrology. This study will test the prototype methodologies which have been developed on one system on a different system.

Estimated cost: R3 000 000

Expected term: 2008 - 2012

Water temperatures and the ecological Reserve

Rhodes University (Institute for Water Research); Freshwater Consulting Group; Albany Museum

No. 1799

In preliminary investigations, scientific literature has been seen to highlight the importance of water temperature as a primary abiotic driver for ecosystems. Northern hemisphere practices cannot be blindly applied to management issues in Southern African rivers. The persistence of these ecosystems is more likely to be achieved through a better understanding of water temperature patterns and processes. This project defines principles based on long-term trends and data of water

temperature variation relevant to South Africa, in order to inform policy. Fundamental research, linking water temperatures and biotic response will inform about the baseline water temperature requirements for the ecological Reserve. The usefulness of these data will be further enhanced through a more complete spatial understanding of water temperatures, and a series of scenario analyses based on temperature simulations using a suitable water temperature model. This project will investigate aquatic invertebrates as indicators of thermal change and identify indicators of thermal change. In addition the team will adapt a generic water temperature model for application to Southern African conditions.

Estimated cost: R2 000 000

Expected term: 2008 - 2011

Development of a revised desktop Reserve estimation model: Application of abiotic components of the Reserve within SPATSIM and other tools

Water for Africa; Rhodes University (Institute for Water Research)

No. 1856

The existing desktop Reserve model is dependent upon the characteristics of the reference hydrology used and largely ignores the advances in understanding of habitat-flow-ecology relationships that have emerged in the last 5 years or so. It also ignores regional differences in these relationships. While a comprehensive ecological Reserve study is expensive and typically addresses the main stem of major rivers and key tributaries and also takes a long time to complete, it is frequently inappropriate for many smaller water resource development assessments where the Reserve is required. The Desktop Reserve model has been demonstrated to be an appropriate analysis tool, whether used with default parameters or after adjustment through a Rapid Reserve assessment. However, the uncertainty associated with the outputs from the Desktop Reserve model remains a major concern, especially if these outputs are ever likely to be challenged in a court of law. Recent research has made a great deal of progress towards improving our understanding of the relationships between physical drivers and biotic response and how these relationships vary in different parts of the country. The existing project is expected to develop initial databases related to the habitat requirements of fish and invertebrates that could contribute to quantifying the parameters of an improved Desktop Reserve model. The research will further enhance our understanding of the relationships between flow and ecological functioning, as well as enhancing our ability to use that understanding to make improved Reserve estimates. Research carried out within this project seeks to review the current understanding of the links between habitat availability and ecological functioning for different eco-regions, develop a hydraulic habitat generator model, and to incorporate the hydraulic habitat generator model and the ecological functioning rule base into an updated version of the Desktop model.

Estimated cost: R850 100

Expected term: 2008 - 2010

Programme 6: Socio-economic considerations

Knowing, caring, and acting: making use of socio-cultural perspectives to understand and improve conservation

CSIR (Natural Resources and the Environment)

No. 1800

This project is an extension of Enriching Freshwater Conservation (**Project No. K5/1678**). This project will focus on issues that make society more aware of the value of a healthy environment for the wellbeing of both current and future generations, i.e. will focus on increasing the success rate of the implementation of conservation. A WRC study entitled Enriching Freshwater Conservation (**Project No. K5/1678**) identified 4 potential 'actor clusters' which feel and act differently towards the environment. In order to understand some of the nuances of the implementation crisis facing freshwater conservation initiatives, one needs to interrogate the 'knowing, caring and acting' sequence. But, the expectation that society should be influenced by, and should adjust their knowledge systems, their values and behaviours in greater support of conservation, is an enormous challenge. This is especially true in the context of freshwater ecosystems where, apart from water, the ecosystem benefits to society are sometimes hidden and typically not felt in a commercial or market-oriented fashion. The overall aim of the project is to develop a conceptual understanding of how the conservation process is influenced by the 'knowing, caring and acting' dynamic.

Estimated cost: R500 000
Expected term: 2008 - 2011

Programme 7: Ecosystem governance

The Shared Rivers Initiative Phase I: Communication and fundraising

CSIR (Natural Resources and the Environment); AWARD; SANParks (Kruger National Park); University of the Witwatersrand

No. 1783

There is growing concern about the continuing decline in the integrity of the Lowveld river systems despite an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management. These river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland) and each has to achieve their own resource and supply priorities within their portions of these basins. There is a clear need to harmonize management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery. This must be done within the constraints of seasonal and longer term variability of the water resources. River systems are complex, comprising interrelated social and ecological sub-systems, which make addressing issues of implementation and compliance difficult within an international river context. Recognising the Lowveld rivers as complex social-ecological systems has many implications in the way they are/should be managed. This project (Phase 1 of a larger initiative) aims to understand and effect change in the implementation of policies and legislations relevant to the wise use of the Lowveld river systems by exploring water policy implementation as a complex social-ecological problem from a theoretical perspective, initiating an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management and to improve broad stakeholder awareness and compliance that leads to the implementation of real solutions to real problems, the outcome of which delivers

the river ecosystem goods and services upon which people depend. Research in the other countries with which South Africa shares these basins will depend on funding from sources other than the WRC. Thus, it is important that, during this phase, other funders are recruited to broaden the geographical scope of the research.

Estimated cost: R548 000
Expected term: 2008 - 2010

Identifying and enabling protection of national freshwater heritage ecosystems for South Africa

SANBI; CSIR (Natural Resources and the Environment)

No. 1801

Freshwater ecosystems and biodiversity comprise a valuable natural resource, but it is becoming increasingly apparent that these may be the most threatened ecosystems in the world. The National Spatial Biodiversity Assessment (2004) found that 44% of South Africa's freshwater ecosystems associated with main rivers are critically endangered, compared with only 5% of terrestrial systems. Rivers and wetlands reflect the state of the catchment and as such the conservation of freshwater ecosystems depends on whole-catchment management in a manner integrated to maintain ecological integrity as well as achieving sustainable development in the social and economic spheres. To this end, this project seeks to identify a national network of freshwater conservation areas, national freshwater heritage ecosystems and national freshwater rehabilitation priorities. It seeks also to develop an institutional basis to enable effective implementation of this national network of freshwater conservation areas.

Estimated cost: R930 000
Expected term: 2008 - 2010

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland Rehabilitation

Guidelines for the determination and management of wetlands buffer zones

University of KwaZulu-Natal

No. 1789

Watercourses are able to adapt to changing circumstances, but the current state of watercourses in the country is a clear indication that a threshold is easily reached and impacts of surrounding land uses and human activities can be detrimental. The Reserve, resource class and resource quality objectives are, however, legislative tools developed to reverse or prevent such detrimental impacts/consequences for the resource. The main importance of a buffer zone is to act as a safeguard or a defence against surrounding impacts when resources are stressed or negatively impacted on. The research conducted within this project seeks to identify ways of delineating the riparian buffer zone in order to protect the resource and the riparian fringe in order to provide ongoing protection for the resource. It is envisaged that the results of this buffer zone study, in addition to the appropriate delineation, would be used by all relevant departments for activities associated with watercourses.

Estimated cost: R2 500 000
Expected term: 2008 - 2011



Contact Persons

THRUST 1: ECOSYSTEM PROCESSES

Dr Steve Mitchell (until 31 March 2009)

Dr Stanley Liphadzi (from 1 April 2009)

Email: stanleyl@wrc.org.za

Tel: +27 12 330 9020

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Dr Stanley M Liphadzi

Email: stanleyl@wrc.org.za

Tel: +27 12 330 9020

THRUST 3: ECOSYSTEM REHABILITATION

Dr Steve Mitchell (until 31 March 2009)

Mr Bonani Madikizela (from 1 August 2009)

Email: bonanim@wrc.org.za

Tel: +27 12 330 9021

KSA 2 DIRECTOR

Dr Steve Mitchell (until 31 March 2009)

Dr Stanley M Liphadzi (from 1 April 2009)

Email: stanleyl@wrc.org.za

Tel: +27 12 330 9020

KSA 3: Water Use and Waste Management



Mr Jay Bhagwan: Director

Scope

The **Water Use and Waste Management** KSA focuses mainly on the domestic, industrial and mining water sectors. It aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. This KSA also supports studies on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Research on infrastructure for both water supply and sanitation is included. A further focus is on water supply and treatment technology serving the domestic (urban, rural, large and small systems) as well as the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors, with the aim of improving productivity and supporting economic growth whilst minimising the negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, becoming incrementally scarce. Managing water use and the waste released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it.

Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. A changing institutional environment and the need for strong institutional capacity exacerbate this challenge.

Objectives

The primary objective of this KSA is to provide knowledge that ensures reliable, affordable and efficient water use and waste management services to enhance the quality of life, and contribute to economic growth and improved public health.

The secondary objectives are to:

- Improve the management of water services in both rural and urban areas
- Develop appropriate technologies for improving the quality and quantity of our water supplies for both domestic use and industrial applications
- Develop new approaches to manage and enhance hygiene and sanitation practices

- Provide appropriate, innovative and integrated solutions to water and waste management in the industrial and mining sectors
- Develop applications for improved treatment of wastewater and effluent and improve processes for enabling increased reuse thereof
- Improve health, economic and environmental conditions, while supporting the development of appropriate technologies and socially-focused management practices related to water and effluent management

Thrusts and Programmes

From reviewing all the trends and developments in this key strategic area, the thrusts have undergone a few changes. The main changes to the portfolio have occurred in **Thrusts 3 and 4**, with the others remaining unchanged. It became apparent from the strategic needs analysis undertaken during the year in the area of wastewater treatment that greater emphasis and focus was needed to deal with municipal treatment of wastewater. This has influenced the portfolio of **Thrust 3** to be focused to deal with municipal wastewaters. Treatment aspects related to mine and industrial water will in future be dealt with in **Thrust 4**. The thrust areas are as follows:

- Thrust 1: Water Services – Institutional and Management Issues
- Thrust 2: Water Supply and Treatment Technology
- Thrust 3: Sustainable Municipal Wastewater and Sanitation
- Thrust 4: Industrial and Mine-Water Management
- Thrust 5: Sanitation, Health and Hygiene Education

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability is of key importance to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure management, operations and maintenance, sanitation (stormwater, sewerage and on-site sanitation), water-related competencies and capacity required for the strengthening of water institutions (water service providers, water service authorities, water boards, national departments) in providing sustainable water services. Current programmes are:

- Cost-recovery in water services
- Institutional and management issues – Water services
- Innovative management arrangements – Rural water supply
- Regulation of water services
- Impact of water and sanitation interventions

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of sufficient quality and quantity for domestic and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. Linked to water supply is the all-important aspect of the protection of human health. The objective of this thrust is to develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality. Current programmes are:

- Drinking water treatment technology
- Water treatment for rural communities
- Drinking water quality
- Water distribution and distribution systems

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: This thrust focuses on the development of technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector. This includes the reticulation, treatment and management of the residues. The challenge is to implement fitting solutions for a particular application that will remain functional throughout the intended lifespan of the installed infrastructure. This includes the responsible management of the wastewater sludge and faecal sludge that is generated. The need for innovative technologies and solutions is recognised as we prepare for the future – achieving more stringent effluent discharge standards, developing acceptable non-waterborne sewerage solutions, reliable treatment of ever-increasing high-strength domestic wastewater, informing future policy. Current programmes are:

- Emerging treatment technologies
- Application of appropriate technologies and tools
- Stormwater and sewerage systems
- Wastewater sludge and faecal sludge management

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the industrial and mining sectors. Current programmes are:

- Quantification of water use and waste production
- Regulatory mechanisms to improve industrial and mine-water management
- Minimising the impact of waste on the water environment
- Minimising waste production
- Improved ability to predict and quantify effects
- Beneficiation and treatment of industrial and mining effluents

THRUST 5: SANITATION AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national Government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery beyond 2010. The focus is on low-cost and affordable sanitation technologies. Current programmes are:

- Advocacy, health and hygiene education
- Peri-urban sanitation research
- Institutional and management aspects of sanitation service delivery
- Technical sustainability of sanitation services

Research Portfolio for 2008/09

The strategic focus of this KSA is guided by the technical, environmental, social and institutional challenges posed in the supply of water and the treatment and disposal of wastes (including sewage, effluents, polluted drainage and solid waste) in the domestic, industrial, commercial and mining sectors. A key consideration is to achieve integrated and holistic solutions that aid sustainable development. In the domestic sector, greater emphasis has been placed over the past few years on supporting water services issues, in order to accelerate service delivery and implementation of water services legislation. There is ongoing emphasis in this area on assisting and capacitating Local Government in the delivery and acceleration of services, education around sanitation and hygiene issues, and the promotion of sustainable solutions. In the industrial and mining sectors, the focus is on developing and promoting management systems, technology and process improvements which support greater efficiency in the use of material and energy resources and, hence, a reduction in pollution. While continuing to support the development and improvement of treatment systems for environmental and human protection, the emphasis is placed on convincing all sectors to recognise wastes as a resource and the processes for recovery and reuse as commercial opportunities. As in previous years the new portfolio of projects aims to continue providing solutions which support these directions in the following ways:

- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including greywater and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes

Strategic initiatives of the previous years, the consolidation of research and project activities in the year 2008/09, the needs identified by the Minister of Water Affairs and Forestry, and strategic engagement with the Department of Water Affairs and Forestry (DWAF) as well as with other stakeholders have provided the path for strengthening the activities of this KSA related to strategic direction, technology transfer, project management and business processes towards meeting the KSA as well as the broader organisational goals.

Budget for 2008/09

The approved funding of the research portfolio for 2008/09 led to a committed funding budget of R33 062 827. Funding of R8 630 275 in 2008/09 was requested to support new projects.

Core Strategy

Strategic context

Water is an essential ingredient for economic development, the maintenance of natural life support systems and basic human existence. Urbanisation and industrialisation rates in developing countries have escalated significantly and continue to grow. Economic growth and development resulting in a greater demand for water and annual consumption continues to rise in most countries. Ensuring a reliable source of clean water and adequate treatment of wastes and wastewater for large urban populations and rural communities pose great challenges for many developing countries. South Africa is no exception to this situation and this has led the Government to embark on major water-related infrastructure development projects and to introduce water conservation measures, the focus being on optimal utilisation of existing water resources, the upgrading of existing sources and the conservation and protection of catchment areas.

As water consumption continues to rise, Government will face the huge challenge of meeting increasing water supply and wastewater treatment demands, together with overcoming a legacy of poor water resource management, the pollution of water sources and wastes. Only by developing long-term strategies to address these issues, including the introduction of water conservation measures and continued investment in water-related infrastructure, will access to clean water and treatment facilities be available to a greater proportion of the population in the future. It is clear that the cost of providing clean water to an expanding and growing population and growing economy will continue to increase.

Although the water requirements for domestic and urban (23%), industrial and mining (6%) sectors are a fraction compared to total water availability and water consumed, it is the assurance and continuation of the supply that dictates the high capital and infrastructure costs. Industrial and mining processes, though a small user of water, together contribute to the bulk of the pollution affecting our water environment.

Whereas the provision of water for human needs plays a cardinal socio-economic role in the upliftment of people and in promoting a healthy population, it is the industrial and mining sectors which play a primary role in the development of the South African economy and, hence, in the development of the country in terms of wealth creation, employment creation and export earnings. Sanitation and wastewater treatment are essential elements of maintaining a healthy environment for our population. Environmentally, the mining and industrial sectors have common features such as an intensive demand on material and energy resources, a major impact on the landscape, a relatively small demand on the national water use and a proportionately much higher pollutant profile. This includes effluents of high concentration, contaminants that are difficult or expensive to remove, and with the potential to degrade large volumes of water, thereby rendering them less fit for other beneficial uses. Effluents from all of these sources arise either as point sources (e.g. piped effluents from factories or sewers) or as non-point sources (e.g. runoff from non-serviced high-density

settlements and seepage from mine slimes dumps or mine workings).

Global climate change, shortages of high-quality water sources, a growing population, mega-cities, capacity and financial constraints, energy shortages and higher expectations for water are challenging the sustainability of the water industry in the long term. In addition, there is the need to redress past imbalances and the vision of 'some for all'. Efficient use of water for domestic, industrial and mining purposes, as well as improved sanitation, will be critical for improving public health, eradicating poverty and contributing to global competitiveness. Taking into account all the achievements and developments to date, it is clear that South Africa has amassed a substantial knowledge base and the competencies required to face the future challenges. However, there is a need to develop greater environmentally-sound technologies and processes that command greater integration in the solutions they provide. A more holistic and integrated approach is required towards providing sustainable solutions focusing on aspects related to the participation of society, the impact on the environment and resource base, institutional and management issues, minimisation of wastes and other emerging issues.

To achieve the above, more innovative policies and improved implementation strategies for water use and waste management will be required, supported by a strong basis for appropriate technologies, changes in infrastructure approaches and broader water management policies. It is inherent that institutional processes and capacity be in place, supported by sound technologies and methodologies.

Needs analysis

During 2008/09 the KSA, in its endeavour towards identifying research needs as well as developing and improving research strategies at the thrust level, has continuously engaged at a strategic level both nationally and internationally, to identify any gaps and strengthen the portfolio of priority research topics and areas requiring attention. In this regard, a number of projects were fast-tracked to respond to these needs:

- Asset management of water services infrastructure
- Water quality and its impact on HIV-compromised individuals
- Drinking water quality
- Management of sludges

Also in direct response to the national science and technology strategy, the KSA has taken proactive steps in key areas in support thereof, as follows:

- In the area of biotechnology, greater emphasis has been placed on the **biological treatment of wastewater** and reuse. Our proactive approaches are leading towards cutting-edge technological developments. Examples of these are the further improvements to the BioSURE™ and Petro™ processes and biotechnological treatment of olive refinery wastes which, incidentally, also has the potential to be applied in other food-manufacturing environments.
- Use of **nanotechnology** in water treatment
- Investigating alternative energy sources and **biofuel potential** from wastewater and sludge

During the year, strategic engagements with the Minister of Water Affairs and Forestry and DWAF highlighted the topics requiring attention, related to water for growth and development, fluoride in water, regulation of water institutions, servicing informal settlements, implementation challenges of

policy and strategies, water for growth and development, water efficiency and demand management. Similarly, the External Institutional Review of the WRC (2006) also highlighted that the WRC has made great strides in shifting the research agenda of the organisation to meet the immediate needs of society. However, it was felt that greater application was needed.

In reviewing the wealth of information generated through the various processes of needs analysis, consultation with DWAF and other stakeholders, the WRC External Institutional Review and some of the incidents (such as the typhoid outbreaks, drinking water quality issues, and failure of many municipalities to provide basic services), it is clear that the key challenges facing the water sector in South Africa as identified in the previous year remain unchanged and warrant greater emphasis and support. We believe that our strategy and focus are in line with supporting Government's long- and short-term objectives, and especially those of ASGISA (Accelerated Strategy for Growth in South Africa). These being:

- In a changing and dynamic legislative and strategic environment many solutions are required for **sustainable and affordable water services provision**. A key focus over the next few years will be on strengthening the capacity of Local Government to function in this challenging environment, introduction of successful models of service delivery which enjoy the support of all stakeholders, addressing the issue of poverty and service provision (including affordability and cost-recovery), and development of appropriate strategies, tools and policies to regulate water services and give effect to the water services and related legislation. The aspects of community participation and local economic development are central to these objectives.
- The realisation of the challenges of meeting the **Millennium Development Goals'** targets, and in the case of South Africa, eliminating the water backlogs by 2008 and sanitation backlogs by 2010
- The water services environment is in a continuous process of dynamic change. The newly-published related legislation, besides setting a new set of challenges and goals for the sector, has reached a point of review. It will be imperative that the success of these frameworks and legislation will realise the ultimate goal of national water policy and local government legislation.
- Greater emphasis continues to be placed on improving water supply and sanitation coverage
- The **provision of sanitation** is more complex and provides greater challenges as the responsibility is spread across many Government departments. The short-, medium- and long-term goals are to find effective and efficient mechanisms to accelerate sanitation delivery and hygiene education coverage. These components are essential ingredients for sustainability and for achieving public health objectives. Focus areas over the short term are: to develop appropriate technical solutions, finding cost-effective ways to provide high-impact hygiene education, finding acceptable and affordable service arrangements, developing models for sanitation delivery and operations and maintenance (O&M), and improving the legislation and policies that contribute to an enabling environment. The sustainability of low-cost and onsite sanitation systems is already beginning to surface. Short design life, pit emptying, relocation and access to pits are some of the key technical challenges which may jeopardise achievements made to date and the provision of sustainable sanitation.
- It is evident that new issues in water supply (water treatment, distribution, etc.) will continue to emerge as new contaminants are introduced into the water sources. Great challenges also exist in providing sustainable and affordable technical solutions for the poor and indigent sections of the population.
- The current energy situation has raised the need for more efficient use of electricity and the need for **alternative energy sources**. As part of the KSA's objective of efficient and affordable water services, 3 key variables have been the focus for many years, these being energy, chemicals and materials, which together make up an estimated 70% of the operational cost of providing water services. More emphasis is now being placed on energy issues and proactively we have initiated and promoted many approaches to support this important cause. For example, BioSURE™ and Petro™ processes of treating wastewaters require lower energy inputs. We have moved into the area of finding solutions for alternative energy sources from wastewater and sludges. The research on efficient water use has also been stepped up, and this has a direct bearing on the energy requirements of supplying water services. These areas will continue to grow in an endeavour to meet these needs.
- Gearing the sector towards **water for growth and development**
- In water supply and treatment technology, the needs over the next few years revolve around the supply of more affordable water of improved quality, especially to those people who do not yet have reliable drinking water supply. Specific issues and research needs include the reduction in cost of water treatment and supply; the removal of organic contaminants; the removal of *Cryptosporidium*, *Giardia* and other pathogens; safe and efficient water fluoridation; improvement in the cost efficiency and sustainability of small- to medium- sized water treatment plants; dependable and efficient distribution systems; cost-effective distribution systems for rural water supply and sustainable and low-cost small water treatment systems. Medium- and long-term goals are to focus on **infrastructure and asset management**.
- Most of the country's industrial and mining activities are concentrated in areas where there is a lack of water resources. These sectors generate large amounts of wastes (toxic and non-toxic), which have a profound impact on the ecology of the receiving water environments. As urbanisation and industrialisation increase, increasingly complex wastewater streams are introduced. It is imperative that solutions are generated to manage these negative impacts. Furthermore, there is growing recognition for more innovative approaches such as **cleaner production and waste minimisation**. These areas require greater research support for knowledge generation and application.
- The **mining industry** presents additional needs that emanate from its legacy of water quality-degrading waste that has been accumulating for more than a century, and which could potentially affect water quality for future generations. In the case of gold mines these needs have to be addressed with urgency, as many mines are about to close down, which may represent lost opportunities to introduce pollution-prevention measures. Key areas to be addressed include the process of acceleration of cleaner production and waste-minimisation technology and the development of innovative solutions, to deal with the legacy of waste and acid mine drainage potential that has accumulated as a result of mining activities.

- There is a need for **improving institutional capacity** in the management of water and wastewater problems, as it has become increasingly clear that these problems cannot (in the South African context) be solved by technical solutions alone. Institutional reform and strategic management issues (such as regulation, capacity, competencies, partnerships, tariffs, community participation, etc.) all play an equivalent role in achieving an integrated solution. Great strides in information gathering and knowledge generation and application are required in this area over a short period.
- Over the past few years great strides have been made in addressing water and sanitation backlogs resulting in significant achievements. This has also resulted in the expansion and growth in infrastructure in urban and rural areas. More **small schemes** have come into existence and, from international and local experience, they pose greater challenges in their sustainable management.
- Furthermore, the infrastructure and associated resources are the assets of our country and contribute to improving the quality of life and these needs to be managed effectively. Lack of attention over the past few years on O&M, together with the **lack of training and capacity** is beginning to show its weaknesses in the state of our water infrastructure. This valuable investment, if not given due attention, could prove costly for the country.

Overview of technological trends

At an international level there is a continuous move towards new approaches as to the provision of water services and adaptation of new approaches to improved domestic water quality and improved availability of water through alternative advanced technologies. Within these objectives **climate change and energy efficiency** are now becoming key drivers and influences. In the quest to achieve efficient and sustainable water services delivery, it is becoming more and more important to include these 2 variables or factors which have a significant impact on the continuous provision of services. Against the background of South Africa's current electricity challenges, energy efficiency and wise water use are priorities.

An emerging trend in developing countries is to decentralise the management of services to a local level or to a local government level, with the national authorities moving into a stronger regulatory environment. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries when there is the need to address the plight of the poor and indigent who make up a large portion of the customer base. Thus, **innovative institutional arrangements and partnership models** between public/private/community are being investigated to provide optimum solutions. Specifically in Africa, the issue of capacity and competency requirements, technology choices, institutional arrangements and costs and affordability are key areas of activity.

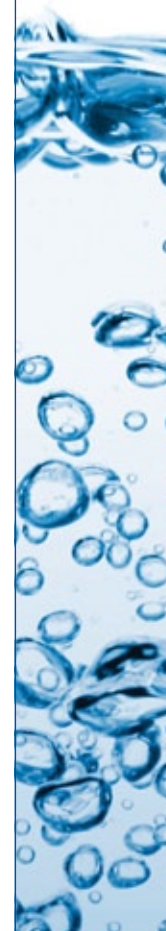
Internationally, there is a new drive to accelerate sanitation and hygiene education delivery and radical new policies and strategies are being investigated to achieve the millennium goals. It is essential that these concepts and ideas be translated at a local level; thus requiring the need for developing improved strategies, policies and mechanisms that create a sustainable and enabling environment. In water supply, the emphasis is on efficient use of water and managing demand, as well as looking at the contributory elements such as energy, pipe components and materials, water supply components and behavioural aspects. In terms of treatment technology, the current international trends are toward the **increased removal of more specific**

contaminants in the water. In addition, it is aimed at adding fewer chemicals to the treated water product (Improved source quality). The removal of pesticides, heavy metals, endocrine disruptors, disinfection by-products and other harmful organics is receiving attention. The removal of *Cryptosporidium* and *Giardia* and the use of **membrane filtration** in this regard are receiving much attention – especially in the USA. There is a strong trend towards improving determination techniques of these new emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues on breaking the transmission of water and faecal-oral related diseases through understanding practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

In the developed world, there is greater attention and focus being placed on managing source quality for improved potable water quality. Secondly, as **desalination technologies** become cheaper, we see more use of these technologies (Singapore/ Middle East are examples). This source of water is also being seriously considered by some South African coastal cities. Further to the concerns of the diminishing levels of fossil fuels, water and waste are being looked at amongst the renewable resources for energy creation. Greater attention is also being given to new promising technologies such as **nanotechnologies**, membranes, etc., as they may greatly benefit water treatment technology.

In both the municipal and industrial sectors, the most significant trend internationally, nationally and at local authority level has been the growing realisation of **recognising effluent wastewater and wastes as a resource**. The treatment of wastewaters and wastes that have been generated without the application of cleaner production and waste minimisation principles is a losing game, ultimately costing all the parties material and energy resources, i.e. money. The consequences are profound: co-regulation becomes a meaningful negotiation; value as co-product is extracted from 'wastes' before discharge, thereby further reducing the waste load requiring treatment; technologies for treatment aim at being 'cleaner', are more focused towards specific waste fractions or even constituents and include recovery and reuse where technically and economically justifiable; resource-efficient technologies are not only favoured, but even their optimum deployment ('where' in the process stream) is critically examined, etc. These trends are predicted to not only continue, but, in fact, to accelerate in the future.

The mining industry has yet to embrace these new realities, and wastewater and waste treatment in this sector presently continues to be material- (e.g. chemicals) and energy-intensive, although more environmentally-friendly solutions are increasingly favoured, for example **biotechnological treatment of acid mine drainage** associated with potential recovery and reuse of the renovated water for a variety of purposes. The cost-effectiveness of **cleaner production technology** is increasingly recognised and will in itself be a strong driving force for the accelerated introduction of the technology. Another driving force is the international trade sanctions that are increasingly being applied against manufacturers that do not apply responsible environmental practices. In South Africa, it is foreseen that the introduction of waste discharge charges will be a further powerful driver towards internalising pollution costs and implementation of cleaner technology. The contribution of mining-related non-point sources to water quality degradation is increasingly appreciated and has given rise to a need for improved techniques with which to quantify their contribution and improved technologies to minimise their effect.



Key stakeholders

The Minister of Water Affairs and Forestry is the shareholder of the WRC and DWAF and the Department of Science and Technology (DST) are its key stakeholders. In addition, the following stakeholders also continue to be of key importance to the WRC in general and to this KSA in particular. Over the years, our international partners and business partners have also proven valuable to us.

The internal stakeholders are the WRC personnel, Executive Management and the Board, the shareholder being the Minister of Water Affairs and Forestry.

The external stakeholders include:

- Government departments and the Ministers representing them – Environmental Affairs and Tourism (DEAT), Provincial and Local Government (DPLG), Health (DoH), Minerals and Energy (DME), Science and Technology (DST), etc.
- Advisory groups
- Beneficiaries (i.e. the users or potential users of research, development and knowledge products produced through WRC funding)
- South African Local Government Association (SALGA), local government, provincial government units
- Development Bank of Southern Africa
- Water boards, water services providers, catchment management agencies, water user associations
- Industrial sectors and industry-representative bodies (mining, forestry, water services, etc.)
- NGOs, CBOs and international aid agencies
- Private consultants
- Tertiary institutions, primary and secondary education institutions, science councils, professional bodies (Water Institute of Southern Africa (WISA), South African Institute of Civil Engineering (SAICE), Institute of Municipal Engineering of Southern Africa (IMESA), etc.) media agencies
- The public
- International coalitions such as Global Water Research Coalition (GWRC), Water Supply and Sanitation Collaborative Council (WSSCC), Water Utility Partnership (WUP), Emerging Technologies (ET), United Nations Environment Programme (UNEP), Stockholm Environment Institute (SEI), WARFSA
- Business

Providers of research

Providers are solicited or unsolicited individuals and organisations who generate research, development and knowledge products with WRC funding. The key providers are tertiary institutions, science councils, consultants, NGOs, water boards, research units within government departments and local government, private companies and individuals.

Strategic Initiatives

National initiatives

- There is an ongoing process within the thrusts in updating and identifying research needs and strengthening the portfolio of strategic research needs to be addressed over the short- to medium-term (2 to 5 years). During the year the following progress has been made:
 - A key initiative driven by the KSA is a project on the development of a framework to regulate competencies of water services managers. This study is of importance

since the lack of competencies of municipal water managers is having a significant impact on the sustainability of water services and infrastructure. The draft outcomes have already influenced legislation and provided input into the Water Services Bill process. DWAF will use the framework to develop a strong set of regulations

- The WRC continues to play a key role in supporting DST's nanotechnology platform, whereby the Water Nanotechnology Strategy and Centre was established through a collaborative effort of MINTEK, WRC and DST
- The WRC participated in and contributed to the National Sanitation Task Team which is focused on issues related to sanitation provision, HIV and AIDS mainstreaming, implementation of the Health and Hygiene Strategy and the International Year of Sanitation Programme
- A research manager, who is also a young professional, is leading the establishment of a joint International Water Association (IWA-SA)/WISA Young Water Professionals Forum. This forum will address the needs of the young water professional in terms of professional growth and building their track record
- The WRC is leading the establishment of a Technical Assistance Centre (TAC) to assist rural water service providers. The Centre will be expanded to also include sewage treatment. Phase 1 (preparatory work for establishment of the structure, facilities and human resources) and Phase 2 (marketing, developing of the information packages, provincial launches in the Eastern Cape and Western Cape) are complete. Phase 3 (implementation in pilot provinces) has already commenced.
- The KSA renewed research with Anglo Platinum into treatment of mine-water currently held in indefinite storage. This strengthens WRC's links with the platinum industry through a project into biological treatment solutions for recalcitrant wastewaters that contain various platinum group metals.
- A staff member was invited to present a keynote address at the Water for Growth and Development seminar held during *WISA 2008*, with the purpose of providing alternative views and perspectives on the concept and its further development
- The KSA was invited to attend the Amathole District Municipality (DM) debate on the implementation of a R14 m. investment in either activated sludge or integrated algal-ponding systems (IAPS) for Bedford Wastewater Treatment Plant in the Eastern Cape
- Appointed to DoH advisory committee on accredited training for environmental health practitioners (EHPs) undertaking water quality monitoring programmes, along with representatives from DoH and DWAF. The training scheme aimed to enable local government staff to comply with SANS214 as regulated by DWAF, with the launch of the new green drop/blue drop strategy and the revision of Regulations 5 and 7.
- KSA serves on a joint DWAF/DoH/WRC task team to develop and implement a national training programme for local government employees in drinking water quality sampling, testing and reporting requirements to meet the revised national standard
- Together with SALGA, DWAF and eThekweni Municipality Water and Sanitation (EMWS), and as part of Sanitation Week, a special workshop and site visit was hosted for

the Minister of Water Affairs and Forestry and key officials, to share outcomes from WRC research which highlight key challenges with the sustainability of VIPs (Durban, May 2009). This meeting had 2 outcomes: firstly, the use of single-pit VIPs is now not recommended as the basic minimum level of service and secondly, the use of additives is no longer supported by national initiatives.

- The KSA supported Rand Water in successfully bidding to host the *IWA International Conference on Water Loss Management* in Cape Town in April 2009. As a key member of the planning team the KSA contributed towards the development of the programme to ensure the showcasing of South African and WRC knowledge on this subject.
- The KSA is a key member of the DST initiative for accelerating service delivery through use of appropriate technology. This team is required to develop a high level strategy to facilitate implementation.
- The KSA continues to facilitate the National Water Services Benchmarking Initiative in partnership with DWAF and SALGA. KSA members have made a number of presentations on live radio on subjects of priority. An area which enjoyed media attention during the past year was that of drinking water quality.
- The KSA is in progress regarding signing a Memorandum of Understanding (MoU) with SALGA with the aim of providing research support and knowledge dissemination. Support in principle has been declared by the parties and they are currently negotiating the terms of the MoU.
- Assessment of Water Information Network South Africa (WIN-SA): Another key national initiative of the KSA is the hosting of WIN-SA. During the period 2008/09 WIN-SA continued to generate knowledge targeted at local government. Partners such as SALGA and the DPLG contributed to the generation of knowledge and strengthening of content by collaborating with WIN-SA on lessons such as the *DPLG Series* and the Benchmarking Initiative. A *Regulation Bulletin* was also released as a new product in collaboration with the DWAF regulation unit. The WIN-SA portal and mailing lists played a critical role in widening information exchange and dissemination. WIN-SA has established strong links with the Cities Network to support and strengthen its knowledge-management strategies and interventions. The assessment for repositioning of WIN-SA was completed with specific recommendations on how to strengthen WIN-SA as a network.

Leadership positions

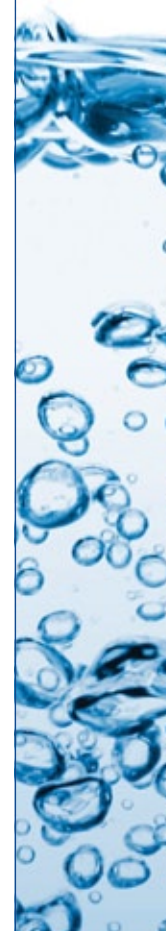
KSA members continue to occupy key positions on a variety of strategic bodies and forums:

- Free Basic Water Services Task Team
- Water Demand Management and Conservation Task Team
- DWAF's Water Services Regulation Team
- Advisor on DWAF's Water Services Infrastructure Asset Management Strategy
- Steering Committee of the Water Dialogues
- DWAF Sanitation Technical Advisory Group
- DWAF's Project Steering Committee concerning the Development of a Comprehensive Framework for Integrated Water Resource Management in the Mining Industry
- DWAF Project Steering Committee for the Development of Best Practice Guidelines for the Mining Industry
- Government Task Team convened by the DME to develop an overarching strategy for mine closure
- DME's Steering Committee for Implementing a Regional Closure Strategy (a concept developed through a WRC project)
- Chamber of Mine's Steering Committee to develop Guidelines for the Vegetation of Residue Deposits Against Water and Wind Erosion
- Coaltech 2020 Surface Environment Committee. This Committee deals with the acid mine drainage issues that are also a major focus area of the WRC research initiative. Through involvement on this Committee the WRC remains up-to-date with industry research initiatives and is able to secure industry involvement in WRC research projects.
- DEAT's Steering Committee to Develop a National Strategy on Cleaner Production and Sustainable Consumption
- Management Committee of WISA's Mine Water Technical Committee
- South African Power Utility Research Advisory Board (Eskom)
- Advisory Board of the DST's new Nanotechnology Innovation Centre
- National Toxicity Monitoring Programme (NTMP) Steering Committee
- Management and Steering Committee of the National Benchmarking Initiative
- DEAT National Strategy for Sustainable Development

Public appreciation

The KSA is on track to complete 2 impact studies, one dealing with WRC's investment in the area of membrane technology and another on investment in the field of sludge management. Both these studies have provided positive feedback:

- Impact of WRC Drinking Water Quality Guidelines. This study considered and evaluated overall all research projects and products (defined as: reports, guidelines, publications, techniques, methodologies, software, hardware, equipment, plant and registered patents) developed by the WRC since 1971 which relate to domestic water quality. On the guidelines the following user groups were interviewed on the use and relevance of the guidelines: municipalities and water boards, tertiary institutions, water consulting firms, researchers, non-governmental organizations and government departments. The impacts can be classified according to economic, social, environmental and health aspects, depending on how and in what context the guidelines were utilised. Preliminary conclusions show that the guidelines have had a broad array of economic impacts. The guidelines are widely used as training material at tertiary institutions, water services providers and water consulting firms as well as the general public. The guidelines aim to enhance skills within the South African water sector. They have also contributed to water treatment equipment sales for municipalities that have been experiencing water problems, as well as, to a large extent, the setting up of water treatment plants in certain areas. Individuals trained through the use of WRC material have experienced personal benefits, in the form of improved salaries and job opportunities. The WRC guidelines have impacted South African society from a social perspective, and there are also examples where failure to use the guidelines has resulted in social costs. In some instances where water authorities have failed to use the guidelines, poor water quality has impacted negatively on people's health.
- Mine-water related research. In this study the impact and benefits of WRC-funded mine-water related research were assessed. This included research conducted from 1990,



when the WRC became extensively involved in this area of research, onward. The study provides a concise assessment of the impact (to date and potential future) of WRC mine-water related research investments and products on socio-cultural, economic, political, technical and environmental aspects of South African society. The history of mine-water research is also sketched, highlighting the change in focus over time. A number of case studies are reported as examples of the benefits or cost savings that are accruing to the aforementioned aspects of South African society. As far as possible these are expressed in monetary terms.

African leadership

- World Health Organization Small Community Supply Network. The KSA represented the WRC at the World Health Organization Small Community Supply Network meeting in Kampala, Uganda, 16-20 November 2008, and confirmed commitment to host the network meeting in 2010. The KSA will act as project manager for piloting the WHO framework for Water Service Providers in Southern Africa. The WRC is a member of the WHO network, which promotes the achievement of substantive and sustainable improvements to the safety of small community water supplies around the world, particularly in rural areas, in order to meet the Millennium Development Goals related to water and sanitation.
- Regional Sanitation Knowledge Hub. The WRC has been informed that it has been shortlisted as a candidate to host the Stockholm Environment Institute (SEI) EcoSanRes Regional Sanitation Knowledge Hub. The initiative provides the WRC with the opportunity to strengthen its networking and knowledge dissemination across the African region.
- The WRC hosted, sponsored and presented at a National Training Seminar on Risk Assessment, Risk Management and Water Safety Planning in Southern Africa, 26-27 November 2008. This is an international interaction to import knowledge from the World Health Organisation and other bodies to the Southern African context.

International player

- The KSA is the coordinator for the South African contributions to a new European Union project – Techneau (Technology Enabled Universal Access to Safe Water). The project aims at rethinking current water supply options.
- The KSA continues to be a member of the WHO International Group for Small Community Water Supply Management.
- The WRC is a member of INAP's (International Network for Acid Prevention) Global Alliance of research organisations. The WRC is currently one of five members of this Global Alliance consisting of organisations in Australia, Canada, Europe and the USA. Currently the major initiative of INAP is to develop a global guide for the management of acid rock drainage, in order to propagate worldwide best practice in the prediction, prevention and mitigation of the acid mine drainage problem. A KSA member took the lead in organising a workshop on the development of the *Global Acid Rock Drainage (GARD) Guide*.
- The KSA was invited to serve on the Scientific Committee for the 8th International Conference on Acid Rock Drainage (ICARD) that is the most prestigious conference dealing with acid mine drainage and which is held every 3 years
- Global Water Research Coalition (GWRC). The GWRC partnership is bringing greater collaboration in research and

benefits. To date the KSA's involvement has been rewarding and includes the following:

- Presentations were made on WRC-funded research projects/programmes at 2 GWRC workshops on behalf of the WRC by Prof T de Jager, University of Pretoria, on Trace Organics & GWRC *EDC Toolbox Kit*, San Francisco, 1-18 and 21-22 May
- Presentations were made on WRC-funded research projects/programmes at 2 GWRC workshops on behalf of the WRC by Prof T de Jager, University of Pretoria, on Trace Organics & GWRC *EDC Toolbox Kit*, San Francisco, 1-18 and 21-22 May
- Took part in review (committee member) of GWRC chapter on hazard identification in *Toxic Algal Management Manual*, written by Dr Bill Harding, South Africa, and in review of GWRC project proposal on pharmaceuticals (review committee)
- The KSA is coordinating and managing the GWRC project on Best Practices in Asset Management
- Presented the South African status on Energy Research and Research Needs in the Water Field, GWRC Meeting, London, 2008
- The KSA is contributing toward GWRC joint activities in endocrine disruptor and algal toxin research, which is coordinated by a KSA research manager
- Further GWRC initiatives include cooperation in a membrane bioreactor research strategy plan, asset management, water and energy and in a water reuse project
- Team member on developing WHO Guidelines for Cost Benefit Analysis of Water and Sanitation Programmes
- *International WASH Conference – 2009*. The *Streams of Knowledge* Group has requested and awarded the hosting of the 3rd International WASH Practitioner's workshop in South Africa. The event aims to bring together water, sanitation and hygiene specialists from the Southern and Northern regions to come together to share good practices. The KSA will lead the organizing of the event.
- The KSA was invited by the UNEP-IETC to give specialist input to the development and review of the international guide on water conservation/water demand management. The final output *Every drop counts* has been published and the WRC input is acknowledged, as well as a number of South African case studies.
- In recognition of WRC's role in the development world, a KSA member was appointed to the Advisory Committee of the International Water Association (IWA) Global Development Agency (GDA). This arm of the IWA is aimed at supporting the capacity development of professionals in the developing countries and dealing with developmental issues of water and sanitation.
- The KSA was invited to give a keynote address at the SEI workshop on *Planning and Implementation of Sustainable Sanitation in Peri/Semi-Urban Settings*, Stockholm 22-24 August 2009, towards establishing a strategy to deal with emerging issues
- Invited to serve as member of the organising committee of *EnviroWater 2009*, which is a conference intended mainly for the exchange of environmental research findings between the South African and German research communities. Assisted with the review of papers and preparation of the scientific programme.
- Invited by the IWA-GDA to give a keynote address on sanitation challenges as part of the workshop on sustainable sanitation during the *IWA Conference* in Vienna, Austria

Innovation

The following are some of the innovative processes and technologies which are being generated through our research:

Limestone teeter bed reactor

The limestone teeter bed reactor (LTBR) was developed for potable water stabilisation and the treatment of waters containing coloured natural organic compounds, such as humic and fulvic acids. Lime is the conventional chemical used to increase the alkalinity and pH of raw waters that are naturally acidic due to naturally-occurring dissolved metals (e.g. Fe, Mn), natural organic matter (NOM) or which have been acidified by metal salts used as flocculants/coagulants. Developments in the use of limestone in place of lime for this application have been driven by a large number of advantages, including ease of handling, lower cost, ready availability, smaller volume and the capacity to be self-controlling in terms of pH. The LTBR has been demonstrated in small-scale and full pilot-scale trials to consistently perform its function of dissolving the limestone to a sufficient extent within a reasonable residence time to raise the pH of the feed water as required. Soft, highly-coloured waters with low alkalinities can be effectively treated in the 2-stage LTBR plant to produce potable water that complies, in all respects, with the SANS 241/2006 specifications for Class 1 Drinking Water (3). No pH control system is necessary, nor is a lime-dosing system. This technology is about to enter the international market through WesTech Engineering Inc.

Immersed membrane microfiltration systems for the treatment of rural and industrial waters

In early work on this topic a novel idea for an immersed membrane microfilter (IMM) was investigated, based on a locally-produced woven fibre microfiltration fabric. The woven fibre microfilter was designed to be operated as an inside-out tubular filter. However, with modifications, the microfilter could be operated in an outside-in configuration, i.e. as an immersed filter. The results indicated that the local development had great potential in IMM applications. Very good separations were obtained, on both raw river water and biological sludges. The local system can be backwashed, not a common practice on other flat sheet systems internationally. However, the overriding advantage of the local development is that it is extremely robust and inexpensive to produce, making it highly applicable for use in developing economies. Trials of this microfiltration system have commenced in the Eastern Cape, to assess the ease of use in rural households and reveal operational issues that might arise when the units are used by the public.

Software tool for the rapid identification of bacteria

PaperBac is a software tool that allows field scientists to rapidly identify bacteria from paper mills with restriction fragment length polymorphisms (RFLP) and Biolog® experimental results. The field scientist performs the Biolog and RFLP experiments and enters the results in PaperBac through an intuitive user interface. PaperBac compares the results to a dataset of Biolog and RFLP results and identifies the organism in question.

Brine desalination through eutectic freeze crystallization

The degradation of water quality is one of the major problems facing South African water users. The increasing use of water recycling technology and increasing efficiency of reverse osmosis technology have resulted in the increased generation of inorganic brines and concentrates. As a rule of thumb the cost of brine disposal is estimated to be about half the total cost associated with desalination. Innovations that reduce the

volume of brine and/or lead to the recovery of useful products are thus sought after. Eutectic freeze crystallization (EFC) is an alternative technology for the separation of highly-concentrated aqueous streams. EFC is a technique that is capable of separating aqueous solutions into pure water and pure, solidified solutes and that is highly energy efficient, without the introduction of any solvents. EFC technology has been demonstrated for single salt solutions. A project at the University of Cape Town is currently developing the technology to deal with complex multi-salt solutions typical of brines.

Employing ferrite to remove iron from acid mine water

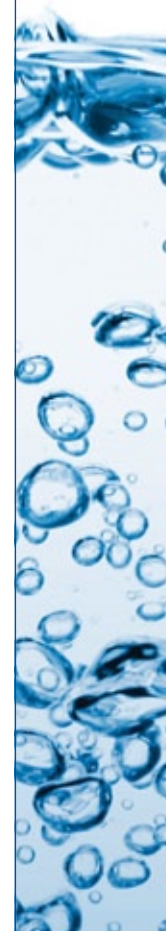
The removal of iron from acid mine drainage and other solutions is problematic in the sense that current technologies produce a bulky sludge with poor settling properties. With current technology, the gypsum and iron precipitates furthermore settle as a part of a mixed sludge, which makes it difficult to extract potentially useful products. These properties associated with current technologies result in expensive disposal options. The WRC patented Ambient Temperature Ferrite Process (ATFP) for the removal of iron from acid mine water largely overcomes these problems. A project is currently being conducted to refine design criteria for the ATFP process.

Wind energy for evaporation

The increasing use of water-recycling technology and increasing efficiency of reverse osmosis technology have resulted in the increased generation of inorganic brines and concentrates. As a rule of thumb the cost of brine disposal is estimated to be about half the total cost associated with desalination. Innovations that reduce the volume of brine and/or lead to the recovery of useful products are thus sought after. Wind-Aided Intensified eVaporation (WAIV) exploits wind to enhance evaporation above brine ponds through the use of extended vertical shade net surfaces. The technology may also be used to increase the lifespan of existing evaporation ponds. The concept was tested using a small-scale pilot unit, which has shown that evaporation rates may be increased by as much as 20 to 30 times relative to natural evaporation from open ponds. One of the main benefits of the technology is its perceived level of simplicity and reduced maintenance requirements compared to traditional evaporators. In addition, the technology primarily utilises a constantly-available (renewable) energy source for driving evaporation. Despite promising results, the technology is still in its infancy and some concerns still need to be addressed. However, it is likely that the technology may reach full scale application in a reasonably short time.

Innovative approaches to handle brine

Dewvaporation is a technology that extracts distilled water from brine and generates a more concentrated brine stream. It is based on the natural cycle of humidification and de-humidification and may utilise waste heat or low-energy steam to evaporate brine. Compared to traditional thermal evaporators, evaporation of water in *dewvaporation* occurs from the surface of the liquid and not from a highly heated metal surface. As such, it is anticipated that scaling will be reduced. Compared to WAIV, the technology is more complex, but offers the advantage of recovering high quality water from brine streams. An innovative module design was developed, combining the characteristics of a shell and tube heat exchanger as well as that of a capillary ultrafiltration membrane. Based on this concept, a small-scale test module was manufactured and tested at bench scale. It was possible to produce product water of a quality comparable to mechanical evaporators.



The Shape Model

Housing costs are made up of a number of variables. These include the land, servicing of the land (which will vary depending on the size of the erf and the standard and type of servicing provided), the number of rooms, and the standard of fittings, finishing and services. In addition, there are the costs of the overheads (such as selling and administration costs). Selecting a house that meets the spatial needs of a household, which is also affordable, is impossible for everyone in the low-income strata. This is especially true when it comes to the selection of sanitation services. While the solution selected needs to be hygienic, convenient and acceptable, it is also important for it to be affordable. Every sanitation choice affects a consumer's disposable income, and people should be

able to make an informed choice. Finding the right solution is therefore fundamental in the quest for sustainability. To improve the situation, the WRC tasked SMM to develop a computer modelling tool to help determine the effective demand for services, with a specific focus on sanitation, among peri-urban residents. The result is the SHAPE (Sanitation and Housing Applied Priorities Enquiry) model. The model establishes the demands for housing and all other infrastructural services (water, sanitation, electricity etc.) simultaneously. This is an enormous advantage to government and other authorities responsible for delivery of services to the residents of informal settlements. The basic objective is to allow the user to specify their preferences for, for example, sanitation, within the context of a global cost for the housing solution.

Growing the Knowledge Base

Capacity building initiatives

At the end of the year 2008/09, 34 projects were finalised, with 33 Masters degrees and 10 Ph.D.s obtained through these projects. An estimated 32 undergraduate activities contributed to these projects. In terms of demographics 56 Black males, 21 Black females, 10 White males and 11 White females were involved.

TABLE 1
Capacity building through student involvement in KSA 3 projects in 2008/09

Organisation/institution	No. of historically-disadvantaged (HD) students	Total No. of students
Althydro CC	3	3
Biostream, University of Pretoria	1	4
Cape Peninsula University of Technology	10	12
CSIR	5	7
Durban University of Technology	8	9
Emanti Management	4	4
Golder Associates Africa	7	7
Hlathi Development Services	5	5
Mvula Trust	1	1
Nelson Mandela Metropolitan University	3	6
Nemai Consulting	1	1
Partners in Development (Pty.) Ltd.	3	5
Process Optimization and Resource Management (PRO&RM)	2	2
Pulles, Howard and De Lange	2	2
Rhodes University	2	4
Sarah Slabbert Associates	1	5
Stellenbosch University	1	6
Sustento Development Services	0	2
The Impact Free Water Group	4	5
Tshwane University of Technology	5	5
Umgenei Water	3	3
University of Cape Town	18	32
University of Johannesburg	7	7
University of KwaZulu-Natal	3	3
University of Pretoria	12	20
University of the Free State	1	2
University of the Western Cape	15	16
University of the Witwatersand	1	6
University of Venda	5	5
UWC consortium	3	3
TOTAL	158	192

Internal learning, innovation and dissemination are paramount to the KSA meeting its goals. The following KSA-specific **workshops** were held:

- A workshop on the *Bio-assay Toolbox* to discuss the assays to be included, University of Pretoria
- A *Sustainable Urban Drainage Workshop* was held with key stakeholders (reference group members) from the various WRC projects related to stormwater and sewerage systems, Cape Town.
- Workshop on *Impact of Winery Wastewater on Soil, Crops and Wine Quality*, Stellenbosch
- A workshop at *WISA 2008* discussed the rollout of the Technical Assistance Centre
- Workshop with Wits University on *Framework to Regulate Competencies of Water Services Managers*
- Workshop to discuss a WRC project dealing with water quality and quantity of the Waterberg coal reserves
- Workshop on the development of the generic framework for EDC risk evaluation studies for humans, animals and the environment
- Held a workshop at the WRC to share information on *Gaps in Sanitation Policy*
- Workshop with participants from municipalities and government, to present the SHAPE model, Pretoria
- Workshop with Kruger National Park officials, DWAF and WRC researchers, on the cyanobacterial problems that cause extensive wildlife losses, Skukuza

Knowledge dissemination

Conference presentations, publications and other activities by staff members

The KSA contributed to WRC Open Day sessions. Other activities included:

- The first article on EDCs 'The ABC of EDCs: Global concern spurs researchers into action' – was published in *The Water Wheel* as part of the awareness and education campaign on EDCs. A 2nd article on the EDC research programme was published in *The Water Wheel*: 'The ABC of EDCs: Building an armoury of knowledge'.
- The National Sanitation Task Team, of which WRC is a member, met on 8 April to discuss sanitation provision, HIV and AIDS mainstreaming, implementation of the Health and Hygiene Strategy and the International Year of Sanitation programme. This led to an invitation to the WRC to present research projects and programmes to the team at their June meeting.
- Hosted a seminar on Lightweight VIP structures for DWAF, SALGA, Minister's Office and DPLG. The objective was to expose decision makers to the research being undertaken by UP and its relevance to current challenges with basic sanitation.
- Held an open day in the Western Cape for municipalities, to disseminate knowledge on desalination and promote the WRC patent on Crossflow Microfilter
- Arranged a field visit for officials and researchers to view piloting of grey-water management alternatives in the informal settlements of Western Cape
- Presented a keynote address at the *Water for Growth and Development Seminar* held during *WISA 2008*
- Gave a keynote address at the SEI workshop on *Planning and Implementation of Sustainable Sanitation in Peri/Semi-Urban Settings*, Stockholm
- Presented a keynote address, together with the University of KwaZulu-Natal on 'Challenges with onsite sanitation'
- Participated in the IWA Biennial Conference, Vienna, Austria;

gave a keynote address on 'Challenges with sustainable sanitation' and presented a paper on 'Challenges with dry sanitation systems'

- Presented at *Waste Minimization Conference* together with DEAT and DWAF officials, Centurion
- Presented at *WISA 3rd Appropriate Technologies Conference*, Johannesburg
- Presented a position paper on 'Water and the economy' at the ESATAP (European – South Africa Science and Technology Advancement Project) workshop, France
- Authored a scientific paper: Strong PJ and Burgess JE (2008) Fungal and enzymatic remediation of a wine lees and five wine-related distillery wastewaters. *Bioresource Technology* **99** (14): 6134-6142
- Authored an article on grey-water, published in the January 2009 edition of *Water, Sewage and Effluent* magazine
- Authored a scientific paper: Manipura A and Burgess JE (2008). Biological nitrogenous compound removal and subsequent rhodium recovery from simulated metal refinery wastewater. *Minerals Engineering* **21** (9): 251-256
- Authored a scientific paper: Burgess JE and Pletschke BI (2008) Hydrolytic enzymes in sewage sludge treatment: a mini-review. *Water SA* **34** (3): 343-349
- Exhibitions were held at the *WASH Fair*, Bangladesh; IMESA, WSSLG (Water Services Sector Leadership Group); National Water Summit
- Presented a lecture on South Africa's water quality and emerging issues to students enrolled for an M.Sc. in integrated water management at the University of Pretoria
- Presented a lecture at the University of Pretoria course on Water and Sanitation

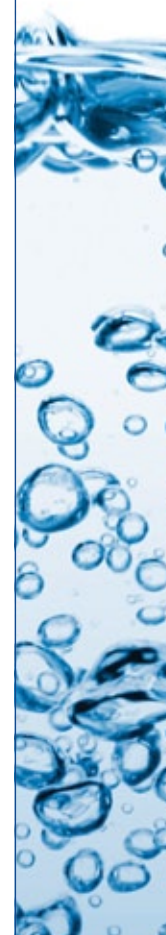
New knowledge dissemination initiatives

- A special publication to support the International Year of Sanitation, which highlighted completed and ongoing research on the subject of basic sanitation, was widely distributed locally and internationally
- The *in situ* demonstration of the fully functional crossflow-microfilter membrane technology unit to around 30 municipalities in the Western Cape

WIN-SA

The activities of WIN-SA are very closely associated with that of the KSA, and there is closer collaboration on dissemination and other WIN-SA activities. Some of the achievements of WIN-SA are as follows:

- 15 *Lessons Series* (including DPLG Lessons) covering issues such as water for sustainable growth and development, National Benchmarking Initiative, the citizen's voice in water services delivery, water conservation/water demand management, asset management, etc.
- 4 *Field Notes* (focusing on HIV/AIDS mainstreaming in Ekurhuleni Metro, gender mainstreaming, drinking water quality, and sector collaboration)
- Workshop on *Integrated Resources Management in the Context of Water for Growth and Development* with local governments in the Northern Cape
- A video on *Water for Growth and Development* was developed
- North-West learning journeys on water conservation/water demand management
- Amathole District Municipality – peer review of performance as a water service authority
- The *Water Regulation Bulletin*



Implementation Plan

Research portfolio for 2008/09

The KSA's continuous activities, in response to the results of the strategic needs analysis and needs expressed by the Minister of Water Affairs and Forestry or through engagement with DWAF and other stakeholders with regard to KSA objectives and thrusts, have been well supported. The 2006 External Review highlighted that the relative weight of this KSA's thrusts seems to be well-balanced regarding the needs of urban-industrial-mining and rural research needs, but, given the urgency to redress past inequities, the need was identified to increase the number/weight and relevance of research projects related to sustainable rural water supply and sanitation projects. Feedback from these exercises has ratified the KSA direction, and the many valuable inputs assisted in strengthening the portfolio. Thus the primary and secondary objectives of the KSA remain unchanged.

During 2008/09 the following consolidation and changes have been warranted, based on reviewing all the trends and developments in this key strategic area. The thrusts have undergone a focused change and the new portfolio is as follows:

- Thrust 1: Water Services – Institutional and Management Issues
- Thrust 2: Water Supply and Treatment Technology
- Thrust 3: Sustainable Municipal Wastewater and Sanitation
- Thrust 4: Industrial and Mine-Water Management
- Thrust 5: Sanitation, Health and Hygiene Education

Changes to the portfolio have occurred in Thrusts 3 and 4, with the others remaining unchanged. The portfolio of Thrust 3 has been integrated to deal mainly with the management and treatment of municipal wastewaters and sludge. Thus, the programmes in Thrust 3 will be as follows:

- Programme 1: Emerging treatment technologies – Preparing for the future
- Programme 2: Application of appropriate technologies and tools
- Programme 3: Stormwater and sewerage systems
- Programme 4: Wastewater sludge and faecal sludge treatment management framework

In Thrust 4 which now addresses both management and the treatment aspects related to mine water and industrial effluents, a new programme specifically addressing treatment has been introduced as follows:

- Programme 6: Beneficiation & treatment of industrial and mining effluents

These changes contribute to strengthening the portfolio of the KSA and direct the KSA towards greater relevancy and emphasis. This process is continuous and will further build and strengthen the research portfolio of the KSA.

The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with DWAF's strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy. To achieve these objectives, strong internal processes are necessary. Strengthening internal processes and capacity will therefore continue to receive greater attention.

The new portfolio of projects aims at providing solutions that support these directions in the following ways:

- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services

- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including greywater and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes
- Opportunities of energy from water and sanitation
- Supporting water for growth and development

The research portfolio for 2008/09 is presented in Table 2, which provides an overview and description of research thrusts and programmes.

TABLE 2

Overview and explanation of thrusts and programmes

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability is key to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure management, water-related competencies and capacity required for the strengthening of water institutions (water services providers, water services authorities, water boards, national departments) in providing sustainable water services.

**Programme 1:
Cost-recovery in water services**

Scope: The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this program intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.

**Programme 2:
Institutional and management
issues – Water services**

Scope: Relationships and partnerships between service providers, both external and internal, are important prerequisites to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.

**Programme 3:
Innovative management
arrangements – Rural water supply**

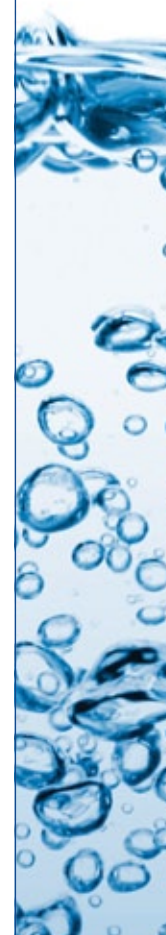
Scope: The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development.

**Programme 4:
Regulation of water services**

Scope: Regulation of water services is important for the sector to achieve improved functioning and performance of the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of the infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.

**Programme 5:
Impact of water and sanitation
interventions**

Scope: The programme will address aspects related to determining and quantifying the sociological, economic, technical, health, etc., impacts and benefits of 11 years of water supply and sanitation interventions in South Africa. Over the years the Government has spent considerable sums of money to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits which improved water and sanitation has brought to the communities and the countries. Thus, the time is most appropriate to undertake a study of this nature.



THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of quality and quantity for drinking (domestic) and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. The objective of this thrust is to develop innovative technologies and processes that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

Programme 1:
Drinking water treatment
technology

Scope: The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.

Programme 2:
Water treatment for rural
communities

Scope: This programme aims to provide, through research products, adequate quantity and quality water to rural communities on a sustainable basis. Expected outcomes required to achieve sustainable water services include community involvement, cost-recovery, effective operation and maintenance, affordability and willingness to pay for water services.

Programme 3:
Drinking water quality

Scope: The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.

Programme 4:
Water distribution and distribution
systems

Scope: The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to the end-users. The programme has the following expected outcomes: to develop reliable processes in predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs; to ensure that the quality and quantity of water is maintained in the distribution system - from the water treatment plant to the furthest end user; and to develop innovative methods, tools and processes that will improve system integrity and reliability.

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: This thrust focuses on the development of technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector. This includes the reticulation, treatment and management of the residues. The challenge is to implement fitting solutions for a particular application that will remain functional throughout the intended lifespan of the installed infrastructure. This includes the responsible management of the wastewater sludge and faecal sludge that is generated. The need for innovative technologies and solutions is recognised as we prepare for the future – achieving more stringent effluent discharge standards, developing acceptable non-waterborne sewerage solutions, reliable treatment of ever-increasing high-strength domestic wastewater, informing future policy, etc.

Programme 1: Emerging treatment technologies – Preparing for the future

Scope: It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as to support government by informing future policy. It supports development of technological solutions addressing amongst others: reuse, recovery, non-waterborne sewerage solutions, greywater management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment etc. It also supports research aimed at informing future policy through data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.

Programme 2: Application of appropriate technologies and tools

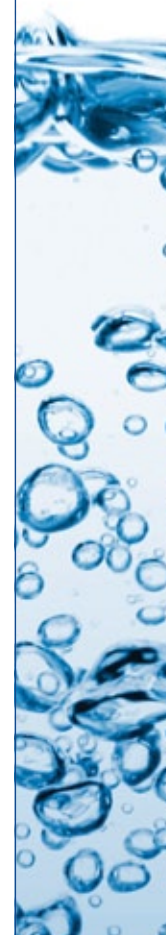
Scope: This programme addresses the improvement and innovative application of existing 'fit for purpose' technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate application to consistently achieve strict standards with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.

Programme 3: Stormwater and sewerage systems

Scope: The programme supports the strategic and technical aspects of managing stormwater and sewerage impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology including water-sensitive urban design (WSUD) and stormwater reuse. It will cover aspects of technical design, and operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.

Programme 4: Wastewater sludge and faecal sludge management

Scope: All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, stabilisation, dewatering, disinfection and beneficiation is encouraged.



THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. This thrust aims to provide appropriate, innovative and integrated solutions for water use and waste management in the industrial and mining sectors.

Programme 1: Quantification of water use and waste production

Scope: In order to prioritise those facets of industrial and mine-water management that need most urgent attention, it is important to quantify the water used and waste produced by different sectors. The NATSURV investigation conducted by the WRC provides the benchmark for water use and wastes that are produced by the major South African industries. While the WRC has reported on water use by coal mines and COMRO on water use by gold mines, no overall assessment of the effect of mining or industrial waste on water quality is available. The available information thus needs to be updated and refined. Furthermore, new information needs to be gathered for those sectors that may present important emerging issues.

Programme 2: Regulatory mechanisms to improve industrial and mine-water management

Scope: The regulatory authorities are responsible for managing the impact of industrial and mining waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used manage water quality, almost exclusively. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new approaches are believed to be more cost effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the regulatory mechanisms that are used to control and reduce the negative environmental effects associated with industrial and mining waste.

Programme 3: Minimising the impact of waste on the water environment

Scope: South Africa has a large legacy of mining and industrial waste products that impact negatively on the water environment. In spite of efforts to the contrary, the quantity and range of waste products are expected to increase for the foreseeable future. It is thus necessary to develop cost-effective techniques and approaches to minimise or reduce the impact that historical and new waste products have on the water environment. Approaches such as pollution prevention, rehabilitation, waste beneficiation and reuse, are investigated to assess their application potential and suitability to reduce and minimise the negative impact of industrial and mining waste on water quality.

Programme 4: Minimising waste production

Scope: A direct link exists between the quantity of waste produced and its impact on the water environment. The type of waste that is produced may, however, often be of even greater importance than quantity. In order to reduce the negative impact of waste production, it is important to reduce both the quantity and toxicity of waste. The international trend towards waste management is therefore to minimise the production of waste by adopting cleaner production processes. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. This programme investigates and promotes the implementation of approaches that minimise waste production.

Programme 5: Improved ability to predict and quantify effects

Scope: The environmental consequences of waste products are almost always long-term in nature, with impacts that may potentially last for hundreds of years. These long-lasting effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impact of their operations and to indicate how these will be remedied. This programme is primarily aimed at establishing and improving pollution prediction capabilities appropriate to the South African situation.

**Programme 6:
Beneficiation and treatment of
industrial and mining effluents**

Scope: In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial and mining activities. This programme aims to support the development of a range of processes for effective treatment, beneficiation and disposal of industrial and mining effluents, with the aim to minimise negative consequences associated with the effluents and derive potential benefits associated with them. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse and fundamental scientific/engineering support for process development.

THRUST 5: SANITATION, HEALTH AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national Government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery (O&M, sustainability, etc.) beyond 2010. The focus is on low-cost and affordable sanitation technologies.

**Programme 1:
Advocacy, health and hygiene
education**

Scope: The main objective of this programme is to support the integration of health and hygiene into the delivery of water and sanitation in order to ensure that these services lead to maximum health benefits for the beneficiary communities.

**Programme 2:
Peri-urban sanitation research**

Scope: The aim of this programme is to provide research support to sanitation in informal and developing urban areas. Until recently the focus of sanitation has been on rural areas, but the situation in urban areas is much more critical and volatile in terms of public health. Urban sanitation differs from rural sanitation issues related to institutional arrangements, community dynamics and management of interventions. Due to the high densities, technical choices are more complex where an affordable and sustainable service is to be provided. Outcomes from this programme will support local authorities in implementing sustainable solutions, which cater for both the user and the institutions' needs.

**Programme 3:
Institutional and management
aspects of sanitation service delivery**

Scope: The main objective of this research programme is to develop institutional models, tools and guidelines that will support the improvement of delivery (O&M, sustainability, etc.) of sanitation services.

**Programme 4:
Technical sustainability of sanitation
services**

Scope: To develop tools, procedures and guidelines that will guide those responsible for implementing projects in their selection of appropriate sanitation technologies that are socially, environmentally and financially sustainable.

KSA alignment with DWAF's objectives

The research thrusts and programmes in KSA 3 have been strategically aligned and structured to respond to its scope, viz. to provide knowledge that ensures reliable, affordable and efficient water use and waste management services to enhance the quality of life, and contribute to economic growth and improved public health. Consequently, the KSA's scope is aligned to DWAF's Strategic Plan for 2007/08 to 2009/10 and the KSA portfolio of thrusts, programmes and projects directly contributes to DWAF's strategic objectives. This is illustrated in Table 3, highlighting the related strategic objectives of DWAF to the KSA, and the relationship and contribution of the KSA thrusts, programmes and projects.

Some of the linkages are highlighted in detail as follows: The WRC initiatives support DWAF's regulatory function in its strategic area of **ensuring protection of the water resources**. The WRC projects focus on developing simple techniques for identifying pollutants, technologies and processes to recover and reduce contaminants in waste streams, and on supporting the strengthening of existing policies, such as closure and decanting of mines.

In the DWAF area of **basic services**, the WRC focus and support are threefold. Firstly, the research supports the implementation of policy; secondly, it evaluates or reviews the effectiveness of

the policy; and thirdly, in response to this the WRC provides appropriate solutions in the event of policy and knowledge gaps. An example of this is the review of current sanitation policy and scope to introduce a free basic sanitation component, and developing techniques to implement a basic sanitation component successfully.

DWAF's strategic role as a sector leader in **ensuring effective services delivery** is supported by research through the development of training aids, guidelines and tools. These instruments are used in support of both capacity building and regulation.

On DWAF's **regulatory role** the KSA 3 research on wastewater sludge and faecal sludge management (Thrust 3: Sustainable Municipal Wastewater and Sanitation) is a good example of how a programme area is contributing towards developing standards through good science; these standards are then translated into guidelines that are used for regulation. Together with DWAF there is ongoing promotion of technology transfer and application of the findings.

In the area of **effective local level O&M**, the KSA 3 programme on technical aspects of sanitation (Thrust 5) is focusing on the build-up of sludges and the future management thereof. The research outputs aim to inform policy and provide support to municipalities.

TABLE 3
KSA alignment with DWAF's objectives

DWAF objectives	WRC thrusts	WRC projects (examples)
Ensure the protection of water resources	• <i>Emerging treatment technologies: Preparing for the future</i> • <i>Stormwater and sewerage systems</i> • <i>Quantification of water use and waste production</i> • <i>Minimising the impact of waste on the water environment</i> • <i>Minimising waste production</i>	• Closure planning in the minerals extraction industry: The role of effective waste characterisation and water-related impact predictions for solid mineral wastes • Development of a first-order decision support system for the sustainable design, operation and closure of metalliferous tailings disposal facilities • Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments • Cleaner production technologies in industry and mining sectors • A first-order assessment of the quantity and quality of non-point sources of pollution associated with the industrial mining and power generation sectors
Ensure provision of basic water supply and sanitation for improved quality of life and poverty alleviation	• <i>Drinking water quality</i> • <i>Water treatment for rural communities</i> • <i>Wastewater sludge and faecal sludge management</i> • <i>Beneficiation and treatment of industrial and mining effluents</i> • <i>Technical sustainability of sanitation services</i>	• Research into urine-diversion toilets • Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa. • Development of an appropriate tool: Voice, measure and intervention in ensuring the sustainability of municipal water services to the poor • Productive use of domestic water for sustainable livelihoods
• Ensure effective and sustainable delivery of water services to underpin economic and social development (sound legislation, policies and strategies for the sector; sound planning culture established within sector) • Promote and support sound policy and practice of water services to achieve millennium targets in Africa	• <i>Regulatory mechanisms to improve industrial and mine-water management</i> • <i>Improved ability to predict and quantify effects</i> • <i>Advocacy, health and hygiene education</i> • <i>Regulation of water services</i> • <i>Institutional and management issues</i> • <i>Water services</i>	• The state of community consultation in the provision of water services • Effective demand for alternative sanitation options in peri-urban settlements. • Financial sustainability of sanitation services • Examine the understanding and interpretation of sanitation policy and programmes • Review of regulatory aspects of water services • Development of framework for the regulation of the competencies of water services managers • Valuing water for South African industries: A production function approach • Towards introduction of good practice and management of SA water service infrastructure and asset management
• Ensure effective water services institutions • Ensure effective local-level operations and management of DWAF water services schemes	• <i>Impact of water and sanitation interventions</i> • <i>Drinking water treatment technology</i> • <i>Water distribution and distribution systems</i> • <i>Application of appropriate technologies and tools</i> • <i>Peri-urban sanitation research</i> • <i>Institutional and management aspects of sanitation service delivery</i> • <i>Cost-recovery in water services</i> • <i>Innovative management arrangements</i> • <i>Rural water supply</i>	• Sustainable options for community level management of greywater in settlements without on-site waterborne sanitation • Franchising in water services. • Enabling water fluoridation in small drinking water treatment plants • Improving the efficiency of disinfection in small drinking water treatment plants • Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof • The development the South African Wastewater Sludge Guidelines • Guidelines for the utilisation and disposal of water treatment residues • Sustainable and beneficial use of biosolids land application strategies: • A manual and training aids for operation and maintenance on small water treatment plants • A management information tool for the efficient operation and maintenance of small water treatment plants • Field guide for inspections at water and wastewater treatment works • National standards for water and wastewater treatment chemicals • A guideline document for emergency disinfection of drinking water • Design manual for small sewage treatment works

Research Projects for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

The development of models to facilitate financial sustainability of water services provision by Water Services Authorities in rural areas, based on an investigation of full costs and income

Mvula Trust

No. 1614

Ensuring sustainability of water services is part of a municipality's legislated mandate and, in order to do this, appropriate tools are required to accurately determine the resources required in order to meet this objective. Budgeting for the complete costs of water services provision is a fundamental building block for municipalities to understand and engage with the resource requirements in order to provide a sustainable service. Within the water services provision function of water services authorities, the ring-fencing of expenditure provides the basis for good governance, as it calculates cost per sector of service delivery and assists with prioritising spending. Water services authorities have accepted responsibility for water services provision. Municipal officials, however, are obliged to deal with daily crisis management, political and community demands and requests, reporting requirements and human resource management in the context of delivering a range of services in a complex environment with limited resources. Most municipalities are also seriously understaffed in their water provision departments and setting up systems and procedures for management is not seen as a priority. This study has developed a tool, and a guideline to the tool, to assist water services authorities to plan for financial sustainability by identifying costs based on activities, including direct and indirect costs accruing from the different levels associated with water services provision. The tool has been designed which is intended for use by municipalities to establish and cost the activities of water services provision. It is designed for use by either local or district municipalities and is not restricted to a particular size of area or institutional boundary.

Cost: R370 000
Term: 2005 - 2008

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa

Palmer Development Group (Cape Town Office)

No. 1713

The purpose of this research was to assess whether being a member of a large consumer unit, defined as more than 8 people sharing a stand, results in inhibited access to water and sanitation services, and whether large consumer units find water and sanitation services to be unaffordable. This research suggests that large consumer units cannot be viewed simply as a homogenous group. Different types of consumer units, and different households making up those consumer units, face different challenges with respect to water and sanitation. Nuanced policy approaches will be necessary to help to alleviate these differing challenges. Such policy approaches might include: considering programmes to upgrade backyard

accommodation, and metering such accommodation separately; increases in the amount of Free Basic Water allocated to large consumer units; revisions to the rising block tariff structures, or consideration of alternative tariff approaches; and education programmes around the wise use of water. Indigent policies should also be reviewed to take large consumer unit size into consideration.

Cost: R390 550
Term: 2007 - 2008

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Membrane fouling and visualisation studies

University of Stellenbosch (Institute for Polymer Science)

No. 1441

Permanent fouling of membranes is the major contributor to the cost of using membranes for water and effluent treatment. The extent of fouling and the success of cleaning protocols are currently measured by flux or pressure changes across the membrane, requiring monitoring over time. The nature and thickness of fouling layers on operating plants are currently determined by expensive and destructive tests such as autopsies. A method was required to measure the thickness and other important characteristics of the fouling layer in real time and without interfering with the module in any way. Further, more efficient, non-chemical methods for the cleaning (de-fouling) of these membranes are required. The aim of the project was, therefore, to develop non-interfering methods for the early detection, measurement, characterization and cleaning of fouling on membrane surfaces. The scope of the project included: the further development and refining of an ultrasonic method developed earlier at the University of Stellenbosch, called Ultrasonic Time Domain Reflectometry (UTDR) hardware and software; the development of this technique on flat-sheet membranes and more complex shapes; characterization of fouling layers from high natural organic matter (NOM) synthetic and real waters; and following the effect of cleaning protocols in real time. The project was divided into 2 parts. The one part researched the measurement and characterization of the fouling layers after treatment of NOM-containing water, whereas the other part investigated the ultrasonic and infrasonic cleaning of these membranes.

The researchers succeeded in refining the UTDR technique as regards hardware, software and data handling and can handle both dead-end and cross flow continuous flow experiments. This has been done using different types of water, oil/water emulsions and beer effluents, with the appropriate membrane materials. They developed a local ultrasonic fouling index meter and had a more inexpensive model built in Germany, as part of a collaborative programme. They further developed an infrasound (low frequency) device and managed to clean fouled membranes successfully. The project, therefore, succeeded in developing a fouling indicator, which is able to measure fouling layer thickness in real time, as well as an infrasound membrane cleaning system. These developments will make an important contribution to increased use of membranes for water and effluent treatment in the future.

Cost: R1 500 000
Term: 2003 - 2008

An investigation into alternative methods to clean filter media in rapid gravity sand filters to ensure optimal performance and quality of the filtrate

Rand Water (Scientific Services)

No. 1525

Rapid sand filtration is an essential process in water purification to remove suspended matter. Filters clog and air scour and wash water are applied. However, filter sand is often unacceptably dirty and backwash systems do not return the media to its initial state. This project analysed the deposit on filters before and after cleaning and showed that only a small fraction of the overall deposit is removed but that it is possible to remove >20% more deposit using shorter consecutive air scours followed by a backwash. The same amount of air and wash water is used so maintenance costs increase only slightly. A further improvement of 12% in the removal of specific deposits can be achieved using calcium hypochlorite and applying a normal backwash. These modified backwashing procedures could improve the performance of filters at a great number of water treatment works by up to 30%.

Cost: R413 500
Term: 2004 - 2008

Development of improved local anti-fouling spiral-wrap membrane systems

University of Stellenbosch

No. 1593

Fouling of membranes is one of the most important phenomena determining the economic use of membranes in water and effluent management. A large market exists for proven defouling technology, as large sums are spent by large industries on the replacement of fouled membranes. A main focus of this project was the incorporation of feasible anti-fouling or anti-scaling technologies in existing membrane plant designs and different spiral-wrap configurations were evaluated in terms of their advantages and limitations. It was shown that the dosing of a Zn compound can inhibit scale formation in RO feed water. The prevention of CaCO_3 scale through the use of magnetic treatment devices on the feed line to the RO membrane proved to be feasible on lab-scale, but this was not observed in the pilot plant scale studies. Further, pilot plant, confirmatory studies need to be performed. Success with either or both of these technologies will have vast benefits in the membrane and water industries.

Cost: R720 000
Term: 2005 - 2008

The generation of design parameters for the use of the limestone teeter-bed reactor for potable water stabilisation and the treatment of Cape coloured waters

RG Batson, TBR Project; Chris Swartz Water Utilisation Engineers; Peninsula Technikon (Department of Building and Civil Engineering)

No. 1594

Many surface and coloured waters are aggressive to concrete and corrosive to metals. The colour should be removed from these waters and the water stabilised. Initial packed-bed limestone contactors to achieve stabilization became easily coated by contaminants and a fluidised bed proved to be too energy-consuming. The project leader aimed to develop an

improved system which moves the pebbles without fluidising them (a so-called 'teeter' action), thereby achieving a cleaning action of the pebbles without too much energy use. It was succeeded in developing a 2-stage process, based on this 'teeter' action, which is capable of treating soft, coloured waters at less than a third of the cost of conventional treatment. Full design specifications are provided. Although the process requires some further refining, this system shows great potential in supplying potable water more cost-effectively from such soft and coloured water sources.

Cost: R390 000
Term: 2005 - 2008

Operational strategies for the cost-effective use of ozone in water treatment

Umgeni Water

No. 1596

Ozone production and operation account for about 35% of the total energy consumption of the treatment works. Ozonation in drinking water production, therefore, needs careful optimization. This project focused on a holistic approach and guidelines to enable the efficient use of ozone in water treatment as an oxidant in the pre-treatment or intermediate stages of the water treatment train. A survey of South African ozone users for water treatment was conducted to establish a South African ozone perspective and operating philosophy. Laboratory-scale work was further conducted at the Wiggins Process Evaluation Facility to optimise analytical procedures and develop a reliable means of controlling ozone dose. A user-friendly, practical guide, that summarises the rationale for the inclusion of pre-oxidation in the water treatment train, selection of an appropriate oxidant for the application, and operational strategies for the cost-effective use of ozone in water treatment, was compiled from the project. The guideline also assists in the selection of hardware, which includes oxygen feed source and preparation, ozone generation, contacting and destruction.

Cost: R651 500
Term: 2005 - 2008

Programme 2: Water treatment for rural communities

Removal of pollutants by membrane technology from groundwater: a social and a technological approach

North-West University

No. 1529

Many groundwater sources in the rural areas show unacceptable levels of hardness, nitrates and fluorides, leading to various aesthetic, household and health problems. It was therefore aimed to investigate membrane technology to bring the concentrations of fluoride, nitrate, other salts and hardness to potable water standards and to train local people to operate and maintain the membrane installation. The study further aimed to explore the consumer's attitude regarding current and general water supply. Both bench and field membrane tests were performed, which showed that the groundwater can be purified to acceptable potable standards using reverse osmosis (RO) membranes. A local teacher was successfully trained to operate the field membrane plant and the village people accepted the field unit and cared for it. The social study also showed that

the people accepted the treated water and the treatment unit very well. The treated water was of a superior quality and tastier than the untreated, hard, borehole water high in nitrates and fluoride. A very useful social guide on water and water treatment further emanated from this project. Overall, the project was very successful (as shown by the large attendance at a demonstration day) and played an important role in establishing membranes as an acceptable rural water treatment option.

Cost: R499 600
Term: 2004 - 2007

Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof

Emanti Management (Pty.) Ltd.

No. 1597

This project identified the minimum requirements for effective and sustainable drinking-water service delivery within non-metropolitan water distribution networks to ensure acceptable drinking-water quality. Interviews with municipalities followed by site visits provided insight into current treatment plant and distribution network operation and maintenance procedures and the key factors that result in water quality failures in non-metropolitan networks. A web-enabled risk assessment tool was developed, as were practical guidelines aimed at different levels and/or users of the water service team, supported by two web-enabled tools available via the electronic Water Quality Management System (eWQMS). The management guides provide assistance in understanding planning, legislation, drinking water quality issues, staff training and reporting. The process controller's guide has been developed to assist operations and maintenance personnel in the operation and maintenance of drinking-water treatment plants and identifies issues that need urgent attention. The distribution system personnel guide assists operations and maintenance personnel in understanding and rectifying typical failures experienced in drinking-water distribution systems.

Cost: R452 300
Term: 2005 - 2008

A manual and training aids for the sustainable operation and maintenance of small water treatment plants

Chris Swartz Water Utilisation Engineers

No. 1599

Several studies have shown that the selection and implementation of the correct water treatment system is only the first step in ensuring sustainable supply of potable water to small communities. Following the correct operational and maintenance procedures is of even greater importance for sustainability of supply. In a previous WRC study (WRC **Report No. 738/1/00**) it was found that many local small water treatment plants experienced problems in operating on a sustainable basis, due to a number of technical and human factors. However, due to the wide and encompassing nature of that previous investigation, it was not possible to identify and characterise these operation and maintenance related problems fully. This follow-on project determined the nature and full extent of the problems experienced and the report provides practical and user-friendly guidelines in the form of a manual for the

required preventative and remedial actions to be taken to rectify the situation. The manual identifies the various technical issues related to operation and maintenance on small water treatment plants impacting upon the quantity and quality of potable water before distribution and provides technical guidelines to small water treatment plant operations and maintenance personnel for the sustainable operation and maintenance of such plants, compiled into a user-friendly manual suitable to be used as a general reference for everyday, practical operation and maintenance on all categories of small treatment plants found in South Africa.

Cost: R1 500 000
Term: 2005 - 2008

Technical and social acceptance evaluation of a novel microfiltration and ultrafiltration membrane system for potable water supply to rural and remote communities

Chris Swartz Water Utilisation Engineers; Cape Peninsula University of Technology; Rural Support Services

No. 1227

Conventional small rural plants have been shown to lack sustainability due to high technical abilities required to operate these plants successfully. As membranes are known to produce high quality water, require less operator attention and may be automated much more easily, this project aimed at evaluating membrane technologies for treatment of surface waters, including the determination of social acceptance factors for transferring the new technologies to the community. Both bench and pilot plant trials were run and 2 communities studied regarding social acceptance of membrane technology. It was found that membrane technology will be eminently suitable in treating surface waters to potable standards with minimal operator input. The social studies showed that community perceptions and preferences need to be taken into account before siting of the plant. The project provided extensive insights into rural water supply with membrane-based plants and the guideline will have a significant and positive impact on doing this correctly in order to ensure the sustainable supply of safe drinking water to rural communities.

Cost: R556 000
Term: 2001 - 2008

Programme 3: Drinking water quality

Methods manual for monitoring phytoplankton and cyanobacteria

Rand Water (Scientific Services)

No. 1533

Reservoirs provide the bulk of South Africa's raw potable, irrigation and livestock water. These reservoirs are variously impacted by eutrophication arising from their catchments. Certain dams, especially those located in the interior of the country, are eutrophic to hypertrophic. Associated with these conditions is the excessive development of phytoplankton, especially cyanobacteria. As is globally common, cyanobacteria are associated with many aesthetically-displeasing (algal blooms, scums, odours) and health-related problems (toxins) which can adversely affect humans and animals. Of greatest importance to the potable water industry is the production of cyanotoxins and taste and odour compounds such as geosmin and

2-methyl-isoborneol (2-MIB). The monitoring of phytoplankton, cyanobacteria and their related organic compounds, therefore, is essential to the production of water which is safe for human and animal consumption.

The objectives of the project were to develop a laboratory methods manual to be used to for the analysis of phytoplankton, geosmin and 2-MIB and cyanobacterial toxins in South African freshwaters including validations for reference purposes. The manual has been written in the format prescribed by SANAS (South African National Accreditation System) and inclusive of the validation data. The following methods were evaluated and validated:

- Spectrophotometric methods for the determination of chlorophyll-a (usually performed on raw water samples) and chlorophyll-665 (total pigment – usually performed on drinking water)
- Filtration (one method) and two sedimentation methods used for phytoplankton and cyanobacterial identification and enumeration
- A reference for the determination of biovolumes for all phytoplankton and cyanobacteria found in South Africa
- A 'purge and trap' procedure, coupled to a GC/MS method, for the determination of geosmin and 2-methylisoborneol (2-MIB)
- ELISA method for the determination of microcystin concentrations
- HPLC method for the determination of microcystin and nodularin concentrations
- HPLC method for the determination of anatoxin-a and cylindrospermopsin concentrations

The condensed methods manual (***Condensed Laboratory Methods for the Analyses of Phytoplankton, including Cyanobacteria, in South African Freshwaters***) mainly includes the step-by-step execution of all the methods, and is aimed to be used in the lab. This condensed methods manual is supplemented by a comprehensive methods manual (***Comprehensive Laboratory Methods for Monitoring Phytoplankton, including Cyanobacteria, in South African Freshwaters***) that includes all aspects of the methods as well as their validations, to serve as reference when methods are being developed or additional information regarding the methods are required. It is envisaged that these 2 manuals will support and facilitate capacity building in South African water laboratories.

Cost: R403 600
Term: 2004 - 2007

National standards for water treatment chemicals
Umgeni Water; SABS
No. 1600

This research shows that the best mechanism of mitigating risks posed by the use of drinking water treatment chemicals (DWTCs) is by regulating the supply industry; that is, imposing stringent standards that specify the maximum contaminant levels, and the minimum chemical requirements, to maintain good quality control. Significant progress was made with the project and 43 new standards covering the majority of the commonly-used priority DWTCs were adopted by the SABS for use. This constitutes the key deliverable of the project. The change from having some degree of control of DWTCs through legislation prior to 1994 to none at all currently, is an area of urgent concern. It indicates an enormous failure and inadequacy of the relevant

pieces of legislation. A considerable amount of research was undertaken in addressing these concerns faced by the water sector. Contamination in DWTCs generally results in chronic health effects. However, acute health and ecological effects may also arise from the production and use of DWTCs. These effects have been identified and presented in the report. Finally, guidelines are provided on SCM processes for the procurement of DWTCs, while complying with good corporate governance.

Cost: R241 800
Term: 2005 - 2008

Programme 4: Water distribution and distribution systems

Assessment of the feasibility of using a dual water reticulation system in South Africa
University of the Witwatersrand
No. 1701

The use and application of dual reticulation systems was investigated in the past by Botha and Pretorius (1998). The study concluded that dual systems offer new possibilities for maintaining adequate water supply and encouraging the appropriate use of the available water resources in South Africa. However, uptake of the recommendations of the study, especially in many water scarce areas of South Africa, has been limited. This is despite the fact that the technology surrounding dual systems and non-potable water use/reuse has evolved since then, with great strides made on the subject. This study therefore emanated from the need to re-visit this subject and evaluate its current applicability within the South African context. The study has found that dual water reticulation systems are technically viable options. As long as regulations and guidelines are adhered to, and fundamental precautions and practice regarding materials, system implementation, and system operation are taken, a non-potable water system is technically no more difficult than other reticulated systems. Wide-area urban/agricultural and industrial dual systems are only viable in an area where a sewer system already exists or is to be implemented. Individual and district dual systems are also viable where sewer systems exist but have also been easily implemented in low-income communities/households where sewers don't exist and dry sanitation is practised.

Cost: R600 000
Term: 2006 - 2008

The state of plumbing in South Africa
University of Johannesburg
No. 1702

Household plumbing products, materials and practices play important parts in the effective and efficient delivery of water and sanitation services. Good products and materials can ensure efficient use of water at a domestic level, thereby reducing wastage of treated water and a scarce resource. Significant changes over the years in the water services sector and the water supply industry have seen a plethora of imported and at times pirated products being introduced onto the market. Linked to this are indications of poor quality of workmanship. These developments impact on the supply as well as resource side of water and cost the sector billions of rand. This project investigated the state of plumbing used in South Africa in order to estimate

the extent of the problems of non-compliant plumbing fittings and on-site leakage. The main goals of this project were to investigate the level of compliance of plumbing fittings installed in South Africa, as well as the extent of leakage from plumbing fittings (on-site leakage). The study found that while South Africa has good water legislation, indications exist that water bylaws are not present in all municipalities in South Africa, and that few municipalities have effective systems to enforce national and local legislation. An investigation of the plumbing fittings available on the market in South Africa revealed that 58% of products on the market are non-compliant and 10% of products that claim the SABS mark do not have the mark.

Cost: R600 000
Term: 2006 - 2008

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Biotechnology of saline and sewage wastewater co-treatment. Volume I: Integrated physical, chemical and biological process kinetic models for anaerobic digestion of primary sewage sludge; Volume II: Integrated beneficiation of mine wastewaters

Rhodes University (Environmental Biotechnology Research Unit); University of Cape Town (Water Research Group, Department of Civil Engineering); University of KwaZulu-Natal (Pollution Research Group, Department of Chemical Engineering); Pulles, Howard & de Lange; ARC (Institute for Soil Climate and Water); Optimal Agricultural Business Systems; Public Domain Management; Rhodes University (Department of Anthropology)
No. 1456

In providing incremental steps in a number of key areas, the overall objective of waste beneficiation of mine wastewater has been advanced in which technology provides an enabling platform for wastes to be managed as resources with economic potential rather than as a dead cost to both the community and the environment. In the first part of this project K5/1456 (Volume I), a kinetic model was developed for the core unit process in BioSURE™ and similar systems, of biological sulphate reduction (BSR) with primary sewage sludge (PSS) as substrate in a UASB reactor. The experimental investigation on the feasibility of the UASB system for BSR with PSS has indicated that this system holds considerable promise but that the effects of sludge bed recycling need to be examined.

The second part of **Report No. K5/1456** (Volume II) investigated the beneficiation of mine wastewaters and their use as a resource. An assessment of water, soil and climatic requirements for crop production in the area was undertaken by the ARC. A list of potential crops was identified which would be suitable for production in the Eastern Ekurhuleni region, and this was used in the subsequent investigations of both extensive and intensive agricultural production models evaluated. The suitability of treated water quality for irrigation was considered for both reverse osmosis (RO) and the BioSURE™ treatment options. The study indicated that some 113 farming and gardening enterprises may be established in this way, generating around 950 additional permanent jobs and a net farming income for the scheme of R26 m. Clearly the system could act as an incubator for the development of agricultural entrepreneurial

skills which could in time relocate to other, possibly more productive, enterprises. This remains a first-order assessment of feasibility and would require a much more detailed follow-up study to provide the rigorous and detailed planning structure on which to proceed.

Cost: R3 000 000
Term: 2003 - 2007

Biological sulphate reduction using primary sewage sludge as energy source in an upflow anaerobic sludge bed reactor
University of Cape Town (Department of Civil Engineering)
No. 1746

Since the economics of biological sulphate reduction (BSR) is driven by the economics of the organic carbon source, the BioSURE™ Process has been developed as a low-cost effective system where primary sewage sludge (PSS) is used as the energy source using an upflow anaerobic sludge bed (UASB) reactor. Studies at 35°C showed that at PSS COD/sulphate ratios of 1.25 and 1.44, and hydraulic retention times and sludge retention times of ≥ 13h and ≥ 18d, respectively, greater than 90% sulphate reduction could occur. Reactors operating at 20°C required a higher PSS COD/sulphate ratio of 1.75, and HRT and SRT of 20 h and 24 d, respectively, to increase the level of VFA's for sulphate reduction removal rates of > 90%. At ambient temperature a high percentage PSS biodegradable organics utilisation and low PSS COD/SO₄²⁻ ratio (1.25) can be maintained provided the sludge age is increased, thus requiring a larger bed and reactor volume. The study also found that bed expansion rather than sludge settle ability was the capacity-limiting process below the lowest optimal HRT which helped establish the optimum balance between HRT and bed expansion (sludge age). A new simple wet chemistry analytical procedure was also developed for COD and sulphur mass balance calculations, which were found to be close to 100%. Furthermore, both a steady state (SS) and a simulation (UCTADM1-BSR) anaerobic digestion model for BSR successfully predicted results that correlated very well to the experimental values. From the models it became evident that many organics, including PSS, are carbon-deficient for BSR and that the alkalinity shortfall is supplied by the sulphide (H₂S/HS⁻) system which establishes the BSR reactor pH. The benefits of the UASB BSR system using PSS as electron donor have already been implemented at pilot and full-scale in the BioSURE™ Process at Ancor (Germiston) wastewater treatment plant based on the results of this study.

Cost: R354 000
Term: 2007 - 2008

Programme 2: Application of appropriate technologies and tools

Development of a diagnostics-based knowledge management system for the efficient operation and training of staff associated with municipal sewage treatment facilities
Rhodes University (Environmental Biotechnology Research Unit); Eskom Enterprises (Pty.) Ltd. (Technology Services International Division)
No. 1337

Technology Services International (TSI) had been approached by the Environmental Biotechnology Research Unit (Rhodes University) in 2001, with respect to providing a solution to

the loss of valuable tacit knowledge at Sewage Processing Plants around the country due to high staff turnover. A knowledge management technique, developed by Gerrit Lok, was proposed as a possible solution and a demonstration site was recommended by the WRC and Rhodes University to evaluate the applicability of this tool. The Integrated Algal Ponding System (IAPS) project, co-ordinated by Rhodes at the Grahamstown Sewage Works was used for the demonstration of this tool. As part of its contribution towards the country's RDP, in terms of provision of low-cost sanitation for low-income consumers, the WRC had embarked upon the IAPS project in Grahamstown. IAPS had been designed as both a demonstration plant and a research facility with the objective of promoting acceptance and advancing knowledge in the operation of low-cost photosynthetic water treatment systems. The primary objective of this initiative was to capture the expertise, skills and knowledge developed by an individual or a team of individuals, who have performed demanding tasks at the IAPS. A secondary objective was to develop the decision support system to allow for the simulation of fault conditions with appropriate remedial actions and reference to background support material. One of the main requirements of the diagnostic system was that it should not be another so-called 'expert system' but would be a 'non-robotic' system. In other words, when used for problem solving, it would actually enhance the learning of the user. A 'hands-on' approach was used in this study to develop a totally comprehensive tool for the layman-operator. A decision support system was developed on an MS Access database using webpage support for the decision tree and reasoning path. The final product was presented in the form of a CD to the client with installation and operational instructions.

Cost: R329 200
Term: 2002 - 2007

Process design manual for small wastewater works

Waterscience cc

No. 1660

A Guide to the Design of Sewage Purification Works was first published in 1973 by the then Southern African Branch of the Institute for Water Pollution Control (IWPC) and over the years this useful reference document has become known as the 'Black Book'. This guide was revised and republished in 1987 and was intended to be less of a guide to design, and more of a manual to assist firstly designers and secondly engineers and/or chemists who may be required to approve the designs for smaller domestic sewage works treating up to 5 Ml/d. Since publication of the revised edition of the Manual for Design of Small Sewage Treatment Works in 1987, no further revision has been carried out, despite the fact that since then there have been a number of new technologies introduced into wastewater. **Project No. K5/1660** was motivated by the need to create an updated manual with the 1987 revision guide in mind, as several new processes are available and the understanding of the activated sludge process in particular had advanced significantly since then. The manual does not consider processes used in small plants of the package plant type as are commonly used in housing complexes. A change from the 1987 revision is that the maximum capacity of 5 Ml/d stipulated in previous versions is considered arbitrary and irrelevant. Although the manual is designed with smaller wastewater plants in mind, it needs to be borne in mind that much of the information and design calculations are applicable to much larger plants and not

confined to works of 5 Ml/d or less. Many larger plants have been built in stages over extended periods of time, resulting in plants consisting of a number of smaller modules. In such cases this manual could be of particular relevance. The ***Design Manual for Small Sewage Treatment Plants*** is however written with smaller wastewater works in mind and is intended to assist in designing, approving and operation of these smaller plants. The manual includes new information on rotating biocontactors (RBC) and submerged media reactors. Furthermore, the regulatory aspects and new legislative requirements were carefully considered in terms of how they were expected to impact on this manual.

Cost: R250 000
Term: 2006 - 2008

Field guide for inspections at waterworks

Golder Associates Africa; Zitholele Consulting; Johannesburg Water; Rand Water

No. 1730

The Department of Water Affairs and Forestry (DWAF) monitors wastewater treatment works (WWTW) as mandated through the National Water Act, 1998 (Act 36 of 1998). This is done through regular inspections of the WWTW. For an inspector to undertake inspections thoroughly and give proper guidance on any problems encountered, it is important that he/she fully understands the complex nature of the various unit processes involved in the treatment of wastewater. Equally, process controllers must have insight with regards to the aspects that are monitored during the inspection. This field guide provides inspectors and process controllers with a tool to conduct inspections on a WWTW. It provides guidance on how to identify possible problem areas and makes recommendations on how to solve common problems. The guideline and electronic checklists will assist the inspector undertaking the inspection, providing guidance where a problem is identified as well as assist process controllers to prepare for an inspection at their WWTW and take corrective action where problems are identified.

Cost: R276 420
Term: 2007 - 2008

Programme 3: Stormwater and sewerage systems

Development of guidelines for stormwater management strategies within integrated urban water management

SRK Consulting

No. 1670

KSA 3 'needs analysis' identified the need to determine and prioritise stormwater research needs, particularly in the field of stormwater control and management. The objectives of this study were to build on the outcomes of **Project No. K8/606** and further identify, characterize and prioritize stormwater management issues requiring attention in South Africa within the context of human settlements. The work programme included: a literature review to establish and prioritise research needs in stormwater management; establishment of the stormwater management status quo in local government areas; conducting a stakeholder consultation process to confirm and prioritize the issues/needs in South Africa and; development of strategic guidance for further research needs. Local government was consulted at 7 workshops held around South Africa. Findings indicated that although

delegates at the workshops had a good grasp of the issues and a clear understanding of what needs to be addressed to improve stormwater management, resources and support from the political level were identified as limiting factors in terms of future improvements in the current status quo and a move towards more sustainable approaches (WSUD) on a national scale. Of the 17 top priority needs that have been identified, 10 are research needs falling within the ambit of the WRC and 7 are sector needs falling under, among others, DWAF, SALGA, IMESA or WIN-SA. Of the 10 research needs, 5 are considered to be implementation research and 5 are considered to be fundamental research. The study concluded that the research project that focuses on alternative stormwater technology will be the first of these projects to be funded and will be initiated in 2008. The other projects will not run concurrently as the reference group felt that the outcomes of the alternative stormwater technology project could influence these projects leading to changes in the proposed focus areas and deliverables.

Cost: R399 863
Term: 2006 - 2009

A first-order national audit of sewerage reticulation issues

Industrial and Urban Infrastructure (Pty.) Ltd.; SRK Consulting (South Africa) (Pty.) Ltd.

No. 1671

Based on a series of workshops held at 8 main centres throughout South Africa, the study recommends that the standardization and setting of minimum requirements and guidelines for sewerage reticulation systems will assist in ensuring that minimum levels of service are maintained, specifically in the smaller local authorities. The greatest research needs from local authorities are to investigate and provide guidance in the fields of: operations and maintenance; environmental issues; benchmarking; and analysis of existing systems. A comparison of smaller local and regional councils, and larger metropolitan council issues revealed that operational and maintenance and system analysis were of greatest importance, whilst the metropolitan council require additional research conducted on benchmarking, social and educational issues. The smaller councils do not have the financial benefit of implementing enterprise-wide information systems or the personnel capacity to manage water service systems. The majority of time is typically spent on keeping the existing sewer system operational with little planned routine maintenance or strategic master planning. The study identified the need to develop national standards in the field of buried flexible pipes, jointing systems and trenchless technologies along with national standards bodies. There is also a need to address the dissemination programme of available information to the industry for valuable research that has been conducted by the WRC and other organizations. The report highlights that the existing frameworks appear to cover all aspects of strategic and technical fields; however there is a need for improved dialogue between governmental, local authority, non-governmental and professional associations to ensure that the correct issues are addressed to ensure sustainability and guarantee appropriate levels of service. Further measures are needed to ensure that dissemination of existing and future research is communicated to the correct participants in the industry.

Cost: R400 000
Term: 2006 - 2008

Programme 4: Wastewater sludge and faecal sludge management

Development and piloting of the integrated biodesalination process for sulphate and heavy metal removal from mine drainage water incorporating co-disposal of industrial and domestic effluents

Rhodes University (Department of Biochemistry and Microbiology)

No. 1078

Acidic wastewaters from mining operations (acid mine drainage, AMD) and various industrial and metal-refining processes often contain high levels of sulphates and heavy metals. WRC studies have shown that AMD volume flows may reach hundreds of mega litres per day for decades, with acute and long-term impacts on the public water resource system, the environment, and community health, and thus consequences for the economic and social development of the water-scarce Gauteng region. The development of suitable biological treatment processes has to date been constrained by reactor design appropriate to the large volume flows and the availability of cost-effective carbon sources. Recent WRC projects have researched algal ponding technologies and applied these low-cost processes to the treatment of mining and tannery wastewaters. This has led to the development of the biological sulphate-reducing (biodesalination) BioSURE™ Process using sewage solids as the carbon source for sulphate reduction and algal activity for precipitating heavy metals and neutralising of acidic drainage streams. In early 1998 a pilot plant was constructed and commissioned at Grootvlei Mine in a collaborative research venture involving the WRC (**Project No. 869**), ERWAT and Grootvlei Mine, with detailed study of the basic process mechanisms being undertaken in WRC **Project No. 972**. In **Project No. 1078** the outstanding components of the pilot plant were constructed to enable evaluation of the complete integrated process over an appropriate time period. Specific aims were: to complete pilot-scale evaluation of sewage as an example of a complex carbon source used as an electron donor in the integrated biodesalination process; to complete construction, operational development and optimisation of the integrated BioSURE™ pilot plant at Grootvlei Mine; and to operate the final configuration as a demonstration plant for an appropriate period for technology transfer, for process decision-making relating to the full-scale engineering of the process and to provide specialist support to WRC research partners in their implementation of process scale-up.

The operationalisation of the BioSURE™ Process in this project has contributed significantly to the development of the current situation, where a full-scale plant is being constructed at Ancor Sewage Works to co-treat primary sewage sludge from ERWAT and acid mine drainage from Grootvlei Mine.

The final report on this project, along with the final report on **Project No. 1336** will be published as *Report 11* in the series *Salinity, Sanitation and Sustainability* (ISBN series 1-86845-853-9, **Volume 4**, Part 3, *Sulphur Production and Metal Removal Unit Operations*). The report will include early results from the full-scale plant currently being built and commissioned at Ancor Sewage Works.

Cost: R1 700 000
Term: 1999 - 2004

Biofloc modification for sludge settleability improvements from selected BNR process conditions and configurations, pilot- and full-scale based settling behaviour evaluations for final clarification enhancement

ERWAT

No. 1340

The majority of short-term mixed liquor suspended solids (MLSS) settling test reports reflect an absence of any form of temperature compensation. This research project evaluated the effects of short-term temperature variations on MLSS settling parameters using traditional batch MLSS settling tests (SVI) followed by the implementation of an on-line MLSS settling test procedure to develop settling models based on diurnal reactor temperature (T_r) fluctuations. Monitoring of local ambient temperature and reactor temperature over the winter and spring period showed that large enough T_r and local ambient temperature (T_a) variations exist at operational plants to affect MLSS settling test results. The study showed that the MLSS sample temperature (T_s) adjusts towards T_a before and during a batch MLSS settling test, thereby influencing MLSS settling results. An on-line automated MLSS settling meter measured settling parameters at the operational T_r of a pilot- and full-scale plant. The settling models clearly demonstrated that parameter correlations improved when T_r is included in on-line MLSS concentration-based settling models. The inclusion of T_r in MLSS concentration-based settling best-fit correlations with SVI, u_{max} , and t_{umax} improves the coefficient of multiple determinations (R^2) by an average of 0.32 for full-scale plant conditions. Best-fit SVI models with u_{max} and t_{umax} have R^2 -values of 0.90 and 0.95 respectively.

Cost: R298 330

Term: 2002 - 2008

The production of aerobic granular activated sludge for enhanced settling in sewage treatment

BKS (Pty.) Ltd.

No. 1451

The success and efficiency in treating domestic sewage applying the activated sludge process depends on the settleability of the sludge produced. Many studies have been conducted on the topic of activated sludge settling characteristics and the factors influencing it. Sludge settleability influences the cost of treatment plants whereby the reactor and the settling tank sizes are determined by the thickening and settling characteristics of the produced sludge. Improvement in the sludge characteristics will have a major influence on the activated sludge process. One of the latest developments in the aerobic treatment process is the production of granular sludge in Sequencing Batch Reactor (SBR) systems. Granulation is induced by applying certain selection pressures resulting in the selection and establishment of sludge with dramatically improved settling characteristics (Etterer and Wilderer, 1999; Beun et al., 2001; Jianrong et al., 2002). In this research it was investigated whether granule formation was possible in an aerobic treatment system using settled sewage as substrate and whether the development of the granule reactor technology, i.e. the establishment of optimal process conditions, could be improved. The aims of this study were:

- Investigation of aerobic granular sludge formation using domestic wastewater (supplemented with acetic acid and sugar) and synthetic waste water (ethanol)

- Investigating the effect of operating parameters on the granulation formation, i.e. selection pressures for optimal granule formation
- Determination of the performance of granular sludge on chemical oxygen demand (COD) removal
- Determination of microbial diversity in the sludge granule

It was found that granule formation during the experimental period was a gradual process, as described by Tay et al. (2004). However, mature granules (maturation phase) did not develop during the experimental periods. High COD removal efficiencies of between 80-92% were achieved. The volatile suspended solids (VSS) concentration in the reactors gradually decreased over time. The following conclusions were made from this study:

- The addition of substrates to domestic sewage, in order to increase the OLR, did not lead to stable granule formation as was expected. With sugar as the carbon and energy source, the granules were not stable. The granules broke-up and were washed-out from the system, which result in low biomass concentrations in the reactor. However, regular-shaped granules were successfully cultivated in the airlift and bubble column reactor with synthetic waste water feed (ethanol). No granule formation occurred when the domestic wastewater was supplemented with acetic acid.
- Granule formation during the experimental period was a gradual process, as described by Tay et al. (2004). However, mature granules (maturation phase) did not develop during the experimental periods.
- High COD removal efficiencies of between 80 and 92% were achieved. The COD concentrations in the effluent were less than 200 mg/l during the experimental period, irrespective of substrate compositions. Higher COD removal efficiencies corresponded with higher OLR.
- The VSS concentration in the reactors gradually decreased over time. The exact reason for the low VSS concentrations in the reactor (lack of biomass build-up), is unknown and needs further investigation.

Cost: R327 700

Term: 2003 - 2008

Development of a commercially-viable implementation model for anaerobic co-digestion of toxic and high strength organic waters

University of KwaZulu-Natal (Pollution Research Group)

No. 1538

Waste minimisation and general environmental awareness results in the identification of concentrated toxic or high-strength organic wastes that should not be discharged directly to the environment, wastewater treatment works or landfill sites. Most companies do not have the technical expertise to treat these streams in-house. Previous research (Sacks, 1998) has indicated that there is a significant volume of unused digester capacity in KwaZulu-Natal. eThekweni Municipality has unused digestion capacity at the Southern Wastewater Treatment Works. The Water and Waste Department have indicated that they would be prepared to motivate to council to refurbish the facilities so as to be able to provide a service to industry by co-digesting toxic (recalcitrant) and high strength (labile) organic wastes. If the lead were to be taken by one municipality and if it proves to be successful, many other municipalities would be expected to implement such a co-digestion facility. Currently the market for such a facility remains invisible as companies

prefer to remain ignorant as to the fate of their waste products, and the concept of waste minimisation and waste segregation is not widely practised. However the increase in the number of ISO 14 001 registered companies will result in a proactive stance towards responsible waste management practices becoming more widespread. Landfill sites are often inappropriate for the disposal of liquid effluents and of compromised foodstuffs. Controlled liquid anaerobic digestion facilities would be a preferred technique for the responsible disposal of such wastes. A previous project (WRC **Project No. K5/1074: Co-digestion of high strength/toxic organic effluents in anaerobic digesters**) investigated the scientific basis for operating a co-digestion service. When industrial effluents which are characterised by a high content of organic matter are fed to an anaerobic digester, an organic overload could seriously impair the performance of the process, particularly the methanogenic stage, and possibly lead to the failure of the digester. Industrial effluents may also contain compounds which display a toxic effect on the anaerobic consortium. This effect may be temporary, i.e. providing that the micro-organisms are exposed to sufficiently small concentrations of the compounds for a sufficiently long period of time, they can eventually adapt to their presence in the feed and possibly even degrade them to a certain extent. But the toxic effect may be permanent and therefore result in worsened performance, or, in more severe cases, in the failure of the digester. The project therefore developed methods to assess whether a particular industrial effluent:

- Can be safely treated in an anaerobic digester
- Must be mixed with some proportion of another readily-biodegradable effluent in order to be simultaneously digested (co-digestion)
- Is not amenable to be anaerobically digested at all
- Having established the scientific basis for operating a co-digestion scheme, it is necessary to evaluate the other aspects required to put it into practice.

Cost: R150 000
Term: 2004 - 2006

Recovery and reuse of domestic wastewaters using integrated algal ponding systems: a key strategy in sustainable sanitation

Rhodes University (Environmental Biotechnology Research Unit)
No. 1619

Algal biomass was harvested from the pilot-scale Integrated High rate Algal Ponds (IHRAP) at EBRU in Grahamstown treating domestic wastewater. Laboratory-based pot trials were undertaken in a controlled environment over 3 growth seasons using algal biomass as a soil amendment and also as a foliar feed application in a range of vegetable types. Chemical commercial fertiliser (2:3:2 N:P:K) was applied as a control based on equivalent nitrogen concentration. From the results of both laboratory and field-scale studies, it has been shown that algal biomass increased yield comparable to, and sometimes exceeding, yield increases shown with the use of chemical fertiliser. The studies on utilisation of IHRAP-treated water and algal biomass led to the consideration of its application in an Integrated Wastewater Resource Recovery study. The Bushman's River Sewage Treatment Works and surrounding community was identified as a site for the demonstration of the concept due to its under-performance in meeting current effluent discharge standards. A preliminary planning study was undertaken and showed that a wastewater resource recovery system

demonstration plant set up at Bushman's River or similar sites would not only demonstrate well-researched IHRAP technology, but would also provide an insight into entrepreneurial opportunities that would be available in horticulture, agriculture and mariculture, and therefore lead to employment opportunity and possibly the self-sufficiency, or even profitability, of sewage treatment works to the wider community. The laboratory studies of algal biomass utilisation and the Bushman's River case study provide the baseline for follow-up investigations. It is recommended that a demonstration plant such as that proposed in the Bushman's River case study be constructed to subject the concept to a detailed and rigorous investigation and that a detailed economic study be undertaken into all aspects of the integrated wastewater resource recovery concept in order to gain support and confidence within the political and sanitation sectors for roll-out in the developing world.

Cost: R395 200
Term: 2005 - 2007

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 4: Minimising waste production

A pilot study into upstream cleaner production technologies for the petroleum-refining industry to meet the requirements of the Waste Discharge Charge System (WDCS)

Process Optimization and Resource Management
No. 1673

The implementation of the Waste Discharge Charge System (WDCS) is expected to have a significant impact on how industries conduct their business. The main drive of the WDCS is to address problems of excessive water pollution by encouraging efficient resource utilisation and promoting sustainable water use. In order to comply, industries tend to resort to end-of-pipe treatments which are expensive and specific to certain constituents. New developments suggest that upstream technologies could be more cost-effective and more efficient in removing the water quality constituents of concern which could result in a considerably downsized end-of-pipe system with a small footprint, including considerable investment savings. This project investigated this premise by focusing on the petroleum industry. In order to validate upstream technologies or cleaner production (CP) options, the project team solicited input from Chevron, which is the main refinery in the Western Cape.

A literature survey of international CP technologies identified the most appropriate technologies for each process unit in the petrochemical industry. The WDCS consists of an Incentive Charge, a Mitigation Charge and combinations of the two, the determination of which are dependent on the efficiency of CP techniques employed, as well as on realistic and accurate cost estimates of these techniques. The intention is to set the Incentive Charge at the minimum level required to serve as an incentive to dischargers to reduce their effluent loads at source, so that the RQOs in the catchment may be met. In order to effectively implement an Incentive Charge, a realistic set of cleaner production techniques first have to be developed so that appropriate costs may be calculated. Although Chevron is currently discharging to a marine outfall, a hypothetical scenario was constructed to compare the application of upstream CP technology with end-of-pipe treatment. It was calculated that

the introduction of CP technology would have been able to achieve the same improvement in effluent quality as projected for the Chevron effluent treatment plant, at 30% lower cost. This project has thus confirmed the premise that upstream CP technologies could be more cost-effective and efficient than end-of-pipe systems in removing water quality constituents of concern. It also demonstrated that waste discharge charges can be calculated and set at levels that should provide an incentive to industries to introduce CP technologies and, in so doing, improve effluent and resource water quality.

Cost: R229 200
Term: 2006 - 2008

Promotion of biodegradable chemicals in the textile industry using the score system: Part I – Pilot study and Part II - Modelling of the effects of textile industry wastewaters on the performance of a wastewater treatment plant
University of KwaZulu-Natal (School of Chemical Engineering)
No. 1363

The score system concept has been introduced to South African stakeholders in the textile industry (textile manufacturers, regulators, chemical and dye suppliers) at a series of workshops in Durban and Cape Town and was broadly accepted by all parties. Regulators saw it as a practical tool for meeting the increasingly stringent and complex requirements of environmental and water legislation while textile companies saw its benefit as a management tool to target their most serious pollution problems. Suppliers indicated a willingness to co-operate with textile manufacturers. The score system was demonstrated at 16 South African textile companies. This system is intended not simply as a method of estimating a (textile) company's effluent toxicity but is meant to provide guidance on reducing in it. Methods for reducing a factory's score profile include ensuring all relevant data including fixation rates and MSDS are available; using cleaner production techniques to minimise waste and maximise re-use of water, chemicals and dyes; replacing toxic compounds with less toxic alternatives; and, finally, effluent treatment. As a result of this project the eThekweni Municipality subsequently revised their trade effluent permitting system to include incentives for companies to adopt cleaner production practices such as the score system. The study also validated the relevance of the score system through biological tests and modelling. The results showed that a high-scoring dye had a greater negative impact on the WWTP performance (specifically autotrophic bacteria) than the low-scoring dye. The recommendations of this project are to sustain the score system in the textile industry and to use the tool in other industrial sectors which contribute high impact industrial waste to wastewater treatment systems and other receiving bodies.

Cost: R700 000
Term: 2002 - 2008

Programme 6: Beneficiation and treatment of industrial and mining effluents

Development of a membrane pack for immersed membrane bioreactors
Durban University of Technology (Department of Chemical Engineering); University of Stellenbosch (Institute for Polymer Science)
No. 1369

An immersed membrane bioreactor (IMBR) incorporates membrane filtration technology in a bioreactor to provide a single unit for biological treatment and high quality effluent production. IMBRs offer various advantages over the conventional activated sludge (CAS) process for wastewater treatment, including: compact process with small footprint; operation at elevated biomass concentrations ranging from 15 000 to 20 000 mg/l, as compared to approximately 4 000 mg/l for CAS; increased sludge age and reduced sludge production; provides a higher quality product, substantially free of pathogens. As a result, IMBRs have become very popular for onsite wastewater treatment, and are increasingly being applied for remediation of domestic wastewater as well as a wide range of industrial effluents. The project aimed to produce a local IMBR based on woven fibre microfiltration technology. It would develop flat-sheet membrane casting procedures, cartridges and a manifold system suitable for use in IMBRs, as well as an aerated hybrid IMBR containing flat-sheet or capillary dewatering membranes, using air sparging and silicone rubber membranes for oxygenation. A flat-sheet system was developed and tested in the laboratory, during which time the manifold system was perfected. A model for the optimization of IMBR hydrodynamics was developed, based on an identification of the important geometric and operating variables that affect circulation and fouling, and on a factorial experimental optimisation of these variables. The model was implemented in the design and construction of a pilot plant IMBR, which was evaluated on both mineral suspensions and a biological suspension (activated sludge). Overall, the evaluations indicated that the IMBR module design produced by this project was technically adequate and competent for IMBR applications. There is a large potential for the application of these types of modules, both in water and wastewater treatment, and this project was a first step in providing a simple and robust immersed filtration system for potable water supply and wastewater remediation and filtration.

Cost: R990 000
Term: 2002 - 2008

The removal of reactive dyes from dye liquor using activated carbon for the reuse of salt, water and energy
University of KwaZulu-Natal (Department of Chemical Engineering)
No. 1542

Dyeing using reactive dyes requires electrolytes (up to 80 g/l) and produces a coloured effluent. The water consumption ranges from 30 to 150L effluent/kg fabric. The dye and salts are 5 times more concentrated at source. In batch equilibrium tests using activated carbon the mass of dye adsorbed increased as the temperature increased and at 20 to 100°C ranged from 2.096 to 78.16 (mg dye/g carbon) / (mg dye/l) for the shades investigated. In continuous tests the adsorptive capacities ranged from 20 to 39 mg dye/g carbon. Colour removal of 100%, salt recovery of 94 to 97% and energy savings of 17 to 32% were achieved. Regeneration using 3 bed volumes of sodium hydroxide was successful for 4 cycles; thereafter the capacity reduced. Dye auxiliaries were thought to irreversibly adsorb to the carbon. Dyeing with reduced auxiliaries needs to be investigated to make this process feasible.

Cost: R272 600
Term: 2004 - 2008

Industrial wastewater remediation via wet air oxidation using immobilised transition metal catalysts

University of the Western Cape (Department of Chemistry)

No. 1543

This project set out to develop catalyst systems with improved activity for use in catalytic wet air oxidation. The approach followed was to immobilise known homogeneous catalysts onto suitable supports. This allows for a way to separate the catalyst from the reaction mixture after the reaction, which is not possible when using homogeneous catalysts which are totally soluble in the reaction medium. The researchers employed 2 immobilisation approaches viz. immobilisation on siliceous supports and immobilisation on dendrimers (highly branched macromolecules). They successfully developed a methodology to anchor salicylaldimine complexes of copper, cobalt and nickel onto the surface of both MCM-41 and Davisil 710 supports. They also developed a synthetic methodology to prepare a range of new salicylaldimine-modified dendrimers to which they successfully complexed transition metals. The efficiency of the immobilised catalysts to oxidize phenol was compared with that of model homogeneous catalysts over a range of pH values. The best catalyst systems were then employed in the remediation of wastewaters from 4 local industries. The silica-immobilised catalysts, especially the MCM-41 systems, performed slightly better than the dendrimer-based catalysts. In all cases the copper-based catalysts were the most effective. Aqueous effluents from the chemical and related industries contain various organic pollutants which are toxic and refractory and occur in concentrations too low for economical recovery but too high for conventional biological treatment. This project aims to investigate and develop catalytic wet air oxidation as a technology for treating such effluents.

Cost: R600 000

Term: 2004 - 2008

Investigation and development of the biotechnology of sulphur biofilms in the beneficiation and treatment of wastewaters

Rhodes University

No. 1545

The development of appropriate technology to oxidise sulphides to elemental sulphur, in order to close the loop in the biological removal of sulphates from acid mine drainage (AMD) and industrial water, remains an obstacle in the commercialisation of the biological removal processes where South Africa has developed a leading edge. Advanced techniques were used to study floating sulphur biofilm structures that developed in a Linear Flow Channel Reactor (LFCR), and to develop a descriptive model integrating the various processes occurring in the floating sulphur biofilm. The LFCR showed potential as a basic unit operation for sulphide removal from AMD. An average sulphide removal of 88%, and sulphur recovery of 66%, was obtained for an 8-Channel LFCR. Further studies led to the development of the Floating Sulphur Biofilm Reactor, which provided for a sump for biofilm accumulation and also investigated surface skimming as a possible improvement over biofilm settling as the sulphur recovery harvesting mechanism. A 400-day operating study achieved an average sulphide removal of 65% and a sulphur recovery of 56%. Substantial performance improvement could be achieved with further optimisation studies.

Cost: R924 810

Term: 2004 - 2008

Development of sustainable low-cost management for saline sewage and saline mine drainage wastewaters using integrated algal ponding systems

Rhodes University (Environmental Biotechnology Research Unit)

No. 1621

Based on recommendations of the 'Salinity, Sanitation and Sustainability' study, this study investigated 'Biotechnology of Saline Wastewater Treatment' culminating in the current 2-volume report series. Volume 1 deals with the evaluation of the ASPAM system at pilot-scale at the Environmental Biotechnology Research Unit (EBRU) at Rhodes University (Grahamstown) using synthetic wastewater feed. The operation of the anaerobic unit of the system functioned well, producing sulphide through the sulphate reduction reaction process. Evidence of elemental sulphur in the settled sludge suggests that this may be where the residual sulphur is located. The metal removal studies reported here demonstrated not only the removal of metals in a synthetic influent stream but showed that metal hydroxide precipitates may be used to remove sulphides from the final stream of a biological acid mine drainage (AMD) treatment operation. This study showed that the basic concept of using algal ponding systems, in general, and the IAPS design in particular, as a process design basis for the extensive, and possibly low-cost, treatment of mine drainage wastewaters, has been demonstrated. The second part of **Project No. K5/1621** investigated the use of chloride saline wastewaters for the reticulation and treatment of domestic and industrial effluents. A range of saline-adapted culture inocula was sourced to initiate the study. Results of the pilot-scale study obtained thus far suggest that the saline IAPS has the capacity to effectively treat domestic wastewater reticulated in either seawater or possibly other brackish water sources of similar salinity, and to be able to meet discharge standards which are currently required for receiving freshwaters. However, further investigations will need to be done to understand floc formation and algal biomass settling.

Cost: R1 473 861

Term: 2005 - 2007

Cellulose fermentation products as energy source for biological sulphate reduction

CSIR (Natural Resources and the Environment)

No. 1728

Biological sulphate removal processes like BioSURE™ are well documented for the treatment of acid mine drainage (AMD) wastewater. One of the limiting steps of the process is the easy availability of volatile fatty acids (VFA) for use by sulphate-reducing bacteria (SRB). The objectives of this study were to: investigate if rumen inoculum (RI) could degrade grass cellulose to volatile fatty acids at ambient temperature for use by sulphate-reducing bacteria; study the impact of indigenous grass micro flora on the biodegradation of grass to VFAs; and study the diversity of the microbial communities in sulphate-reducing bioreactors using t-RFLP technique. These effects were studied in batch and continuous lab-scale hybrid reactors using synthetic and pre-treated AMD wastewater. The overall results from the batch to semi-continuous operated reactors showed that grass can be degraded by RI to VFAs, which can be used as carbon and energy sources for biological sulphate removal. The findings showed that RI could be adapted to ferment grass cellulose at 25°C with high sulphate removal efficiencies. Optimal

results were achieved in a hybrid reactor having a microbial profile consisting of SRB immobilised at the bottom on ceramic rings and RI immobilised at the top on the grass pieces that were being fed to the reactor. At a hydraulic retention time of 2.4 days, the average sulphate removal efficiency was 82% and 92% with synthetic and pre-treated AMD wastewater, respectively. Investigations showed that the indigenous microflora on the grass cuttings did not affect biological sulphate removal negatively. These findings add to the body of knowledge on the types of substrate that can be used to feed sulphate-reducing bacteria in the BioSURE™ and other associated biological sulphate removal processes.

Cost: R350 000
Term: 2007 - 2008

Reactor design for metal precipitation in mine-water treatment

University of Cape Town (Department of Chemical Engineering)
No. 1729

The biological sulphate reduction process provides for the precipitation of low solubility metal sulphides. This project hypothesised that it is preferable to produce a separate, concentrated metal salt precipitate rather than producing a metal-rich biological sludge as part of a process design. It investigated the fundamental mechanisms of the process in order to define the operating conditions that would lead to effective metal precipitation and separation of metal sulphides from solution. The investigation showed that although metal sulphides are highly insoluble, and thus theoretically able to remove metals and sulphides to very low levels, in practical terms the particle characteristics are extremely difficult to control. Even with a mass transfer limitation introduced by using a gaseous source of sulphide, the super-saturation generated is many orders of magnitude higher than that required for controlled particle characteristics and some other method of particle control would be necessary, in order to achieve the aim of not only effective metal precipitation but also separation from solution.

Cost: R197 300
Term: 2007 - 2008

THRUST 5: SANITATION, HEALTH AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

A guideline document for the implementation of sanitation, health and hygiene education (HHE) programmes in informal settlements

Nemai Consulting
No. 1656

The need for this research study was largely informed by the outcomes of the Naidoo et al. (2007) research study, 'The Effectiveness of Sanitation Education and Awareness Programmes in Informal Areas'. Rapid urbanisation in South Africa has resulted in the mushrooming of numerous informal settlements; however, the provision of services, especially sanitation services, has not kept pace. According to the National Sanitation Task Team most water and sanitation projects carried out by local authorities

have lacked significantly in the aspect of health and hygiene awareness. National and international experience has shown that the most successful sanitation initiatives have been those in which emphasis was placed on generating a high level of health and hygiene awareness rather than producing a large number of latrines. In addition, hygiene education programmes lay the foundation for an integrated approach to the provision of a wider set of environmental services. The benefits of effective and sustainable hygiene education programmes in informal settlements are numerous and include reduced infant mortality from diarrhoea, reduced environmental pollution, reduced health care costs, improved conditions of living, reduced operations and maintenance, etc. Hygiene education programmes are among the most cost-effective ways of lowering health costs, especially in high density settlements where residents are at greater risk to diseases related to poor sanitation. The study has determined that hygiene education programmes should be seen as an integral component of the functions provided by the Water Service Authority (WSA). As such, hygiene education can no longer be linked to only new sanitation infrastructure programmes. Instead, hygiene education should be a continuous function, like operations and maintenance, which is an ongoing function of local government. This approach will ensure that the message of good hygiene practice is continuously reinforced and the approach is supported by existing policy and legislation.

Cost: R570 000
Term: 2006 - 2008

Programme 2: Peri-urban sanitation research

Effective demand for alternative sanitation options in peri-urban settlements

Sigodi Marah Martin (Pty.) Ltd.
No. 1664

The level and quality of the services that communities are to receive must be discussed with, and accepted by, the community members. Quite important also are the economic considerations of these principles, namely that services must be provided economically and efficiently in order to give citizens the maximum value for money. Experts have long noted the importance of determining the 'effective demand' for services such as sanitation as expressed by the willingness of users to pay for these services. Too often the solutions proposed are inappropriate in terms of what the people want. As a result sanitary facilities are misused, badly maintained or even vandalised. If they are too expensive, the bills will not be paid which may give rise to the discontinuation of services and consequently to riots and/or violence. If the solutions do not meet the social norms, they will not be used. Finding the right solution is therefore fundamental in our quest for sustainability. Through the use of the SHAPE model developed through this research, it was possible to show that peri-urban residents eagerly preferred waterborne sewerage systems, but when integrated affordability considerations started to play a part, about 30% of the participants chose to accept on-site sanitation options. Further, affordability affects choice, but there is not close correlation between incomes and sanitation options chosen by the inhabitants of dense settlements. Whatever the reason may be, it proves that policies stipulating only certain sanitation options when new housing schemes are built are restrictive and not in line with the Batho Pele principles. The conclusion was drawn that many peri-urban residents are willing to accept

smaller houses in exchange for higher levels of water and sanitation services in their homes.

Cost: R630 000
Term: 2007 - 2008

Current Projects

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues - Water services

Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas

CSIR

No. 1610

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and proven, which would then allow piloting and implementation to be much more attractive. The concepts will contribute to wider participation of small-scale entrepreneurs in the management of water services.

Estimated cost: R600 000
Expected term: 2005 - 2009

Review of technology used in strategic asset management: existing and future needs

Africon

No. 1785

The past few years have seen significant advances in information technology such as software and hardware tools for use by the water industry. The aim of this research is to undertake a review of such technologies available to the water industry that are particularly related to the protection of the assets commonly found in the industry. Furthermore, the proposed review will consider the development of technologies that could be of advantage to the industry now and in the future, and which facilitate practice in different countries to enable technological benchmarking. The review will provide a tool whereby utilities could assess whether they are using the latest appropriate technology.

Estimated cost: R500 000
Expected term: 2007 - 2009

Development of an asset management toolkit

WRP

No. 1786

A key element for ensuring greater understanding of Strategic Asset Management (SAM) and its needs is a toolbox of advocacy and awareness materials targeting customers, officials and policy makers. This element has been identified as a priority action which has received little attention in many international initiatives, and which has as a result led to poor uptake. It is therefore of key importance that the linkages of SAM are

made to the daily operations of water services, maintenance, planning and strategic decision making. Thus it became imperative to develop a user-friendly multi-media tool for asset management that can be used as a guide and reference point for water suppliers, water managers, and various government organisations who are involved with water delivery in South Africa. The objective is to create different modules which enable various users to adopt the concepts of SAM. The tool will also serve as a training aid. The tool provides guidance to the user, through a multi-media platform, on how to get started and should provide sufficient information on the processes involved with asset management and how it should be implemented.

Estimated cost: R700 000
Expected term: 2007 - 2009

Programme 3: Innovative management arrangements – Rural water supply

Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector

Council for Geoscience

No. 1612

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made? This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralisation of services. Are these new arrangements supporting gender mainstreaming?

Estimated cost: R600 000
Expected term: 2005 - 2009

Productive use of domestic water for sustainable livelihoods

Nemai Consulting

No. 1666

Poor communities in both rural and urban areas use water for various purposes other than merely domestic use. The source of this supply can vary from traditional sources to improved water supplies, and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor in these additional requirements of water for poor communities to be able to sustain their livelihoods. Further, the general approach and thinking about productive uses is limited to small-scale agriculture; however, in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities, and also what levels of supply will be adequate for this purpose. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000
Expected term: 2006 - 2009

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities

Cape Peninsula University of Technology
No. 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services. Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty-alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324
Expected term: 2007 - 2009

Programme 4: Regulation of water services

Review of regulatory aspects of the water services sector African Centre for Water Research **No. 1667**

The changing water services institutional and legislative environment in South Africa has indicated the need for a strong and competent regulatory component to oversee the activities of the sector, such that objectives of sustainability, equity and efficiency are achieved and maintained. There have been many debates and discussions on this topic, as to whether the regulatory function should be an independent function or whether the sector can afford a regulatory function and who will finance such an initiative, e.g. DWAF has commissioned a number of studies in this regard. However, the subject area is very new to the sector and there is a great deal of information required to support decision making and input is required to support this regulatory function. The area also poses many challenges in its implementation. The study aims to support and build on national initiatives to find optimum models and mechanisms for effective regulation of the water services sector. The study will cover:

- Review of international models for water services sector regulation and highlight pros and cons of the different regulatory models
- Assessment of institutional and human capacity required to implement sector regulation
- Evaluation of the cost implication of sector regulation on municipalities
- Exploration of the feasibility of using incentives to regulate the water services sector

- Investigation of international best practice on proper regulation, identifying institutional, financial and operating procedures of relevance to South Africa
- Investigation and evaluation of case studies of independent regulation and central regulation, capturing lessons and experiences of relevance to the South African situation
- Investigation of water sector and consumer opinion on independent versus central regulation and aspects that should be addressed
- Determination of the scope of water services regulation and the linkage/integration with water resource management
- Identification of the capacity and competency requirements to facilitate regulation across the sector
- Evaluation of the cost implications of water sector regulation and its impact on tariffs/chain of costs
- Exploration of the feasibility of using incentives to regulate the water services sector

Estimated cost: R800 000
Expected term: 2006 - 2009

Development of a framework and model to regulate the competencies and training of managers and technicians in the provision of water services University of the Witwatersrand **No. 1715**

Currently there is a lack of an understanding of the appropriate generic approaches to qualifications, competence and skills in a technical sector such as water services. Reviewing the water services and related (municipal, health, construction, electricity) legislation and regulations, it is evident that there is a huge gap in identifying current institutional arrangements for regulating qualifications, competencies, training and development. Furthermore, this is compounded by a lack of a conceptual framework and model for the qualifications competencies and skills required for effective provision of water services. This study aims, on the basis of engagement with stakeholders, to develop an appropriate framework for competencies and skills in water services. It will develop an understanding of the specific qualifications, competencies and skills that are required for the effective provision of water services in South Africa. It will also clarify options and propose mechanisms that can be used to ensure that necessary qualifications, competencies and skills are available to all water services authorities and providers.

Estimated cost: R350 000
Expected term: 2007 - 2009

Programme 5: Impact of water and sanitation intervention

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa Tshwane University of Technology **No. 1700**

Over the years, the government has spent billions of rand to meet the backlogs in water supply and sanitation services in South Africa, and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a

number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental).

Estimated cost: R1 200 000
Expected term: 2006 - 2009

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Evaluating the potential for upgrading existing SA filtration plants to high-rate filters

Umgeni Water

No. 1395

International experience indicates that gravity sand filters can be operated at filtration rates of up to 30 m/hr. Standard practice in South Africa has been to design and operate filters at filtration rates of between 7 and 10 m/hr. These are conservative filtration rates and are based on historical English and French design criteria. The maximum filtration rate achievable in a filter is determined by its hydraulic design. However, the maximum rate which can be achieved before deterioration of filtrate quality or unacceptably short run times occur depends on the floc strength and filter media design (size and depth). High-rate filtration typically requires deeper beds and coarser media sizes than conventional rapid filtration and filter aid is often required to meet filtrate turbidity standards. However, in some cases it is found that existing filters operating at conventional rates can tolerate higher rates without any upgrades or changes in chemical pre-treatment. Sand filters contribute a substantial part of the total capital costs of water treatment plants. Upgrading existing filters to high-rate filtration, as opposed to building new filters, could potentially minimise or totally eliminate the need for capital expenditure on upgrading existing plant capacity. This in turn would have a direct impact on the water tariff being paid by the consumer. Once the maximum feasible filtration rate for various filter designs is determined, the potential for, and costs of, upgrading existing conventional filters to high-rate filters can be assessed.

Estimated cost: R208 000
Expected term: 2002 - 2009

Biological filtration of iron and manganese from groundwater

Umgeni Water

No. 1526

The project aims to develop criteria for the design of biological filtration systems that will remove iron and manganese from groundwater in rural areas in an economical and sustainable fashion. The effectiveness of such systems will further be demonstrated by the operation of a small water treatment system in a rural area in KwaZulu-Natal.

Estimated cost: R750 000
Expected term: 2004 - 2009

Development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply

University of Stellenbosch

No. 1527

The project proposes to further develop a filter with floating plastic media for the supply of water for rural communities. Performance of the filter both on its own, and as a pretreatment system for ultrafiltration membranes, will be evaluated and the operability of the system will be compared to that of a conventional coagulation, sedimentation and sand filtration plant. This system should be a more efficient and cost-effective alternative to sand filters if the research is successfully executed. It is also simple to operate and requires less head for back-washing than conventional sand filters. A successful project can ensure that more small communities will have the benefit of membrane-treated potable water supply.

Estimated cost: R914 000
Expected term: 2004 - 2009

The defouling of membranes by moving magnetic dipole polymer beads, containing nano-magnetic particles, in a scouring motion across the membrane using external magnetic fields

University of Stellenbosch

No. 1592

Fouling of membranes remains the main problem preventing the large-scale and economic use of membranes in more applications internationally. Various chemical, hydraulic and ultrasonic membrane-defouling methods have been investigated, with varying success. This project aims to investigate nano-technology for the *in situ* defouling of membranes. Nano-magnets will be incorporated into small polymer beads and the magnetic fields in all of the nano-magnets inside the beads will be aligned. Movement of the polymer beads on the surface of the membrane will then be induced in order to scour the surface, which will hopefully clean and prevent fouling on the membrane surface. The resulting system will be evaluated on a typical coloured surface water purification application.

Estimated cost: R794 000
Expected term: 2005 - 2009

Development of a durable and reliable wave-energy reverse osmosis system

The Impact Free Water Group

No. 1716

Small, rural communities living at or close to the sea along the coastline of the country rarely have a good and reliable supply of potable water – nor do they generally have electricity. The project aims to further develop an innovative reverse osmosis system which utilises ocean wave power in order to produce the elevated pressures required in the desalination of seawater to potable standards. A few prototypes will be constructed to evaluate the effect of various wave parameters on the system performance and improve the system into a practical, working technology.

Estimated cost: R650 000
Expected term: 2007 - 2010

Two-stage reclamation of filter backwash water at treatment plants using source water with high algal content

University of Pretoria

No. 1717

Backwash water is wasted rather than sent back to headwaters due to concerns over the accumulation of organic compounds released from algae and cyanobacteria, a source of disinfection by-products (DBPs) during chlorination. Additionally, backwash water has been demonstrated to be difficult to settle. In this project, a treatment technology for efficient solids separation and elimination of organic compounds before recycling of backwash water will be investigated. A system based on advanced oxidation semiconductor photocatalysis in the fixed-phase will be developed and will be tested against a method using ultrasonic cavitation to degrade the organic compounds in the backwash. Current cost-effective membrane separation techniques will be used to complement the photocatalytic or ultrasonication methods.

Estimated cost: R830 000
Expected term: 2007 - 2009

Programme 2: Water treatment for rural communities

Development of appropriate brine electrolyzers for disinfection of rural water supplies

University of the Western Cape (Department of Chemistry)

No. 1442

Chlorine disinfection is required for rural water treatment since it has residual disinfecting powers after water has been carried into the homes. This project will further develop a novel system for the generation of chlorine from common table salt. The unit to be developed will not produce toxic chlorates as side-products – as can easily happen when employing currently available salt chlorinators. The unit will further allow pH control of the dosed chlorine liquid, allowing much more efficient disinfection and is a main advantage over the current systems.

Estimated cost: R480 000
Expected term: 2003 - 2009

The development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters

Durban Institute of Technology

No. 1598

This project will focus on developing the local woven-fibre immersed membrane micro-filter into systems for the pre-treatment of high turbidity surface waters as well as the gravity-fed treatment of water in remote regions. The project will complement and enhance the applicability of other local technological developments in rural water treatment, e.g. the locally developed capillary ultrafiltration system. The project will develop a standard membrane pack for immersed microfiltration membrane applications. Different configurations and operating protocols will be evaluated so as to minimise fouling and maximise ease of cleaning. A simple, gravity-fed water treatment system for water provision in remote areas will be demonstrated.

Estimated cost: R765 000
Expected term: 2005 - 2009

Compliance of non-metropolitan South African potable water providers with accepted drinking water quality and management guidelines and norms

University of Fort Hare

No. 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers that are preventing compliance to these guidelines and norms, and communicate these solutions to the municipal management authorities. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000
Expected term: 2006 - 2009

A management information tool for the efficient operation and maintenance of small water treatment plants

Chris Swartz Water Utilisation Engineers

No. 1718

The performance of small (and also some medium-sized) water treatment plants in terms of the provision of a potable standard of drinking water to the end consumer is suspect. Studies have shown that the overall management of water provision is not as effective as it should be – with particular reference to plant operation and maintenance. One of these reasons is the lack of an adequate and efficient management information system. The project, therefore, aims to develop and compile a practical and user-friendly management information tool to facilitate the efficient operation and maintenance of small water treatment plants under the jurisdiction of a water services authority.

Estimated cost: R800 000
Expected term: 2007 - 2009

Programme 3: Drinking water quality

New detection methods for EDCs

University of Stellenbosch

No. 1534

The project will aim to produce and test an endocrine-disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand-binding domain (LBDER) into a suitable yeast (*Pichia pastoris*) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotinylation of LBDER and preparation of biotinylated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialised polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection

Estimated cost: R647 500
Expected term: 2004 - 2009

Investigation of the distribution and diversity of South African toxic freshwater cyanobacteria with special reference to analysis of the neurotoxin BMAA and molecular genetic methods for microcystin screening

Nelson Mandela Metropolitan University

No. 1719

There is a lack of standardised methods and facilities for analysis of toxic cyanobacteria and quantification of cyanobacterial toxins in South Africa. Commercial primer sets for such screening will soon be available, but their suitability or applicability to South African isolates is totally unknown. No comprehensive analysis of wild strains has been attempted using any molecular technique. The application of appropriate techniques will yield information on the relationship between South African and other strains and information on the distribution and spread of strains within South Africa. Screening studies by various laboratories have indicated that all known species of cyanobacteria can produce BMAA. This has obvious implications for the human/health-related chronic exposure to BMAA in water, where cyanobacterial aggressions occur. The aim of the study will therefore be to investigate the distribution and diversity of South African freshwater toxic cyanobacteria from a phylogenetic/phylogeographic perspective with specific reference to toxicity for known toxins and including the establishment of analytical procedures for the novel toxin BMAA.

Estimated cost: R1 000 000
Expected term: 2007 - 2009

Situation and gap analysis of water quality testing in South Africa

Jeffares & Green

No. 1720

The irregularities and occasional health risks currently experienced in water quality throughout South Africa highlights the urgent need for the introduction of an accepted and practical water quality testing standard to be employed by all laboratories in South Africa and enforced at national regulatory level. In order to produce such a standard, it is imperative that a thorough investigation be carried out into existing conditions, problems and capacities of all water-testing laboratories in South Africa. The assessment of the current status of testing laboratories will therefore play an important role in establishing what action needs to be taken to ensure acceptable water quality throughout South Africa. The overall aim of the project will be to develop a strategy for a national programme that will address the needs of the water quality assessment in South Africa.

Expected cost: R800 000
Estimated term: 2007 - 2009

Programme 4: Water distribution and distribution systems

Grouted lining systems for the renovation of old steel pipelines and the design of new pipelines

Rand Water

No. 1448

Steel pipes are used extensively in South Africa and need to be protected against corrosion, hence the need for internal linings and external coatings. In pressure pipes there are many problems associated with the use of grouted-viscous-elastic linings at joints, bends and fittings, etc. This study aims, through laboratory trials and investigations, to provide solutions to this unresolved problem experienced by water suppliers, which costs them large sums of money due to failures.

Estimated cost: R736 300
Expected term: 2003 - 2009

Inverse transients to determine deficiencies in pipelines

University of Pretoria

No. 1721

A major shortcoming in the optimal utilisation of water distribution systems is the uncertainty about the physical status and the identification of operational deficiencies. In a WRC study (**Report No. 1177/1/04**) the influence of localised air pockets on the hydraulic capacity of pipelines was shown. Another major problem that negates the optimal distribution of water is the presence of unidentified leakages in the systems. Inverse transients can be used to determine the location and magnitude of leaks and air pockets. The technique was already tested in laboratory conditions, indicating the advantage of this technique. The procedure could be applied without isolating the section to be investigated (no interruption of the service). The objective now is to test and develop this further and provide assistance in the implementation of this procedure. The value of the development of this technique is that a non-destructive, non-intrusive and non-intermittent procedure will be available to investigate the status of water distribution systems.

Expected cost: R530 000
Estimated term: 2007 - 2010

Guidelines on how to determine and reduce apparent losses

Conward Consulting

No. 1722

Non-revenue demand is one of the key performance criteria of water services providers (WSP) in South Africa. The current level of non-revenue demand is estimated at more than 30% of the total water supplied. Non-revenue demand can be divided into 2 main categories: real losses and apparent losses. Before WSP can begin to address non-revenue demand, they need to understand the extent of real losses versus apparent losses. Currently, there is no common approach or guidelines on how to estimate apparent losses and this is widely considered as one of the main constraints in dealing with the overall issue of non-revenue demand. The development of guidelines on how to accurately determine apparent losses will provide a key breakthrough for WSP to deal with non-revenue demand and for the regulator in setting benchmarks and targets.

Expected cost: R400 000
Estimated term: 2007 - 2009

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

To investigate the performance and kinetics of biological nitrogen and phosphorus removal with ultrafiltration membranes for solid-liquid separation

University Cape Town

No. 1537

This project is a follow-on to **WRC Consultancy No. 514**, which was specifically commissioned as a 1-year feasibility study in 2003 to test whether nutrient removal could be accomplished in this type of robust, low-cost sewage treatment system which is independent of the sludge bulking problems which in turn often compromise the effective performance of activated sludge processes. The low pressure-drop ultrafiltration (UF) membranes being used are supplied and funded for this purpose by the suppliers (MembraTech, UK). Recent information indicates that the process is operating satisfactorily. On the basis that the preliminary promise has been delivered, a fuller investigation is therefore required to provide a rigorous and definitive examination of this type of system. A parallel 'next step', which is already in hand, will be to investigate whether UF membranes of similar or superior performance can be locally sourced, and/or designed and manufactured.

Estimated cost: R1 132 400

Expected term: 2004 - 2009

Evaluation of a South African clinoptilolite for ammonia-nitrogen removal from secondary sewage effluent for pollution control

University of Pretoria (Department of Chemical Engineering)

No. 1658

Ammonia discharged into the water environment accelerates eutrophication of dams and depletes dissolved oxygen in receiving waters, and, in its undissociated form, is also toxic to fish even at low concentrations (0.5 mg N/l). The current discharge limit for ammonia-nitrogen (NH₃-N) in treated sewage effluent is 10 mg/l (likely to be reduced to 6 mg/l in the near future). At many wastewater works in South Africa, particularly in winter when biological activity slows down because of lower temperatures, it is difficult to produce treated effluent containing less than 10 mg/l NH₃-N by the usual biological nitrification process, with consequent negative environmental and ecological impacts. As an alternative or stand-by process, absorption of NH₃-N by clinoptilolites (naturally occurring zeolites) has potential as an effective low-cost means for final polishing of treated sewage to reduce NH₃-N to acceptable levels. Previous work in this regard has been carried out using imported clinoptilolites, with cost and foreign exchange implications, and knowledge is needed in South Africa on the performance of the locally-mined clinoptilolite for removing NH₃-N from treated sewage. The aims of this project are to determine the performance of local clinoptilolite for removing NH₃-N from treated sewage effluent on laboratory- and pilot-scale, to determine the efficiency of ammonia recovery from the spent regenerant, to develop appropriate process design criteria and costs, and to develop an operational and maintenance manual for the process.

Estimated cost: R317 000

Expected term: 2006 - 2009

Energy from waste

University of Cape Town

No. 1732

The energy shortages which are facing the country suggest a need to broaden the suite of energy supply options. During this study, trends and developments on the subject of energy from domestic and industrial wastewater and the residues will be reviewed and consolidated. It will provide a first-order estimate of the quantity of domestic and industrial waste available and the potential contribution this can make to the national energy needs. It will document sustainable methods and technologies for generating energy from domestic and industrial wastewater. The project team will identify issues of concern, challenges, and research needs in this area which are relevant to South Africa. They will also highlight activities that are already taking place by other role players. This information will be used to develop guidelines for the approach to be adopted by the WRC with other role players to address the issues/needs identified.

Estimated cost: R420 000

Expected term: 2007 - 2009

Programme 2: Application of appropriate technologies and tools

Practical implementation of external nitrification in biological nutrient removal activated sludge systems

University of Cape Town (Division of Water Quality Engineering)

No. 1262

In this project, full-scale trials are being run on external nitrification in biological nutrient removal activated sludge (BNRAS) systems to test the fundamental, laboratory-scale and economic studies done to date by this research group, which have shown that external nitrification in BNRAS systems can be a more efficient and cheaper (20 to 25% lower) alternative compared to other BNRAS systems covering both green-fields and retro-fitting situations. In this collaborative exercise between UCT, the Cape Metropolitan Council, and Water & Sanitation Services SA (Pty.) Ltd. (the local agent for CIRSEE/Suez Lyonnaise-des-Eaux), the cash contributions by others (excluding contributions in kind) amount to about 40% of the total budget.

Estimated cost: R1 280 000

Expected term: 2001 - 2009

A status quo assessment of the effectiveness of wastewater pond systems for containment and treatment of wastewaters, and the development of practical operating guidelines

Emanti Management (Pty.) Ltd.

No. 1657

In various parts of South Africa, algal ponding systems constitute a significant proportion of the installed capacity for sewage treatment and have generally been effective in limiting environmental pollution and associated health impacts. In a preliminary study of waste-stabilisation ponds recently commissioned by the Free State DWAF office, the current status of waste-stabilisation ponds in the Free State was documented. Some of the key findings from the study were that the pond systems were generally well-designed and showed good operational performance, but scored very poorly in terms of maintenance, safety and supervision/management. A simple strategic decision-support tool was accordingly developed to guide future interventions. Considering that the above situation is not only limited to the Free State but is commonplace throughout the country, there is a need to document the occurrence of

pond systems throughout South Africa, investigate their current operational status and practices followed, identify in what instances the technology is applicable or whether alternative technologies should be considered, identify how operation and maintenance (O&M) of these systems can be improved (through capacity building, technical guidelines, monitoring, etc.), and assess the potential for reusing treated effluent from pond systems. These aims are addressed in this project, using the Free State and the Eastern Cape as case-study areas. Guidelines will be prepared highlighting O&M procedures, common issues of concern, best practice techniques, criteria for selection of treated effluent for reuse purposes and criteria for selection of alternative technologies (if applicable). The existing MS Excel-based strategic support tool will be updated and further developed to a web-based format, allowing easy access to pond system information for all relevant stakeholders.

Estimated cost: R700 000
Expected term: 2006 - 2009

Support to EU - EUROMBRA project: Development of an anaerobic membrane bioreactor

University of KwaZulu-Natal (Pollution Research Group)
No. 1661

The highest development priority in the South African water sector at present is the provision of affordable but safe community wastewater treatment (MDGs, etc.) and particularly also to provide a barrier against the transmission of water-borne diseases in the context of a population which is immunologically-challenged and under-nourished. Aerobic treatment systems, other than algal ponding systems (which however have a land footprint not suitable for urban or peri-urban situations) require a significant and probably unsustainable energy and/or chemical input to be effective in terms of the treated water quality achieved. Anaerobic systems have a significantly lower resource requirement, but to date have not been able to produce the microbiological water quality required for community health safety and concomitant quality-of-life. This project targets this problem, using an innovative approach based on established anaerobic treatment technology enhanced by the use of membranes (which over the past few years have become sustainably affordable and increasingly robust in their performance, with the major and strategic benefit of providing a physical barrier to microbial passage). The research issues addressed are the basic system performance and the requirement to limit membrane fouling and/or to develop a membrane-cleaning regime that does not require external energy inputs. If successful, the system would have an immediate and major impact on the provision of low-cost and safe sanitation to a range of communities in South Africa. This project supports an EU programme, and the potential for roll-out to a wider base, e.g. SADC/Africa/the developing world, is thus strong.

Estimated cost: R693 280
Expected term: 2006 - 2009

Programme 3: Stormwater and sewerage systems

Stormwater ingress in South African sewer systems: Understanding the problem and dealing with it

Duzi-uMngeni Conservation Trust (DUCT)
No. 1731

A cost-effective way to reduce the burden on the sewer system would be to reduce domestic stormwater ingress into the sewers.

This study will investigate the extent to which stormwater ingress is overloading the sewage treatment plants in South Africa; investigate the causes of the stormwater ingress; identify legislation and local by-laws that can be used by municipal departments to prevent stormwater ingress; and develop and test a cost-effective education and inspection programme to reduce stormwater ingress to sewer systems using a case study. Using this case study, other municipalities could note the benefit and adopt similar approaches, if applicable.

Estimated cost: R334 250
Expected term: 2007 - 2009

Development of a South African guide for the design and operation of waterborne sewerage systems

University of Pretoria
No. 1744

Among the various sanitation options available, waterborne sanitation and its associated conventional sewerage system, or derivatives of such a system, still offers numerous advantages, especially in high-density settlements. A study of the methods used to treat the effluent arising from waterborne sewage has been completed and it is opportune to look at the reticulation systems themselves. With the growth in the economy, there will be growth in the residential and commercial developments in metros, cities and small towns. This will place greater demand on water services authorities to provide sanitation services. With new emerging authorities, lack of capacity and competency at a local level, the situation can escalate and be costly to the country. Presently, there is no dedicated guide in South Africa which addresses the design and operation of waterborne sanitation systems. Much of the information is scattered in publications such as the Red Book (CSIR) and the good practical experience gained over the years within municipalities. Thus, the objectives of the study are to consolidate technical knowledge, information and advancements (local and international) on all waterborne sanitation systems.

Estimated cost: R615 000
Expected term: 2007 - 2009

Programme 4: Wastewater sludge and faecal sludge management

Scale-up development of the Rhodes BioSURE™ Process for sewage sludge solubilisation and disposal

Rhodes University (Department of Biochemistry, Microbiology and Biotechnology)
No. 1336

The overall aim is to derive process design criteria for full-scale implementation of the Rhodes BioSURE™ Process for sewage sludge solubilisation. To achieve this, the demonstration-scale BioSURE™ plant established at Ancor Sewage Works (Springs) will be operated, monitored and optimised, and the facility will be extended to include sulphide bio-oxidation and sulphur recovery. A smaller pilot plant at Makana Sewage Works (Grahamstown) will be operated and monitored to study process variables in finer detail, to identify and investigate areas of sulphidogenic sewage sludge solubilisation that require further development for scale-up.

Estimated cost: R1 510 900
Expected term: 2002 - 2009

Influence of sludge conditioners on the soil-conditioning properties of sewage sludge

University of Pretoria

No. 1540

This project aims to determine the influence of sludge conditioners used during sewage treatment processes on the soil conditioning properties of sewage sludge.

Estimated cost: R101 000
Expected term: 2004 - 2009

Materials mass balances modelling of wastewater treatment systems

University of Cape Town (Department of Civil Engineering)

No. 1620

This project follows on WRC **Project No. K5/1338** in which the novel and far-reaching integrated chemical/physical/biological process modelling approach for biological waste treatment processes was developed and confirmed. In the new project, the overall aims are:

- To develop a mass-balance-based steady state model for wastewater treatment plants (WWTP) for preliminary design and operations overview
- To develop a kinetic simulation model that integrates the mixed weak-acid/base chemical, physical and biological processes for detailed design, dynamic simulation, process operation and optimization
- These two aims represent high-end long-term objectives that require closing of several important knowledge gaps with experimental research at laboratory and full-scale supported by theoretical modelling. The project has far-reaching implications with significant spin-off benefits for other WRC research projects, as already demonstrated in the previous **Project No. 1338** which is delivering modelling of activated sludge, algal ponding, and methanogenic and sulphidogenic anaerobic digestion processes.

Estimated cost: R720 000
Expected term: 2005 - 2009

Development of the South African wastewater sludge disposal guidelines dealing with land and ocean disposal, beneficial use, use in commercial products and thermal treatment

Zitholele Consulting (Pty.) Ltd.

No. 1622

Soon after the publication of the 1st edition of the guidelines on the **Permissible Utilisation and Disposal of Sewage Sludge** in 1997, the WRC embarked on a process to revise these guidelines. A research programme was initiated to characterise South African wastewater sludge and better understand sludge disposal practices in order to develop a local knowledge base and a better appreciation of the issues that should form the basis for a comprehensive revision of the 1997 Guidelines. An Addendum to the 1997 Guidelines was published in 2001 to clarify and elaborate on certain issues where this was required. A start was made on the development of the 2nd edition of the South African Sludge Guidelines in 2003. This initiative saw the publication of the first 2 volumes (a general overview document and guidelines for beneficial agricultural use) of the new guidelines in 2006.

The current project, which is being co-funded by DWAF, will complete the process and produce a further 3 documents, which will give guidance for:

- The non-beneficial disposal of wastewater sludge by employing options such as dedicated land disposal, landfills, lagoons and ocean discharge
- The beneficial use of wastewater sludge at high loading rates in agriculturally-related practices, such as mine tailing rehabilitation, nursery growth material and landfill capping
- The production of commercial products such as bricks, cement and fertilisers as well as thermal treatment of wastewater sludge

Estimated cost: R1 428 800
Expected term: 2005 - 2009

Guidelines for the utilisation and disposal of water treatment residues

Golder Associates Africa

No. 1723

WRC **Project No. 1148** found that the disposal of water treatment residues (WTR) to land could have positive effects. No local guidelines for land disposal exist at present. In order to determine what information is still required to develop such guidelines, a follow-on project (**No. 1601**) produced a scoping report on the development of guidelines for the land disposal of WTR. Although a number of knowledge gaps remain, this new study will develop guidelines based on the best current local and international information. The objective is to revisit these guidelines after 5 to 10 years of application and include actual field data and experience gained during this period. A national survey will determine the variation in the characteristics of different WTRs. The previous research and survey data will be used to develop guidelines that describe the requirements for the land disposal and agricultural use of WTR. A stakeholder consultation and scientific peer review process is planned to gain broad acceptance for the guidelines.

Estimated cost: R746 820
Expected term: 2007 - 2009

Sustainable and beneficial use of biosolids land application strategies: Quantifying nitrogen and phosphorus plant-soil mass balances

University of Pretoria

No. 1724

The recently-published **Guidelines for the Utilisation and Disposal of Wastewater Sludge** promotes the sustainable use of sewage sludge as a soil ameliorant and source of nutrients for crop production. However, limited research on the topic has been conducted under local conditions. This study will investigate aspects of the use of wastewater sludge on land, including high application rates. This will focus on N and P release from sludges and on soil-plant-water interactions with the released nutrients, in order to promote responsible sludge use and minimise groundwater pollution. Use will be made of laboratory, lysimeter and field experiments. Findings will be incorporated into a mechanistic daily time-step nutrient and water balance model to improve the management of sludges and effluents.

Estimated cost: R1 150 000
Expected term: 2007 - 2010

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 1: Quantification of water use and waste production

A first-order inventory of water use and waste production by the South African industrial, mining and power generation sectors

Arcus Gibb; University of Pretoria

No. 1547

The aim with this project is to compile a first-order inventory of the amount of water used and waste produced by the South African industrial, mining and power generation sectors, and to assess the impact these have on water quality. Information in this regard is required to judge whether the present investment in research has the right mix and to provide strategic direction to research initiatives. The investigation will make optimal use of existing information such as the NATSURV investigation that provides a benchmark for water use and waste production by major South African industries, the COMRO report on water use by gold-mines, a WRC report on water use by coal-mines, a CSIR report on national waste production and DWAF's Water Resource Strategy on water requirements by different sectors. The available information will where necessary be supplemented by targeted field investigations and compiled into a consolidated overview that presents the total picture. The data on water use and waste production will furthermore be interpreted for the effect they can be expected to have on receiving water quality. In order to ensure credibility of the findings, they will be verified through a workshop with practitioners.

Estimated cost: R600 000
Expected term: 2004 - 2009

A first-order assessment of the quantity and quality of non-point sources of pollution associated with the industrial, mining and power generation sectors

Pulles, Howard & de Lange

No. 1627

It is increasingly recognised that non-point source (NPS) pollution plays a major role in the degradation of water quality, specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore, increasingly accepted that it is not feasible to properly manage water quality without addressing the contribution from non-point sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. This project will determine at a scoping level, the quantity and quality of NPS pollution that originates from the mining, industrial and power generation sectors. This information will, *inter alia*, be used at a strategic level, to determine whether the present investment in research in this KSA, and more specifically the thrust on industrial and mine-water management, reflect the need in this regard.

Estimated cost: R1 000 000
Expected term: 2005 - 2009

Programme 2: Regulatory mechanisms to improve industrial and mine-water management

Valuing water for South African industries: A production function approach

CSIR (Natural Resources and the Environment)

No. 1366

The industrial sector in South Africa is one of the fastest-growing sectors and relies to varying degrees (ranging from wet to essentially dry industries) on water resources as an input to many production processes. Industrial water use currently comprises about 10% of the total water use in South Africa (WSAM, 2000) and is therefore a significant water-using (and effluent-generating) sector. Very little is, however, currently known about the responsiveness to water pricing within the industrial sector in South Africa, probably because of historically low pricing structures and the perception that industrial water use is better suited to engineering rather than economic analysis. International literature offers mixed results, with industrial price elasticities ranging from very inelastic to more elastic. In the context of the National Water Act and its emphasis on economic pricing, and the significance of industrial water use in South Africa, it is necessary to provide econometric tools to decision-makers. The project aims to quantify and characterise the role that water plays in various local industries and their responsiveness to price changes; and to develop a set of indicators and judgement criteria for policy-makers, decision-takers and other stakeholders to use economic analysis for appropriate water resource management. The project's overall aim is to determine the marginal value of industrial water in South Africa, in keeping with the National Water Act's objectives to price water correctly. The specific sub-goals are listed below:

- To assess the role that industries play in the overall water demand for South Africa, and to determine which industries are the most water-intensive industries and which industries are relatively 'dry'
- To determine price elasticities of demand for water for the respective industrial sectors within South Africa, and develop a set of indicators that can be used in existing models or to assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge

Estimated cost: R549 600
Expected term: 2002 - 2009

Geochemical sampling and analyses for environmental risk assessments using the Wits Basin as a case study

Pulles, Howard & de Lange

No. 1624

Each environmental risk assessment (ERA) study is faced with questions regarding the location, number, size and type of samples that need to be collected for a proper assessment. Answers to these questions are partially dependent on the predictions that need to be made, the available material and costs. This project will establish a methodology to guide users of an ERA process to quantify the uncertainty associated

with predicted mine drainage quality as a function of sample representivity. Existing mineralogical and geochemical data for the Wits Basin, that are available from previous studies, will be used to demonstrate the application of the methodology that will be developed.

Estimated cost: R562 000
Expected term: 2005 - 2009

Development of guidelines for urban metros to facilitate legal compliance with respect to industrial waste management

Nancy Oosthuizen Consulting
No. 1733

eThekweni Metro has recognised that better waste management practices should be achieved as ineffective waste management practices are impacting negatively on cities' water resources. This case study aims to develop a set of easy-to-interpret, laymen's guidelines aimed at industry, ports, and intermediate waste contractors to achieve legal compliance related to responsibly managing wastes to achieve legal compliance. The products will not only benefit eThekweni, but all large metros and coastal cities as well.

Estimated cost: R350 000
Expected term: 2007 - 2009

Protocol for quantitative assessment of industrial effluents for discharge permitting

University of KwaZulu-Natal
No. 1734

Local authorities manage industrial wastewater by:

- Using its wastewater treatment plants for remediation
- Issuing discharge permits with limits on discharge
- Charging a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system

An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of the WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000
Expected term: 2007 - 2011

Programme 3: Minimising the impact of waste on the water environment

Arsenate resistance in microbial communities developing in maturing FA-AMD solids

University of the Western Cape (Department of Microbiology)
No. 1655

The WRC and the mining industry are investigating the use of fly ash to neutralize AMD and produce useful by-products,

such as zeolites. The use of fly ash AMD substrate as backfill in underground mines is under consideration. However, the potential mobilisation of undesirable metals and other contaminants by microbial activity gives rise to concern. A recently-completed project (**No. 1549**) found that while microbial populations are slow to develop in the substrates, they are readily sustained once they are introduced. This project will continue with the current research and study specifically arsenate reactions, as proxy for other contaminants that are subject to redox reactions.

Estimated cost: R220 000
Expected term: 2006 - 2009

Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments

Pulles, Howard & de Lange
No. 1659

Defunct gold mines on the East and West Rand are rapidly filling up with contaminated water that will decant into the Vaal River system. Previous studies focused on either reducing inflow to the underground or on diverting decant water to preferred locations for treatment. This project will identify locations within the flooded basin where water quality is relatively good and which are also major recharge points (and therefore decant drivers). It is proposed to dewater the basins from these points. If found feasible, the extraction of water from such points, would serve as a source of water for Gauteng and at the same time reduce the magnitude of decant.

Estimated cost: R501 300
Expected term: 2006 - 2009

Refinement of the decision support system for metalliferous tailing disposal facilities

Golder Associates Africa
No. 1735

WRC **Project No. 1551** developed a first-order decision support system (DSS) for the sustainable design, operation and closure of metalliferous tailings disposal facilities as part of a long-term programme to deal with these facilities on a sustainable basis. This follow-on project will refine the first-order DSS by developing guidance and support to demonstrate that the environmental impacts on the surface stability and water aspects are acceptable and to identify new and promising technologies and approaches.

Estimated cost: R2 200 000
Expected term: 2007 - 2009

Consideration of the impact of classification and landfilling of hazardous waste

CSIR
No. 1736

The minimum requirements for general and hazardous waste have been in place for over a decade. A systematic assessment is needed to determine whether the desired groundwater protection has been achieved, particularly at sites that have received delisted wastes. The assumptions made in the delisting process (i.e. whether they are conservative or not) are tested

against field data from operational landfills. Further, the impact of the disposal of hazardous waste on leachate quality and landfill processes is required. This study aims to begin the process by considering the impact of selected delisted hazardous or industrial waste on a selection of landfill sites. The study includes an assessment of leachate quality from a selection of general waste landfill sites that receive hazardous wastes compared to those that do not, to validate the assumptions made in the delisting process and to determine to what extent a selected hazardous waste type impacts on leachate quality.

Estimated cost: R800 000
Expected term: 2007 - 2009

Programme 4: Minimising waste production

The introduction of cleaner production technologies in the mining industry

Digby Wells & Associates
No. 1553

While the mining industry has played a major role in the development of South Africa (and is still continuing to do so) it has also been identified as the largest producer of waste and as a major contributor to water quality degradation in many of our important catchments. It is recognised that the long-term solution to waste management is to minimise waste production and introduce cleaner production technologies. An analysis of the WRC's past and present project portfolio indicated that most of the research effort to address water and waste management in the mining industry was devoted to minimising the impact of waste on the environment, to improve our ability to predict and quantify effects, and to develop technologies to treat polluted waters. No projects devoted specifically to waste minimisation and cleaner production technologies were undertaken. Although cleaner production is an essential backdrop against which to do environmental management, and the mining industry has launched initiatives such as the mining, minerals and sustainable development project, it does not appear as if the industry has embraced cleaner production as yet. This project is aimed at introducing cleaner production to the mining industry and at entrenching its concepts where it is already being practised. For this purpose, multi-faceted initiatives will be undertaken to raise the awareness of the mining industry concerning the benefits and need for adopting cleaner production approaches. The project will start by assessing the level of awareness in the industry and identifying threats that could be alleviated by cleaner production technologies. Opportunities will be created to implement these and establish cleaner production forums (waste minimisation clubs) so that success stories can be generated which in turn can be used in an awareness campaign.

Estimated cost: R3 295 000
Expected term: 2004 - 2009

Development of a complete process integration framework for wastewater minimisation in multipurpose batch plants

University of Pretoria
No. 1625

The approach followed was to employ mathematical programming principles, where the overall chemical plant is mathematically modelled. The objective is to maximise profit while minimising effluent. The development of the model

was conducted while taking into account the current gaps in research and limitations of current methodologies so as to ensure that the overall methodology addressed the problems at hand. The mathematical model is based on mathematical programming principles using optimisation as an underlying framework. The main contribution of the project was to treat both scheduling and wastewater minimisation as optimisation problems within a unified framework, which indeed proved more appropriate and optimal than published methods. The final stage was the application of the developed mathematical technique to a pharmaceutical production facility. This was done in 3 steps. The 1st step involved the application of a single contaminant methodology to the operation. The 1st step gave insight into the operation and the data that was required. From the 1st step it was observed that product and wastewater compatibilities needed to be taken into account. Based on this the multiple contaminant wastewater minimisation methodology with a single storage vessel was applied to the industrial site. This formed the 2nd step of the application. During the application of the multiple contaminant model an important change came about in the sanitising method used. The chemical sanitising step was changed to a heat sanitising step. Based on this a final model was derived in the final step of the application of the methodologies. The final model schedules the production in such a manner as to maximise the amount of water that is reused, thus producing less effluent. The amount of water saved for each washout is dependent on the amount of water used for the sanitising step. The amount of water saved varies between 22% and 55%. The derived model finds practical application as it takes the current water usage into consideration. The output from the model was a production schedule, which shows the allocation of mixers to various products under the actual production requirements. Since water from the sanitising step goes to a central storage vessel, independent of the mixer, no extra pipe connections are needed to achieve water savings.

Estimated cost: R198 000
Expected term: 2005 - 2009

Cleaner production evaluation system and optimisation for metal finishing

Durban Institute of Technology
No. 1626

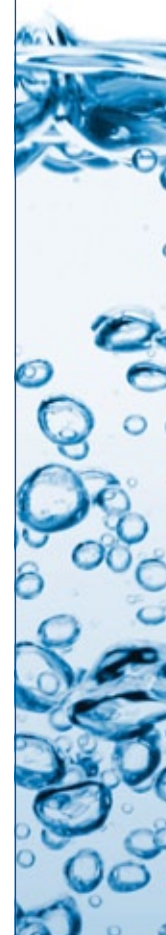
The metal-finishing industry is notorious for its polluting activities. Cleaner production audits to benchmark a company's operations and identify room for improvement, require a level of detailed information that is normally not recorded by smaller companies. This project aims to develop a tool that can be used to readily conduct a systematic environmental evaluation of electroplating plants and which will provide a comprehensive audit, with limited data, in a consistent way.

Estimated cost: R492 000
Expected term: 2005 - 2009

An investigation of innovative approaches to brine handling

Proxa
No. 1669

The problems associated with the management of inorganic waste products (sludges and brines), that are being produced as a result of water treatment and recycling, present a major stumbling block to improved wastewater management.



Available technologies are either prohibitively expensive or unsatisfactory because of the long-term liabilities and associated risks to water resources. This project will develop management solutions appropriate for the South African situation by assessing the current situation, establishing the present state of the art, developing a fundamental understanding of brine chemistry and the identification and proof-of-concept testing of promising innovative solutions. Promising solutions, which pass the proof-of-concept test, will be further evaluated in follow-on projects.

Estimated cost: R1 290 000
Expected term: 2006 - 2009

Programme 5: Improved ability to predict and quantify effects

Evaluation and validation of geochemical prediction techniques for underground coal-mines in the Witbank/Highveld region

Pulles, Howard & de Lange

No. 1249

The Witbank/Highveld coal-field in Mpumalanga is the most important coal-mining area in South Africa. While this coal-field makes a significant contribution to the economic development of the country it is also the source of potentially the most serious water quality problem facing the region over the longer term. There is thus an urgent need to develop and test tools with which to predict the progression of acid mine drainage (AMD) over time, and to develop, test and apply management options that will alleviate the situation. This project, together with **Project Nos. 1263** and **1264** will investigate the management of groundwater flow in collieries at various stages of closure, with the aim of minimising the salt load emanating from them, evaluating alternative geochemical prediction techniques to use in the longer term, comparison of alternative management options, and the mapping of modal proportions of primary and secondary minerals. The contribution of this project will be to evaluate alternative geochemical prediction techniques for the prediction of water quality at underground coal-mines, based on on-site investigations and predictions, and to develop the ability to provide a long-term prediction of water quality and the effect of alternative management strategies on this water quality.

Estimated cost: R1 416 100
Expected term: 2001 - 2009

Development of water balances for operational and post-closure situations for gold-mine residue deposits to be used as input to pollution prediction studies for such facilities

Pulles, Howard & de Lange

No. 1460

The area covered by slimes dams is in the order of 400 km². Previous research has indicated a varying but significant potential for pollution underneath these dumps. The overall water balance of a dump is the main driving force behind this pollution. The water balance of tailings and rock dump facilities is not very well understood at present, both locally and internationally. This seriously limits our ability to make reliable predictions of post-closure pollution potential and to properly evaluate environmental management/rehabilitation strategies. This project aims to develop a procedure and methodology that can be used in developing water balances for gold-mine waste

residue deposits. These water balances play a critical role in geochemical modelling of such deposits.

Estimated cost: R913 500
Expected term: 2003 - 2009

Study of the kinetic development of oxidation zones of tailings dams with specific reference to the Witwatersrand gold mine tailings dams

Pulles, Howard & de Lange

No. 1554

Project No. 1347 aimed to determine and predict the depth and rate of weathering on gold tailings dams, and to develop rapid procedures to assess the risk for a specific tailings dam to produce AMD. This project will complement and extend the earlier investigation by building on its findings and extending them. The large-scale reclamation of dams, ranging from 10 to 100 years in age, provides a perfect opportunity to study tailings dam profiles and characterise their oxidation profiles. The project aims to advance our knowledge and ability to practically implement improved prediction capacity in the following areas:

- Establishment of validated kinetic variation of oxidation zones
- Increasing the accuracy of predicting the depth of oxidation zones
- Increasing the accuracy of predicting the phreatic surface
- Applications to any other similar environment, e.g. platinum group metals (PGM) and copper mine tailings

Estimated cost: R360 000
Expected term: 2004 - 2009

Prediction of how different management options will affect drainage water quality and quantity in the Mpumalanga coal mines up to 2040

Golder Associates Africa

No. 1628

Coal-mining in the Mpumalanga coal-field is a mature activity. Many mines have already closed and several more are heading for closure during the next 20 years. The acid mine drainage (AMD) that emanates from closed and operating mines has a huge impact on the water quality of the area. Because of the lag effect, it is likely that this impact will increase in future. Several investigations over the last decade were aimed at obtaining an improved understanding of how different management options would affect the quantity and quality of AMD emanating from mines. This project will mainly build on available information to predict how the quantity and quality of acid mine drainage emanating from coal mines in the Mpumalanga Highveld will change over the next 40 years, for a range of different management scenarios.

Estimated cost: R1 500 000
Expected term: 2005 - 2009

Origin of sodium and its applications to water quality prediction in the South African coal mine environment

University of Fort Hare (Department of Geology)

No. 1663

In addition to experiencing an AMD problem, the Mpumalanga coalfields also experience an increase in the sodium concentration of mine drainage from north to south. This

phenomenon adds to the unacceptability of mine drainage. This project aims at finding an explanation for the phenomenon and, to a lesser degree, to propose treatment, prevention and management strategies to address the problem.

Estimated cost: R337 600
Expected term: 2006 - 2009

Programme 6: Beneficiation and treatment of industrial and mining effluents

Continued evaluation of the integrated managed passive water treatment system (IMPI), long-term monitoring of VCC passive treatment plant and three-dimensional characterisation of decommissioned sulphate-reducing units

Pulles, Howard & de Lange

No. 1623

In South Africa a sustained 9-year research programme with a 2004 value of around R21 m. (from various funding sources) has aimed at developing passive water treatment technology that can reliably remove sulphates, acidity and metals from AMD waters. This research effort has resulted in the development of a degrading packed bed reactor that is a world leader in volumetric sulphate removal rates from mine-waters, by almost an order of magnitude compared to other international technologies. A key feature of the technology is that it will generally be required to operate for a number of years, typically decades, and continue to perform in accordance with its specified duty. A strategic concern of the mining industry and the regulatory authorities relates to the confidence that can be placed in the long-term performance of such units and their eventual fate. As a logical final stage in developing and evaluating passive treatment processes, this project will extend and intensify the monitoring of existing passive AMD treatment plants while at the same time de-commissioning and autopsying other similar long-running units.

Estimated cost: R400 000
Expected term: 2005 - 2009

'Health-for-purpose' in wetlands treating waste streams

University of Cape Town

No. 1725

Wetlands used for the treatment of high COD and BOD effluents need to be managed to avoid imbalance and overload. The presence of key degrading organisms in a specific biodegradative community offers the potential to develop a 'fingerprinting' technology for identifying the presence and monitoring the 'health' of such a community. The study hypothesises that the impact of pollutant addition on natural microbial populations can be demonstrated by molecular methods to monitor the survival and, more importantly, the health of the microbial population responsible for the biodegradation of the impacting pollutant. The study aims to: develop molecular fingerprints of microbial communities and key degradative enzymes involved in the degradation of specific pollutants; develop methods to demonstrate microbial population changes resulting from the impact of polluting wastewater; and investigate the effects of specific interventions on the 'health-for-purpose' of the wetland microbial population.

Estimated cost: R1 465 000
Expected term: 2007 - 2011

Beneficiation of agri-industry effluents

University of Cape Town

No. 1726

This study focuses on extractive treatment of agro-industrial effluents (specifically effluents produced by the fruit and wine industries and the simultaneous recovery of high-value by-products. The study builds on research which focused on the characterisation of specific wastes with respect to potential economic value and separation and bioconversion technologies. The study aims to characterise the wastes from the fruit and wine industries; develop and customise new extraction processes to obtain antioxidants; investigate and optimise fermentation of residuals after extraction; and investigate and determine the economic and commercial aspects. The outcome of this research potentially lends itself to a broad range of applications not yet developed in South Africa.

Estimated cost: R825 000
Expected term: 2007 - 2010

Novel technology for the recovery of water and solid salts from hypersaline brines: Eutectic freeze crystallisation

University of Cape Town

No. 1727

With increasing use of recycling technology and water recovery by industry, there is an increase in the generation of inorganic brines and concentrates. This study will conduct a proof-of-concept study for South African conditions and brines on the novel technology of eutectic freeze crystallisation as a means to recover water and salts from hypersaline brines. This technology is reported to be significantly cheaper than the present benchmark of evaporative crystallisation. The research team will cooperate with the Dutch developers of the technology.

Estimated cost: R793 305
Expected term: 2007 - 2010

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS

University of Venda (Department of Microbiology)

No. 1653

The spread of the human immunodeficiency virus (HIV), which causes Acquired Immunodeficiency Syndrome (AIDS), is taking place at an alarming rate. The situation for HIV/AIDS-infected individuals is exacerbated by the fact that a large proportion has no access to safe water or adequate sanitation. The lack of safe water compounds health risks to HIV/AIDS individuals leading to increased vulnerability, decline in productivity and income and consequently a general decline in their socio-economic status. HIV/AIDS is not a water-borne disease therefore there appears to be little relation to each other but a poor microbiological quality of their drinking water could have detrimental impacts on the health of HIV/AIDS-infected individuals. This project aims to do a health impact assessment study based on the microbiological

quality of drinking water used by rural households that have at least one HIV/AIDS-infected individual. The presence of selected pathogenic and opportunistic bacteria and viruses in drinking water with those present in stool samples of both people living with HIV/AIDS and healthy individuals will be correlated to identify the relationship between point-of use drinking water quality and health indicators (such as diarrhoeal morbidity and mortality).

Estimated cost: R800 360
Expected term: 2006 - 2009

Develop the guideline: *Management of Microbial Water-Borne Diseases Vol 5: What We and Our Children Ought to Know*

University of Venda
No. 1672

This volume will include home hygiene and a link to sanitation, different water sources and handling of water from the sources. Disinfection and its side effects, the boiling of water and when not to boil, danger of burn wounds, etc. The origin and transmission of diarrhoeal diseases, prevention and care, will be included, as well as emergency treatment of diarrhoeal cases and special care of the immuno-compromised. Handling of containers in households, storage, contamination, etc. will also be included. All of these need to be described in a simple, demonstrative way taking into account the posters, pamphlets and reports already available at the WRC, Department of Health and DWAF, as well as other such documents developed by water suppliers, NGOs, Department of Education (school curricula), etc., to get the most suitable and effective method of transferring the message to the community. Cultural differences and preferences have to be taken into consideration.

Estimated cost: R400 000
Expected term: 2006 - 2009

A guideline document for emergency disinfection of drinking water

Tshwane Institute of Technology
No. 1737

Untreated or inadequately treated water is still drawn directly from rivers, ponds, streams and boreholes in some South African rural communities for domestic use. Various water-related infectious diseases including diarrhoea are often contracted, in some cases causing the death of the immuno-compromised individuals. In some instances, following natural disasters, a local authority may urge consumers at risk of contracting water-borne diseases to follow emergency disinfection measures. Messages and recommendations regarding the 'emerging' disinfection of untreated water do not take into account the variation in the quality of the source water. General guidance and recommendations on the use of a disinfectant or boiling of the water is usually given. In some instances this could add to the detrimental health effects of the water. The aim of this study is to consolidate available literature and information and develop a user-friendly guideline for emergency disinfection of untreated water.

Estimated cost: R600 000
Expected term: 2007 - 2009

Assessment of water, sanitation and hygiene services in relation to home/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas of South Africa

University of Venda
No. 1738

This project will be done in collaboration with the Department of Health (DoH) and will provide an extension of the project funded by DoH. The HIV/AIDS epidemic has a devastating effect on the health and well-being of the South African nation, but it also presents grave consequences for the socio-economic development of South Africa. Safe water and sanitation are basic needs and a human right, especially for people affected by HIV/AIDS, as it will help them to live longer in good health and with increased dignity. This project will highlight the issues underlying the broad context for water supply, sanitation, and hygiene behaviour, and the need for systematic attention to these. This will be done in collaboration with DoH and the Medical Research Council. The aim of this study is to provide insight into the extent to which water, sanitation and hygiene issues/practices are important and relevant for service providers and people living with HIV/AIDS, especially with regard to home/community-based care.

Estimated cost: R500 000
Expected term: 2007 - 2009

Programme 3: Institutional and management aspects of sanitation service delivery

Financial sustainability of sanitation services

Partners in Development
No. 1632

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially-viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices:

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall cost strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best-practice case studies
- Exploration of credit finance options for household sanitation improvement programmes

Estimated cost: R600 000
Expected term: 2005 - 2009

Examine the understanding and interpretation of sanitation policy and programmes

Hlathi Development Services

No. 1741

South Africa is faced with a sanitation backlog that has to be redressed by 2010, and at present policy and strategy focus on delivery, rather than on sustainability of the sanitation services provided. The 2010 targets have been set by National Government as being a basic level of sanitation because all effective sanitation must focus on people and not only the infrastructure. The primary focus of the policy is on the services provided by the Water Service Authority, but also highlights that the end-user households share responsibility for good sanitation and effective sanitation practices. The Water Service Authority is given the responsibility of monitoring and desludging on-site facilities, and/or relocation of on-site toilets when pits fill. There are, however, no existing policies or strategies that set out the detail of how this process is to be implemented. This implies that the operation and maintenance of rural sanitation systems are less than optimum, leaving the user with a level of service that is below the national average. This has numerous implications for the user and national Government. Amongst the implications are health and cost factors.

Estimated cost: R400 000
Expected term: 2007 - 2009

Free basic sanitation – is it possible?

Hlathi Development Services

No. 1742

The South African Government has made a commitment to provide free basic water and sanitation services to the poor households. A review of progress in the implementation of the free basic water policy showed that the 3 poorest provinces are lagging behind with regard to the provision of free basic water (KZN, Limpopo and EC). More than 60% of the people without access to basic sanitation services are found in these 3 provinces. From this analysis, it is clear that the objective of providing free basic water and sanitation services to the poor households is proving to be difficult to achieve. The implementation of the free basic sanitation policy is more complex than water provision because of the different sanitation technologies that are used; e.g., for poor households with full waterborne sanitation, it is unclear whether the water for flushing or the cost of treating sewage should be subsidised. Should the municipalities be responsible for providing O&M for on-site sanitation? There is currently no policy for funding relocation of superstructure for full toilets or construction of new ones where relocation is not feasible. Thus, there is a need to identify successful and cost-effective approaches of implementing sanitation subsidies for sanitation infrastructure in order to achieve the 2010 sanitation target. Financial models and innovative strategies are required for assisting municipalities to provide sustainable free basic sanitation services to the poor household and to pay for ongoing O&M for these services. Good practice must be identified and scaled-up where possible.

Estimated cost: R700 000
Expected term: 2007 - 2009

What do we do to accelerate sanitation?

Hlathi Development Services

No. 1743

The need to accelerate the provision of safe and hygienic sanitation to the approximately 8 million South Africans who still lack it is an urgent priority. Safe sanitation and improved hygiene practices can save thousands of children's lives every year. The dignity and quality of life of mainly poor people can be considerably enhanced. Government has accorded sanitation a very high priority and has committed itself to eliminating the backlog by 2010. However, at the current pace of delivery, this target will not be achieved. There is thus an urgent need to find ways to accelerate the pace of delivery, and to do so in such a way that the sustainability of the facilities provided and behaviour changes achieved are sustainable. The bottlenecks to faster delivery need to be identified and analysed, examples of how they have been successfully overcome documented, and tools and guidelines produced to help municipalities to achieve the required rate of sustainable service delivery. Ways also have to be found to reduce the cost of sanitation delivery to urban areas, and informal settlements in particular.

Estimated cost: R549 600
Expected term: 2007 - 2009

Programme 4: Technical sustainability of sanitation services

Sustainable options for community level management of grey-water in settlements without on-site waterborne sanitation

University of Cape Town (Department of Civil Engineering)

No. 1654

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects which influence the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be applicable for extension to the rest of South Africa. This will be supported by preparation of educational material for community-level training concerning grey-water management options and techniques.

Estimated cost: R750 000
Expected term: 2006 - 2009

Understanding the sludge accumulation in VIPs and other on-site sanitation systems and strategies to manage desludging in the future when pits are full

Partners in Development

No. 1745

Current emphasis in sanitation rollout and the millions invested therein have a bias towards putting in sanitation facilities in the form of dry VIP toilets. Though this is one of the essential components of sanitation delivery and the easier component, less emphasis is afforded to aspects such as ownership, participation, hygiene education and ongoing maintenance which are basically the more challenging and also essential elements for sustainability in sanitation. It can be estimated that

more than 1 million VIP systems will be built to meet backlogs. This is a huge investment by the Government; however, very little foresight and strategies have been developed as to how to manage these systems into the future. The research aims to tackle these questions of sustainability and, through the knowledge which is generated, make the sector better prepared to deal with the challenges. This study will develop an understanding of the sludge accumulation in VIPs and strategies to manage desludging in the future when pits are full.

Estimated cost: R1 600 000
Expected term: 2007 - 2010

Develop more robust and lighter VIP structures

University of Pretoria

No. 1781

The premise of this study is based on the difficulties experienced in relocating VIP superstructures to new pits or to allow access for desludging. Thus, it would be ideal to develop a structure which can deal with these aspects where it can be sustainable, provide longer design life, be a durable, lightweight superstructure (with a total weight in the region of 500 kg) and which can be built and moved by rural households to new sites or to ease desludging. There are many advanced modern composites such as combinations of fibre-reinforced high strength concrete and plastics, which, if made appropriate, could contribute to sustainable sanitation provision. Various combinations of composites can be developed in the most cost-efficient manner, which can be durable and affordable. The aim is thus to create designs which facilitate the reuse of superstructure building materials which, in turn, facilitate labour-intensive processes, as well as provide easier building techniques such that homeowners can rebuild their superstructures over a new pit without the services of a highly-skilled builder.

Estimated cost: R1 100 000
Expected term: 2007 - 2010

New Projects

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Guidelines on domestic water accounts – Towards a consistent approach in RSA

Sarah Slabbert Associates; Neilsen Company; Zitholele Consulting

No. 1810

In the endeavour to provide municipal financial services of the highest quality to its customers and businesses, in an efficient and progressive manner, while safeguarding assets and upholding the public trust, water bills or accounts play a key interface in educating and encouraging participation in water management. Customers' water accounts provide a significant opportunity to further engage customers in relation to water conservation, regulation, risk management as well as planning. The water customers in South Africa are split along the lines of being literate and illiterate, rich and poor. Domestic water accounts form an integral part of many communities who

receive improved water services. The standardisation of water accounts is an innovation aimed at building linkages between customer awareness, customer accountability, participation and regulation of water services. The objective of these guidelines is to identify the key elements that would make domestic customers' water accounts more informative.

Estimated cost: R500 000
Expected term: 2008 - 2010

Guidelines on pricing and debt management for municipalities

Arcus Gibb (Pty.) Ltd.

No. 1811

Poor debt management and pricing continue to be some of the elements which are resulting in municipalities not performing in a financially viable manner and the customers not receiving an affordable service. DWAF produced a document entitled *Model Credit Control and Debt Collection By-Laws* (DWAF, 2005), which sets a framework and rules around this subject. It was aimed at water services authorities who did not have any legal framework to introduce effective debt collections and credit control. Thus the by-laws were seen as model by-laws. Though the bylaws (DWAF, 2005) provided the necessary legal framework, not much has however been done with regards to the provision of guidelines, tools and strategies to assist water services institutions to give effect to the bylaws and its contents. In the complex environment of water services delivery and the growing gap of poor revenue collection, it is becoming apparent that very radical and innovative approaches are required with regard to debt control and credit control.

Estimated cost: R600 000
Expected term: 2008 - 2010

Programme 2: Institutional and management issues – Water services

Situational analysis of water services provision in South Africa – establishing future strategies for consideration by municipalities

PD Naidoo & Associates (Pty.) Ltd.

No. 1812

To date centralised service provision has been the norm in the development of many cities and towns. The attraction towards centralised systems is based on established experience and practice of the benefits obtained from the economies of scale offered. Questions of efficiency, vulnerability, long-term technology decisions which prevent application of new technology, etc., are all new constraints which are questioning current approaches. This is further compounded by the fact that as cities and areas within cities get established it becomes more challenging to replace and rehabilitate existing infrastructure. These approaches come with pros and cons; however, the new and future challenges are different from those which influenced centralised approaches, from both new developments, operation and maintenance, energy constraints/costs and the availability of new technology. Similarly, decentralised systems also have their pros and cons. There is good evidence of the challenges faced in managing stand-alone and dispersed schemes, with the contributing factors being capacity and competency constraints. Thus this study will contribute to the growing understanding of

the operational realities of decentralised and centralised water and sanitation systems. An analysis and review of the approaches required will assist the sector to plan smarter for the future and shape our growing cities/towns/villages to support sustainable water services.

Estimated cost: R600 000
Expected term: 2008 - 2010

Development of strategies and guidelines for integrated water meter management

University of Johannesburg; Rand Water

No. 1814

Water metering plays an indispensable role in proper management of water distribution systems. Measured consumption forms the basis for most Water Services Authority and Water Services Provider accounts, and thus affects revenue directly. Bulk water meters are used to measure water entering the system, whether from raw water sources, water treatment plants or bulk water suppliers and is used to manage the system, including water balances, water loss calculations, consumption patterns and trends, pumping requirements and future planning. It is thus very important for all parties involved in the supply or consumption of potable water that water meters are used appropriately, managed optimally and maintained at regular intervals to ensure that water accounts, loss estimates and management decisions are based on accurate information. There is currently a lack of proper water meter management in South Africa, with many bulk water suppliers and municipalities without optimal and integrated meter calibration, replacement, reading, and information management systems. In addition, water meters of 80 mm and smaller are regulated by the Trade and Metrology Act, while larger meters are not.

Estimated cost: R660 000
Expected term: 2008 - 2010

Programme 3: Innovative management arrangements – Rural water supply

Development of people-centred programmes

Mvula Trust

No. 1815

The challenges in developing good operations and maintenance (O&M) practice are perhaps greatest in remote rural areas with stand-alone schemes. There are no economies of scale for this kind of infrastructure provision as there are vast distances between the location of WSA/WSP and where human settlements are scattered. Given this geographical reality, innovative solutions are required to ensure the sustainability of infrastructure in these areas. International and South African experience has shown that community-based approaches yield sustainable results in the field of service delivery. Several factors, however, have contributed to the decline of community-based (or people-centred) approaches in South Africa. The main reason seems to be that water services authorities (WSAs), have neither the experience nor the tools to apply people-centred approaches. From the viewpoint of service delivery sustainability and the rights of communities, this research will try to close this gap.

Estimated cost: R800 000
Expected term: 2008 - 2009

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 2: Water treatment technology for rural communities

Application and performance of slow sand filtration

Cape Peninsula University of Technology

No. 1836

Slow sand filtration is generally highly recommended in small and rural community water treatment because of its simplicity in design, operation and maintenance. However, little awareness of the application of slow sand filters exists in South Africa. Very little is further known about the slow sand filters in operation in South Africa and how they are performing. The project, therefore, aims to investigate the extent of slow sand filtration applications in the country and practical performance of these filters, covering both successful and failed examples. It will also investigate and document the types, application and performance of the various pre-treatment processes prior to slow sand filtration. A database of all sand filtration plants in the country will further be compiled.

Estimated cost: R760 000
Expected term: 2008 - 2011

Programme 3: Drinking water quality

EDC bio-assay toolbox

University of Pretoria; A Burger (independent consultant); North-West University, CSIR (Natural Resources and the Environment)

No. 1816

The WRC has been funding a structured and well planned endocrine-disruptor chemical (EDC) and toxicant research programme from 2001. Education (training) and awareness building and management of EDCs form an integral part of the programme and several manuals will be developed. The sampling, biological and analytical procedures used in this programme and in collaboration with the Global Water Research Coalition (GWRC), now need to be taken a step further to the development of training and user-friendly manuals. It is also of utmost importance to the success of the programme and benefits to the country that the training manuals will be ready during the 3rd phase of the EDC programme, and the implementation of the National Toxicant Monitoring Programme (NTMP) of DWAF in 2008. This volume (III) will focus on the identification, selection and standardisation of biological assays for EDCs, with special reference to oestrogenic compounds.

Estimated cost: R870 000
Expected term: 2008 - 2010

Programme 4: Water distribution and distribution systems

Durability of FC tanks

Partners in Development

No. 1818

Ferro-cement is a cement-rich reinforced modified mortar which is easily adaptable to rural construction projects and

well suited to smaller sizes of reservoir. Ferro-cement reservoirs are constructed using very simple sets of shuttering and consequently can be built predominantly by utilising local labour with the assistance of a foreman and team leader. They are also considerably cheaper than reinforced concrete reservoirs. However, although the construction cost of ferro-cement reservoirs is significantly cheaper than for reinforced concrete reservoirs, they are not particularly well known and thus are often regarded with a fair amount of scepticism. As they are also a relatively recent technology, very little is known about their long-term durability. This study hopes to address this problem by investigating the status of numerous reservoirs built over the previous 15 years in KwaZulu-Natal and the Eastern Cape in order to ascertain a better estimate of their design life.

Estimated cost: R220 000
Expected term: 2008 - 2009

Investigating private on-site water use and its impacts

University of Stellenbosch

No. 1819

Water resource managers, water demand managers and water infrastructure planners alike, are faced with an acute lack of knowledge regarding private on-site water resources (conveniently termed 'POSWAR' in this application). The most common water resources of this nature include:

- On-site groundwater abstraction by means of private boreholes
- Rainwater harvesting from rooftops
- Grey-water reuse

The nature and extent of POSWAR application by individual water users, particularly in residential areas, impact on all infrastructure elements of the water supply and waste cycle. POSWAR-application creates an apparent load reduction on all piped reticulation systems, treatment works and on the water supply resources. Unfortunately these 'insignificant' resources are entirely neglected during urban and resource-planning exercises. This study will determine and confirm the extent to which and in which way water demand and wastewater flow are influenced by the application of POSWAR.

Estimated cost: R300 000
Expected term: 2008 - 2009

Determining the change in hydraulic capacity of pipelines

University of Pretoria; Rand Water

No. 1820

It is generally accepted that the operational life of pipelines could well be longer than the 30 years which are used in the economic analyses of pipeline systems. Networks of Rand Water and other water utilities prove this, although there are a number of reported cases where pipelines fell short of the expected operational lifespan. Funding of new water projects in the near future will have to compete with the capital that is required for the renovation, replacement and upgrade of existing infrastructure. An informed status assessment of a pipeline can only be made if the operational performance history of the pipeline is known. Optimal capital expenditure and operational cost is based on the performance and the expected hydraulic performance decay rate of pipeline systems. Long-term performance data are essential for this

assessment and an effort should now be made to gather information on a regular basis for a number of different pipelines in South Africa.

Estimated cost: R785 000
Expected term: 2008 - 2011

Dual grey-water and drinking water reticulation for high density urban residential dwellings

University of the Witwatersrand; University of Johannesburg;

University of Cape Town

No. 1821

South Africa views water as one of its most fundamental and indispensable natural resources. Although renewable, water is also a finite resource, distributed unevenly in time and space. Increased development of South African communities has led to an overall increase in water demand. This water demand has traditionally been met with water from the best available sources. However, over the years, it has become evident that high quality water sources in many provinces are inadequate to meet demands and, that not all uses require the same water quality. Some water uses can be supplied with water of an inferior quality, which frees the high quality sources for higher quality uses, e.g. drinking water production. Dual grey and drinking water reticulation systems (henceforth called dual systems) are particularly promising for application in high-density (especially multi-storey, access-controlled and centrally managed) urban residential dwellings (HDURDs) (e.g. university halls of residence) located in arid South African environments. This project is aimed at investigating the potential for implementing dual systems in HDURDs, primarily for toilet flushing and if possible, limited private irrigation using a pilot study in a university.

Estimated cost: R1 055 500
Expected term: 2008 - 2011

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER MANAGEMENT AND SANITATION

Programme 1: Emerging technologies and solutions

Mass balance modelling over wastewater treatment plants III

University of Cape Town; University of KwaZulu-Natal

No. 1822

The series of projects aims to develop a plant-wide wastewater treatment plant (WWTP) model used to accurately predict the outcome of the various biological, physical and chemical processes taking place in a WWTP. These tools can result in more economical wastewater plant design and operation and improved effluent quality. Significant advances have been made towards developing steady state mass balance-based integrated WWTP models which link primary sedimentation, nitrification-denitrification activated sludge and aerobic or anaerobic digestion of primary and waste activated sludges (**K5/1338** and **K5/1620**). This project aims to determine the kinetics of P release from biological P-removal systems and determine the extent to which mineral precipitation takes place. The P release in anaerobic digestion will be compared to that observed in aerobic digestion. Certain aspects such as the

mineral precipitation in aerobic digestion, the un-biodegradable fraction of primary sludge and the un-biodegradable fraction of the waste activated sludge from nitrification-denitrification systems will be confirmed. The research will determine whether the presence of primary sludge will assist in the hydrolysis of waste activated in anaerobic digestion.

Estimated cost: R998 950
Expected term: 2008 - 2010

FISHing for indigenous anammox bacteria

Stellenbosch University; CSIR (Natural Resources and the Environment)

No. 1823

Nitrogen is conventionally removed from wastewater via nitrification followed by denitrification. Nitrogen removal via anaerobic ammonium oxidation (anammox) requires only 24% of the total primary energy as compared to conventional nitrification. Anammox bacteria were first discovered in the Netherlands during the 1990s and have since then revolutionized the wastewater industry. Different configurations of anammox reactors are now appearing all over the world. In this project the researchers aim to locate and identify indigenous anammox bacteria from anaerobic habitats. Once these have been found and enriched, they aim to compare the kinetics and stoichiometry between known organisms (from literature) and the organisms located in local habitats. Parameters defining the key physiology of the local bacteria, including their optimum growth conditions under varying temperature, pH, ammonium-nitrite concentration, and dissolved oxygen concentration would be the first pointers towards implementation of this process on a larger scale in South Africa.

Estimated cost: R612 750
Expected term: 2008 - 2010

Effects of urine separation and treatment on wastewater effluent quality

CSIR (Stellenbosch); AFRICON; University of Stellenbosch

No. 1824

The project deals with alternative sewage collection and treatment for both low and high income communities in urban settings. The concept includes the separate treatment of urine and the rest of the black/grey sewage to achieve better effluent quality. This project aims to demonstrate at pilot scale that the DWAF Special Standards can be achieved through (partial) separate collection of urine. In addition, this increases the capacity of the receiving wastewater treatment plant which could delay extensions. The research will be reconfiguring toilets and urinals to allow (partial) urine separation on pilot scale. It will determine the composition of urine and demonstrate the effectiveness of treating wastewater with less urine than normal in varying quantities to achieve very low nutrient effluent concentrations (DWAF special authorisation), as well as relatively low salt effluent concentrations. The study will assess the operational issues, such as struvite and other forms of scaling in urine drains, odours, etc. This project will assist in creating awareness for the potential positive impacts of urine separation and the feasibility thereof.

Estimated cost: R1 200 000
Expected term: 2008 - 2011

Programme 2: Application of appropriate technologies and tools

Denitrification in trickling filters

CSIR (Stellenbosch); Virtual Buro; Tshwane University of Technology

No. 1825

Many wastewater treatment plants in South Africa are equipped with trickling filters which could be obsolete if they cannot achieve denitrification. The researchers aim to demonstrate (at full scale) that trickling filters can denitrify by changing the effluent recycle over trickling filters and/or limiting the rotation speed of distribution arms. They will then model the processes of aerobic COD removal, nitrification and denitrification in a biofilm system and calibrate the model with results from 2 trickling filters in order to gain a better mechanistic understanding of the combined processes. This will result in a set of practical operating guidelines to achieve denitrification in trickling filters.

Estimated cost: R930 500
Expected term: 2008 - 2010

Programme 3: Stormwater and sewerage systems

Alternative technology for stormwater management

University of Cape Town; SRK; City of Cape Town; eThekweni Municipality; Johannesburg Municipality; City of Tshwane; IDS

No. 1826

Currently, stormwater planning and design in the urban areas of South Africa focuses on collecting runoff and channelling it to the closest watercourse, frequently having a significant impact on the environment through the resulting erosion and siltation. Whilst some local authorities reduce runoff peaks through the use of retention and detention ponds, few examples exist of quality improvement apart from pumping the base flow of the most polluted streams to sewerage, and the installation of litter traps. Internationally, numerous alternatives to the traditional stormwater management approach have been developed to manage the quantity and quality impacts associated with urban runoff, generally by dealing with stormwater as close to its source as possible. This solicited project aims to identify and develop new and appropriate, practical and affordable alternative stormwater management technology/technologies for South Africa in line with water-sensitive urban design (WSUD) principles. The researchers will also evaluate the technology options in terms of the ability to improve stormwater management in urban areas, i.e. reduce impacts on receiving watercourses resulting from increased velocities and volumes of runoff and deterioration of runoff quality. Four large local authorities (CCT, eThekweni, JHB and Tshwane) have expressed interest in participating in pilot studies.

Estimated cost: R1 800 000
Expected term: 2008 - 2012

Improving sewerage for South Africa

University of Cape Town; City of Cape Town; eThekweni Municipality

No. 1827

With ever-increasing development and expansion of municipal sewerage networks it is important to ensure that the current

rationale applied to the selection of new sewerage is sustainable over the longer term. The integrity of the existing systems also needs to be maintained through systematic replacement of sewers that have exceeded their design. It is therefore necessary to evaluate whether there is a better way of sewerage areas which would offer long-term benefits over current conventional practices. The primary objective of this solicited project is to establish whether there is a viable alternative to conventional reticulated sewer systems, which offers tangible improvements over current conventional reticulated systems. The focus will be on application in new development and unserved areas as well as the potential as a solution for the replacement of conventional sewers which have exceeded their design life. The research will critically evaluate impending technologies and provide practical guidance to implementers on where suitable circumstances exist where these technologies will prosper. The project is supported by some major local authorities committed to assist with a pilot project to assess the operation of the new or proposed technologies.

Estimated cost: R1 500 000
Expected term: 2008 - 2012

Sewer master planning tools and guidelines
Stellenbosch University; GLS Consulting Engineers
No. 1828

The objective of this solicited project is to establish design tools and guidelines for the compilation of sewer master plans for local authorities which will ultimately assist in the improvement of planning functions, service delivery and inputs to the water services development planning process through enhanced methods, practices and interventions. The tools should assist managers at all levels of local and regional authorities to complete basic assessment of their sewer systems through compilation of basic inputs and generation of results or reports. The guidelines should give structure to the master planning process and include a methodology for compilation of such a plan. The intention is to develop a simple product that gives immediate benefits to the user by providing fundamental principles in developing a sewer master plan and providing usable tools to the sewer manager/engineer.

Estimated cost: R600 000
Expected term: 2008 - 2010

Programme 4: Management of wastewater and faecal sludges

Investigating the potential of deep row entrenchment of pit latrine and wastewater treatment works sludge for forestry and land rehabilitation purposes

Partners in Development (Pty.) Ltd.; University of KwaZulu-Natal
No. 1829

A substantial amount of existing basic sanitation infrastructure (conventional pit latrines and VIPs) has reached or is reaching the end of its design life. Urgent interventions are required to deal with the escalating accumulation of sludge in these basic units. The options for disposal of this sludge are limited. This project aims to investigate how the sludge entrenchment technique may be applied under South African conditions

and what safe working procedures (handling and transport, maximum application rates, etc.) should be developed to protect the health of workers, local communities and the environment. Research will be conducted at different sites that vary in such features as soil characteristics, slope, aspect, microclimate and end-use potential. The study will specifically focus on:

- Monitoring changes in the sludge contents of the covered trench and movement of solutes and any changes taking place in the surrounding soil and groundwater
- Investigating the management, logistics, health and politico-legal aspects of transporting sludge, excavating trenches and planting trees/vegetation
- Assessing the commercial and any other opportunities created (agroforestry, biofuel-producing tree species and environmental rehabilitation).

Estimated cost: R1 600 000
Expected term: 2008 - 2011

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 1: Quantification of water use and waste production

An assessment of how water quality and quantity will be affected by mining method and mining of the Waterberg coal reserves

University of the Free State
No. 1830

The Waterberg coal reserves are the only remaining large area with proven coal reserves in South Africa and they are being targeted for large-scale mining in the foreseeable future. It is appropriate that the lessons which have been learnt in other mining areas should be applied here. This project will therefore undertake a scoping level study to consolidate the existing information (with limited field work where existing information is lacking) about the geohydrology and pre-mining water quantity and quality of water resources associated with the Waterberg coal reserves, predict how the water resources would be affected by alternative mining methods, make provisional recommendations on the management of the water resources and identify which further research concerning the impact of mining of the Waterberg coal reserves on water resources should be undertaken.

Estimated cost: R700 000
Expected term: 2008 - 2009

Programme 3: Minimising impact of waste on the water environment

A systematic approach to sulphidic waste rock and tailings management to minimise AMD formation

University of Cape Town
No. 1831

Acid mine drainage (AMD) is almost certainly the biggest environmental issue facing the South African mining industry. Changes in legislation have put the burden of responsibility for perpetuity on mining companies. This has led to a change

in process thinking in order to reduce potentially harmful emissions from deposits and thus reduce long-term costs of tailings management and AMD remediation. This project will address aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides, specifically with the focus of reducing capacity to form AMD through removal of the sulphidic component of the waste. It will use the understanding of the factors governing AMD generation from dump rock and tailings (similar to those governing mineral bioleaching) with the view to the improved categorisation, separation and planned disposal of its components to mitigate AMD generation.

Estimated cost: R598 320
Expected term: 2008 - 2010

Programme 4: Minimising waste production

Technical guidelines for the implementation of cleaner production initiatives (for point sources of pollution) in support of determining an incentive charge for municipal effluent charges

Process Optimisation and Resource Management (PRO&RM)
No. 1832

This project surmises that the only realistic way to calculate an incentive charge to promote the implementation of cleaner production technologies by industries disposing of their effluent into municipal sewers is to determine the equivalent implementation cost of cleaner production initiatives. The imminent implementation of the Waste Discharge Charges System adds impetus to the need for such a study. The objective is to develop Technical Guidelines through which the insights gained in the study can be transferred to other applications.

Estimated cost: R570 619
Expected term: 2008 - 2010

Programme 5: Improved ability to predict and quantify effects

Environmental sustainability of inland industrial complexes

CSIR, Eco Innovation, University of KwaZulu-Natal, University of Stellenbosch, University of Cape Town

No. 1833

Significant economic activity and prosperity of South Africa is associated with a few large industrial complexes. Since these areas are important nodes of economic growth, it is in the interests of the country that they continue to generate wealth, but do so in a sustainable way. This project will examine several inland industrial complexes as case studies with a view to establishing factors/solutions that can enhance their long-term environmental sustainability, promote high percentages of reuse of industrially generated waste streams, and lay foundational blocks in raising awareness on the significance of symbiotic industrial ecology for future economic sustainability through optimal utilisation of resources. More than one industrial complex will be selected since certain factors may be unique to a given complex.

Estimated cost: R3 000 000
Expected term: 2008 - 2011

Programme 6: Beneficiation & treatment of industrial and mining effluents

Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine drainage

Rhodes University

No. 1834

The treatment of acid mine drainage typically consists of a series of unit processes which include the pre-treatment (neutralisation and metal removal) followed by the removal of salinity and residual pollutants. Several passive and semi-passive unit processes have been developed locally for the neutralisation of acid mine drainage water as well as the subsequent sulphate reduction. Biological sulphate reduction is now well understood and several innovative technologies have been developed and are currently still being developed including the IMP and the Rhodes BioSURE™ Process. The subsequent sulphide oxidation step is also well researched and applied in active treatment systems. However, limited passive biological sulphide oxidation and subsequent sulphur removal solutions exist. This solicited project aims to further develop the tubular fixed biofilm reactor developed by Rhodes University to remove sulphur in a passive system. This study will focus on the design, development and operational configurations for the tubular sulphur biofilm reactor. The technology will be demonstrated on laboratory and pilot scale.

Estimated cost: R1 500 000
Expected term: 2008 - 2011

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

How does the HIV and AIDS epidemic in South Africa impact on the water, sanitation and hygiene sectors?

University of the Western Cape

No. 1813

In South Africa HIV/AIDS tends to be treated predominantly as a health issue with intervention efforts narrowly focused on prevention and treatment. Issues like accessibility to clean water for people living with HIV and AIDS (PLWHA) in both urban and rural areas, and related issues like sanitation and hygiene have not received a lot of policy debate, support and attention in South Africa. Safe water and sanitation constitute the most basic needs and human right issues, especially for PLWHA as it will help them to live longer in good health and increase their dignity. Therefore, information on water, sanitation and hygiene is important for making the right decisions. Access to basic sanitation and effective solid waste management is essential in reducing morbidity and mortality, particularly for those with a reduced immune function such as PLWHA. Access to clean water is essential in promoting effective health and hygiene practices amongst PLWHA. Effective health and hygiene requires an enabling environment that includes not just safe water supply, but effective wastewater disposal and solid waste management. The raising of health and hygiene awareness amongst affected households will be of little value unless safe water supplies are available

to these households, so that they can practise good hygiene. Hygienic behaviour in turn reduces opportunistic infections and lengthens the time period between HIV infection and full-blown AIDS, thereby extending the period in which HIV sufferers can be both domestically and economically active. A complicated web of relationships exists between water and HIV and AIDS and cannot be underestimated. An investigation of the linkages and perspectives between PLWHA, water, hygiene practices and sanitation will enhance the development of integrated approaches. The central objective of this research study is to provide insight into the extent to which water, sanitation and hygiene sectors must strategise for services provided to people living with HIV and AIDS. Further the study intends to look at 3 distinct cross-sections; urban, peri-urban and rural areas across 3 or 4 selected provinces. The rationale being that the impact of intervention measures ought to differ across the 3 segments and across provinces.

Estimated cost: R700 000
Expected term: 2008 - 2010

Contact Persons

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Mr JN Bhagwan

E-mail: jayb@wrc.org.za
Tel: +27 12 330 9042

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Dr Jo Burgess

E-mail: job@wrc.org.za
Tel: +27 12 330 9039

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Dr Valerie Naidoo

E-mail: valerien@wrc.org.za
Tel: +27 12 330 9038

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Mr HM du Plessis (until 31 May 2009)

Dr Jo Burgess (from 1 June 2009)

E-mail: job@wrc.org.za
Tel: +27 12 330 9039

or

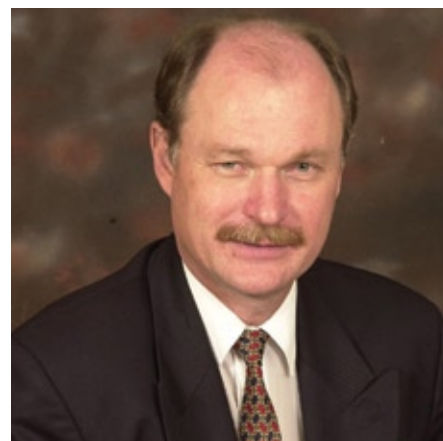
Dr Valerie Naidoo (from 1 June 2009)

E-mail: valerien@wrc.org.za
Tel: +27 12 330 9038

THRUST 5: SANITATION, HEALTH AND HYGIENE EDUCATION

Ms A Moolman

E-mail: annatjiem@wrc.or.za
Tel: +27 12 330 9042



Dr Gerhard Backeberg: Director

KSA 4: Water Utilisation in Agriculture

Scope

The strategic focus in this KSA, as described in previous years, is on increasing the efficient use of water for production of food, fibre, fuel-wood and timber; ensuring sustainable water resource use; reducing poverty and increasing the wealth of people dependent on water-based agriculture. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers is addressed through creation and application of water-efficient production technologies, models and information systems within the following interrelated sub-sectors of agriculture, namely:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

The challenge for applied research and knowledge dissemination is to provide solutions to practical problems which are experienced in the process of utilisation, development and protection of water resources, thereby contributing to productivity growth in agriculture.

Objectives

The primary objective is to increase household food security and to improve the livelihoods of people at a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture. The secondary objectives are to:

- Increase biological, technical and economic efficiency of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices

Portfolios of current projects have been grouped into strategic thrusts and programmes which directly address the above-mentioned objectives and are summarised as follows:

Thrusts and Programmes

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the

knowledge of the processes of production of field, horticultural and industrial crops. Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water-use efficiency in agriculture. Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in the assessment of the fitness-for-use of water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams. This thrust includes 2 programmes:

- Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture
- Fitness-for-use of water for crop production, livestock watering and aquaculture

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops. In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuelwood and timber production. This thrust includes 1 programme:

- Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water. Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women,

children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can be promoted further through participatory action research which improves knowledge, farming skills and leadership capabilities. Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources. This thrust includes 2 programmes:

- Sustainable water-based agricultural activities in rural communities
- Integrated water management for profitable farming systems

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use. With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation. Agricultural decisions to use land and to conserve rainfall or abstract water from rivers, dams and boreholes have wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts. This thrust includes 2 programmes:

- Sustainable water resource use on irrigation schemes and within river catchments
- Impact assessment and environmental management of agricultural production

Research Portfolio for 2008/09

In this KSA a holistic approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction in rural areas and prevention of resource degradation. These efforts are aligned to

the agricultural sector plan and national water resource strategy in South Africa and to the comprehensive Africa agricultural development programme of NEPAD. Work will continue to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following themes of the research portfolio:

- Irrigation and water use efficiency
- Fitness-for-use of water in agriculture
- Water use efficiency in agro-forestry and woodlands
- Aquaculture in rural livelihoods
- Rainwater harvesting and conservation
- Adaptive research of technologies in rain-fed and irrigated agriculture
- Technology transfer of water management models
- Impact of land use management on point and diffuse pollution in agriculture

During the past 5 years a strategic shift has been made to achieve a balance between research projects in irrigated and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further to practical application of results with technology transfer projects. An overview of completed and ongoing projects indicates the direction and priorities for future research. In the years that follow, emphasis will be placed on the water use of trees/crops and the area which is suitable for bio-fuel production based on bio-climatic criteria; impacts of micro-organisms, parasites and chemicals in irrigation water on food safety; modelling of water use, biomass production and economic value of indigenous trees under plantation conditions; structures and incentives for empowerment of women and including emerging farmers in rain-fed and irrigated agriculture in the mainstream of the economy; extent of salinisation and drainage of degraded lands, precautionary measures for wastewater disposal and adaptive practices to reduce vulnerability to climate change.

Budget for 2008/09

The approved funding of the research portfolio of current projects and projects commencing in 2008/09 leads to committed funding of R20 340 772. Funding for new projects of R2 974 500 was requested for 2008/09. The proposed new projects will support development and application of models, techniques, tools and guidelines for efficient and beneficial agricultural water management.

Core Strategy

Strategic context

The water resource base is of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people.

Water utilisation can best be quantified as rainfall-dependent, surface water-dependent and groundwater-dependent use. Approximately 12% and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grasslands, woodlands and forests, respectively. Rainwater runoff and deep percolation become available as surface water and groundwater of which approximately 62% is used for irrigation. It is therefore clear that the biggest share of water is used for both extensive and intensive production in agriculture.

In South Africa, at least 35% of the economically active population are directly or indirectly dependent on agriculture. This consists primarily of small-, medium- and large-scale enterprises, which provide employment opportunities for formal and casual labour. Furthermore, 42.7% of the population are rural survivalists with traditional agrarian lifestyles. Recent estimates also show that 48.5% of the population are living below the poverty line.

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low at between 2 to 3% of gross domestic product (GDP). The forward linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Agriculture is also a net exporter of food, contributing 10% of total exports of which 50% are processed products.

Critical issues in the forthcoming years and the next 2 decades are increasing pressures on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing income levels of consumers. Expansion of agricultural production on land suitable for cultivation will be constrained by the availability of water. Increasing hazards of rainfall variability, with western parts of South Africa getting drier and eastern parts wetter over the long term, are caused by climate change. This requires adaptive management practices to reduce the vulnerability of people in rural areas and prevent disasters of crop failures, income loss and widespread famine. At the same time, there is a high ratio of people to cultivated land and a dependence on agriculture in rural areas to increase the material income and improve the social wellbeing, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background which remains valid to date, the strategic focus of water research in this KSA, which was also found to be relevant by the External Institutional Review in July 2006, will continue to be on:

- Increasing the efficiency of water use for food, fibre, wood and timber production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Ensuring sustainable water resource use in rain-fed and irrigated areas (i.e. improving the knowledge of natural processes and people-induced impacts of resource use)
- Increasing the household food security and profitability of farming and thereby the livelihoods of people dependent on agriculture (i.e. improving the knowledge of management processes by people who are using water)

In drawing up plans to implement these strategies, cognisance has to be taken of the national needs, technological trends and stakeholder expectations.

Needs analysis

Previously identified needs, re-affirmed by recent reports and reviews, continue to give direction to applied research.

During 2000 the Presidential Imperative Programme on **Integrated Sustainable Rural Development** was announced. The goal of the programme is to promote development and improve the quality of life of marginalised groups and communities. The objectives are to alleviate poverty through enhanced production, productivity, creation of employment opportunities and a more equitable distribution of resources. Outputs which are envisaged include agricultural production systems and sustainable utilisation and management of natural resources and the environment.

At the end of 2001 the **Strategic Plan for South African Agriculture** was released by the National Department of Agriculture, Agri SA and the National African Farmers Union (NAFU). The strategic goal is to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural sector, contributing to a better life for all. This strategic goal is expected to guide all relevant partners in their quest to deliver and implement a range of programmes in accordance with basic premises of amongst others:

- Fair reward for effort, risk and innovation
- Security of tenure for present and future participants
- The sustainable use of natural and biological resources
- Sound research, science, knowledge and technology systems
- Market forces which direct business activity and resource allocation

The outcomes which are envisaged to flow from successful implementation of programmes include:

- Increased creation of wealth in agriculture and rural areas
- Increased sustainable employment
- Increased income and foreign-exchange earnings
- Reduced poverty and inequalities in land and enterprise ownership
- Improved farming efficiency
- Improved national and household food security
- Increased investment in agricultural activities and rural areas

One of the three core strategies which are discussed in the strategic sector plan for agriculture is **sustainable resource management** which also impacts on water systems. Central to this strategy is, *inter alia*, the promotion of sustainable use of soil and water through increased crop and livestock productivity and intensified farming systems, while farmer participation is a key success factor. Degradation of soil and water resources is considered to be a serious threat and therefore programmes must be designed to overcome the causes of degradation. Such soil and water conservation programmes will focus on areas where there is a reasonable chance of success as determined by, e.g., available technologies and access to markets, inputs and services.

On a regional level the **Comprehensive Africa Agriculture Development Programme** (CAADP) of the New Partnership for Africa's Development (NEPAD, 2003), places the focus on land and water management as 1 of 4 pillars for priority investment. It is stated that 'water and its managed use has been an essential factor in raising the productivity of agriculture and ensuring predictability in outputs. Water is essential to bring forth the potential of the land and to enable varieties of both plants and animals to make full use of other yield-enhancing production factors. By raising productivity, water management (especially when combined

with adequate soil husbandry) helps to ensure better production both for direct consumption and for commercial disposal, thereby enhancing the generation of economic surpluses which are necessary for uplifting rural communities.

A call is made for increased investment in land and water and the point is made that 'protecting and improving water and the soil makes good business sense'. It is indicated 'that by enabling a rapid increase in production, irrigation can make food more readily available but that its impact on reducing hunger depends on appropriate arrangements for the poor to have access to irrigated land'. The further point is made that 'while increased irrigation is not a panacea for all agricultural ills, it nevertheless makes possible other opportunities for agricultural growth such as better husbandry of soils and resources in general, and makes more worthwhile the use of fertilisers, improved plant varieties and upgraded infrastructure'.

The *Development Report* by the DBSA (2005) found that 'the poverty problem remains a predominantly rural phenomenon'. Furthermore farming still provides 'a major source of income for many rural communities in South Africa' and therefore contributes to poverty alleviation. This role can be strengthened by investment in the drivers of agricultural development, namely human capital, biophysical capital, rural institutions and agricultural research. The conclusion is 'nonetheless, while agriculture plays a major role in **poverty alleviation**, promoting the growth of smallholder agriculture alone cannot solve the poverty problem in South Africa. More attention should also be given to the promotion of non-farm activities (e.g. agro-industries), particularly those that are linked to the smallholder agricultural sector. A strategy that strengthens farm/non-farm linkages is likely to yield better results with regard to employment and income generation'.

In the biannual *Overview of the World Food Situation* by the International Food Policy Research Institute (IFPRI) at the end of 2007⁹ it is stated that renewed attention must be given to **agriculture, nutrition and health** in adjusting research agendas. Strategies must be directed at poor members of society. In this regard social security measures must be taken that focus on early childhood nutrition, particularly of poor households. With increasing risks caused by climate change, more investments must be made in agriculture to improve productivity. This includes investment in agricultural science and technology to facilitate a production response to rising food prices.

These needs as expressed by Government, public organisations and farmer representatives at national, regional and international levels are still relevant and as in previous years, highlight the key issues which must be addressed in the WRC research portfolio:

- Increased productivity of water for crop and livestock production
- Uplifting rural economies through commercial production
- Eradication of hunger and poverty
- Improved nutrition and health
- Prevention of soil and water degradation
- Involvement of farmers in research

Overview of technological trends

Efforts continue to stay at the forefront of technological developments and ensure application of existing technologies. This is achieved by purposefully leading the innovation cycle, which involves scientific research, practical application of inventions and exploitation of the commercial potential of the research output. A balance must therefore be found between research projects and technology transfer projects and also

between research on appropriate technologies for irrigated and rain-fed agriculture.

With a growing demand for water in the domestic and industrial water-use sectors, the competition for water currently used for agricultural production will increase in future. Technologies, models and methods are available to improve the **efficiency of irrigation water use** in different stages, e.g., canal and on-farm water distribution, field application and irrigation scheduling. With the demand for food also increasing in a globalised trade environment, agricultural production will have to be competitive in both local and overseas markets. While irrigated agriculture contributes 25 to 30% of gross production, technological and managerial innovations are required in all subsectors of agriculture to reduce costs and to increase income.

In particular, attention will have to be given to **rain-fed agriculture** and the existing technologies which have been developed for **water harvesting** in Sub-Saharan Africa. The impending challenge for research is therefore to adapt or develop and apply technologies which will enable water conservation in rain-fed agricultural production on dry-lands, grasslands and woodlands. In the case of irrigation, locally-available technologies must be integrated and the financial benefit of efficient water use must be demonstrated over all stages of water distribution and application. Emphasis must be placed on making all technologies and models user-friendly. This requires attention to the specific needs of traditional subsistence farmers and modern commercial farmers.

The twofold effort to develop technologies for increased water-use efficiency in both rain-fed and irrigated agriculture, is also in support of global trends: as part of the water focus of the World Summit on Sustainable Development (WSSD), the recommended target is to increase water productivity in rain-fed and irrigated agriculture to enable achievement of food security for all people without increasing water use above levels for 2000. Furthermore, one of the 4 programmes identified within the New Partnership for Africa's Development (NEPAD) initiative, is to expand the extent and operation of integrated land and water management, with the main emphasis on the eradication of poverty in Africa. These trends have been reinforced by the *Comprehensive Africa Agriculture Development Programme of NEPAD*, published in July 2003.

Key stakeholders

This KSA strongly supports South African Government strategies and initiatives where water conservation and especially water utilisation for agriculture is of concern. Government departments, especially the Department of Water Affairs and Forestry (DWAF) and the Department of Agriculture are important key stakeholders. In addition, District Municipalities, Provincial Departments of Agriculture, water user associations (WUAs), catchment management agencies (CMAs), cooperatives and agribusinesses, are all stakeholders with whom the WRC is engaging.

Key stakeholders and beneficiaries of this KSA remain as previously described. These are farmers who are represented by Agri SA and NAFU. It is estimated that there are 50 000 commercial farmers, 240 000 emergent farmers and 3 million subsistence farmers.

Communication channels exist with officials in the representative organisations at a national level. A more effective range of communication strategies must be designed to reach farmers and their representatives at a provincial and local level. The purpose is to obtain an accurate indication of practical problems which they are facing and what their assessment is of the priorities for research, technology transfer and extension.

Other stakeholders

Other organisations providing services to water users in agriculture largely have remained the same as in previous years and are the Provincial Departments of Agriculture (PDAs), the National Department of Agriculture (DoA) through its Directorate: Water Use and Irrigation Development and DWAF through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC are, *inter alia*, an initiative by the DoA to give policy direction to development through integrated water management for agricultural use; and a water conservation and demand management strategy in agriculture that DWAF is implementing. An Interdepartmental Co-ordinating Committee on Support for Small-Scale Irrigation has also been formed, and as part of this action a task team is revising guidelines for project evaluation and implementation of an irrigation strategy.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The Integrated Development NPA is to undertake research which is designed to promote sustainable development in rural and urban areas. In addition various Institutes of the Agricultural Research Council (ARC) obtain funding and undertake research on water-related subjects. Of particular relevance is water research in relation to soils and climate, engineering, field, horticultural and forage crops. At 8 universities across South Africa there are faculties or departments of agriculture, many of whom have in the past mainly relied on WRC funding to undertake water research.

Globally the International Water Management Institute (IWMI), as a member of the Consultative Group on International Agricultural Research (CGIAR), has a sub-regional office for Southern Africa in Pretoria. Since the establishment of the IWMI Africa Office, which is now based in Ghana, the WRC is serving on the IWMI-South Africa Consultative Committee with the main function to determine priorities for IWMI's work in this sub-region. The mission of IWMI is to improve water and land resource management for food, livelihoods and nature.

Providers of research

The main suppliers of research projects are universities and colleges (currently Universities of Pretoria, KwaZulu-Natal, Free State, Stellenbosch, Rhodes, Fort Hare and Tshwane University of Technology); science councils (various institutes of the ARC and CSIR Natural Resources and the Environment); as well as established and emerging private consulting groups.

Strategic Initiatives

National initiatives

- South African National Committee on Irrigation and Drainage (SANCID) Annual General Meeting was held in April 2008, at which the Chairman and Treasurer presented reports for the year 2007 to SANCID members. An overview was given of all activities of SANCID for the period 2005-2008 and this report was also sent to the Central Office of the International Commission on Irrigation and Drainage (ICID). The biennial Symposium of SANCID was also held from 18 to 20 November 2008 at Club Mykonos, Langebaan in the Western Cape. The main theme of the Symposium was 'Agricultural Water Management for Sustainable Livelihoods' and was attended by 105 delegates. Altogether 23 papers were presented of which 50% were based on WRC research projects and included a paper by GR Backeberg and AJ Sanewe on 'Research issues on rural livelihoods and water utilisation in agriculture'.
- South African Institute of Agricultural Engineers (SAIAE) presented a national event for continuous professional development on the subject of 'Energy, Water and Agriculture' in KwaZulu-Natal, 22-23 September 2008. An invited review was given of "Water research issues in South Africa into the future", based on the research strategy of KSA 4.
- Network on Irrigation Research and Extension for Smallholder Agriculture (NIRESA) annual meeting was held on the Zanyokwe irrigation scheme in the Eastern Cape, 1-2 October 2008. Members from government departments, universities and private consulting firms participated in a site visit and debated key challenges for sustainable land and water management for smallholder irrigation.
- The opening presentation was made at a Symposium on 'Underutilised Indigenous and Traditional Crops: Agronomy and Water Use', University of Stellenbosch, 18-19 January 2009. The Symposium was an output of a WRC research project which is being undertaken by the University of KwaZulu-Natal and was attended by delegates from England, India, Malaysia, Botswana and South Africa.
- Formal stakeholder relationships were established with Agri SA, NAFU, Department of Water Affairs and Forestry (Directorate: Water Use Efficiency) and Department of Agriculture (DoA). In the last-mentioned case a meeting was held with officials in various Directorates at the beginning of October 2008, to obtain inputs for identifying research questions and priorities. As part of strategic positioning presentations on 'Managing the innovation process: From research to application' were made on invitation at *Potato SA* on 31 October 2008 and the ARC Vegetable and Ornamental Plant Institute on 13 November 2008.

Leadership positions

- Chairman, Treasurer and Executive Committee members of SANCID
- Member of the Advisory Board of the Institute for Water Economics and Governance in Africa (IWEGA)
- Chairman of Southern African Regional Irrigation Association (SARIA)

Public appreciation

- A consultancy project of the environmental, economic and social impact of the Water Administration System (WAS) was initiated. The report will demonstrate the different dimensions of the impact on water saving which has been achieved with implementation of WAS on commercial irrigation schemes in South Africa.
- The WRC has been supporting the Agricultural Research Centre at Glen near Bloemfontein as well as various other organisations for the past 10 years to conduct research and development in in-field rainwater harvesting (IFRWH) techniques and the dissemination thereof to the inhabitants of 42 villages surrounding Thaba Nchu. An impact study entitled 'Rainwater harvesting and water conservation techniques: Quantifying the impact of ten years of WRC-funded research in Thaba Nchu' was conducted to assess the uptake and impact of IFRWH in these villages. A quantitative survey revealed that uptake and impact of IFRWH is positive – respondents were aware of and able to apply IFRWH. A qualitative survey indicated that social and leadership issues are the determining factors regarding the future success and expansion of IFRWH to croplands, with villages exhibiting strong social cohesion and leadership showing advanced uptake of IFRWH.

African leadership

- Attended the 3rd Regional Conference on Agricultural Water Management in Eastern and Southern Africa, Addis Ababa, Ethiopia, 15 - 19 September 2008. This conference was initiated by the International Fund for Agricultural Development (IFAD) together with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and ICRISAT (an institute at CGIAR) under a programme known as 'Improved Management of Agricultural Water in Eastern and Southern Africa' (IMAWESA). The theme of the conference was, 'Investment in Agricultural Water Management Pays'. The Chairman of SARIA contributed to the conference under the regional initiatives theme participated in the discussions and informed delegates of SARIA's regional initiatives.
- A workshop on *Rainwater Harvesting and Conservation (RWH&C) in the Eastern and Southern Region of Africa* was organised and facilitated by KSA 4 with funding by the Department of Agriculture, 4 - 5 February 2009. The workshop was attended by 9 delegates from SADC countries who are members of SARIA (Southern African Regional Irrigation Association) and 30 delegates from South Africa. A field visit took place to on-farm and on-station research trials of in-field rainwater harvesting and conservation at Thaba Nchu and Glen. During the workshop in Bloemfontein, 7 presentations on different aspects of RWH&C were made and discussed. One presentation was by Mr Patrick Hayombe of the Kenya Water Institute (KEWI). This is the first formal action to implement the exchange of research results in terms of the Memorandum of Understanding (MoU) between the KEWI and the WRC. In addition the Director of KSA 4 was nominated to represent the WRC and serve on

the Advisory Board of the Institute for Water Economics and Governance in Africa (IWEGA), which will be based at the University of Eduardo Mondlane in Maputo, Mozambique.

International player

The KSA represented South Africa with inputs at three international forums:

- The *Sustainable Irrigation 2008* Conference of the Wessex Institute of Technology was attended from 11 to 13 June 2008 in Alicante, Spain. A paper by WL Nieuwoudt and GR Backeberg was presented by Prof L Nieuwoudt during the conference, which was also published as a chapter with the title 'Application of economic instruments, tradable licenses and good governance for sustainable water conservation' in the book *Sustainable Irrigation: Management, Technologies and Policies*, published by WIT Press.
- The *XIIIth World Water Congress* of the International Water Resources Association (IWRA), 1-4 September 2008, Montpellier, France. A paper on 'The challenge of water conservation and water demand management for irrigated agriculture in South Africa' was co-authored and presented by Mr A Pott. This paper was revised and submitted for publication in the journal *Water International*.
- A paper on 'Lessons learnt from an integrated technology exchange project of five water related decision support models by the commercial irrigation sector in South Africa' was co-authored and published in the proceedings of the *20th Congress of ICID*, held in Lahore, Pakistan, 13-18 October 2008. This was one of 3 papers from South Africa and is based on the WRC report TT267/08.

Growing the Knowledge Base

Capacity-building initiatives

Capacity building and competence development occur at the individual, organisational and community level.

In the year under review, 158 students received training as part of KSA 4 projects, of which 113 (72%) were from previously disadvantaged (PD) backgrounds. The total number of students as well as students from previously disadvantaged background has therefore increased by respectively 41% and 38%, compared to 2007/08. Fifty-three (53) female students (30 Black and 23 White), or 34% of the total number, received project-related training. Seven projects were undertaken by private consultants. Four of these are emerging consultancy groups which received research funding for the first time.

TABLE 1
Capacity building through student involvement in KSA 4 projects in 2008/09

Organisation/institution	No. of historically disadvantaged w(HD) students	Total No. of students
Aquagreen Consulting	2	5
Agricultural Research Council (ARC)	9	10
Asset Research	4	12
CPH Water	1	1
CSIR	8	9
Rural Integrated Eng	11	12
Sigma Beta	7	11
Tshwane University of Technology	9	9
University of Fort Hare	13	13
University of the Free State	7	11
University of KwaZulu-Natal	17	29
University of Pretoria	15	16
University of Stellenbosch	8	18
Umlhlab Consulting Group	2	2
TOTAL	113	158

Ongoing efforts are being made to undertake participatory action research projects where farmers benefit directly while the research is being done. At least 60% of the current and new projects involve some form of on-farm research in previously disadvantaged communities which enables project-related education and training of farmers. More concerted focus on this type of research is envisaged for new projects in 2009/10 and thereafter.

Effective knowledge sharing was achieved by organising 8 workshops to develop Terms of Reference (ToR) for new projects during May and June 2008. A wide range of stakeholders from universities, science councils, government departments and private consulting groups were invited and participated. The subjects discussed during the workshops were as follows:

- *Empowerment of Women in Rural Areas through Tenure Security and Skills Training for Gender Equity and Poverty Reduction*, Pretoria
- *Co-Operative Governance in Food Value Chains in Rain-Fed Agriculture to Include Emerging Farmers in the Mainstream of the Economy*, Pretoria
- *Adaptive Practices and Techniques in Agriculture to Reduce Vulnerability of Households/Farms to Climate Change*, Pietermaritzburg
- *Water Use and Economic Value of Biomass of Indigenous Trees under Plantation Conditions*, Pietermaritzburg
- *Impacts of Micro-Organisms, Parasites and Chemicals on Food Safety*, Pretoria
- *Water Use of Crops and Land Suitable for Bio-Fuel Production*, Pretoria
- *Drainage of Degraded Land and GIS Mapping to Monitor the Status of Salinisation and Water Tables on Irrigated Land*, Pretoria
- *Impact of Wastewater Disposal by Wineries on Soils, Crop Growth and Product Quality*, Stellenbosch

Knowledge dissemination

A national drive was undertaken for capacity building and implementations of in-field rainwater harvesting. This involved sending 3 sets of Technology Transfer reports to stakeholders in national and provincial government departments as well as universities; distributing a CD of presentations during the SARIA workshop; publishing an advertorial in *SA Irrigation* (Vol. 30, No. 6, Oct/Nov 2008) with the topic 'On-farm application of in-field rainwater harvesting techniques and practices', and an article in *The Water Wheel* (Vol. 8, No. 2) on the WRC initiative to support up-scaling of in-field rainwater harvesting and conservation (IRWH&C) from homestead food gardens to communal croplands. Continued efforts were made to improve the public understanding of water-related issues by means of popular articles in *The Water Wheel*, and providing brief summaries of recently-published WRC reports in the magazine *Agri*, which is distributed nationally to farmers and agricultural interest groups. One new mechanism for knowledge dissemination was initiated with TV inserts of technologies and practices developed through WRC research projects, which were televised on *AgriTV* (SABC2 on Thursday mornings) during 2008/09.

Conference presentations, publications and other activities by staff members

KSA 4 participated in one internal WRC Open Day, as well as the launch of the WRC Knowledge Review. Leadership in water-centred knowledge comprised chairing national meetings of SANCID, NIRESA and SARIA; participating in

national and international conferences; presenting papers at 2 national conferences and co-authoring papers presented at 2 international conferences:

- An invited review was given at the national event for continuous professional development of the South African Institute of Agricultural Engineers (SAIAE)
- A paper by GR Backeberg and AJ Sanewe on 'Research issues on rural livelihoods and water utilisation in agriculture' was presented at the biennial Symposium of SANCID
- A paper was presented as the *Sustainable Irrigation 2008* Conference of the Wessex Institute of Technology, Alicante, Spain, which was also published as a chapter with the title 'Application of economic instruments, tradable licenses and good governance for sustainable water conservation' in the book *Sustainable Irrigation: Management, Technologies and Policies*, published by WIT Press
- A paper was presented at the *XIIIth World Water Congress* of the International Water Resources Association (IWRA), Montpellier, France. The paper, entitled 'The challenge of water conservation and water demand management for irrigated agriculture in South Africa' was later revised and submitted for publication in the journal *Water International*.

Implementation Plan

Research portfolio for 2008/09

As in previous years, the primary objective was to increase household food security, improve livelihoods of people and to increase efficient growth and equitable distribution of wealth on a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture. The secondary objectives were to:

- Increase biological, technical and economic efficiency of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices

The research portfolio for 2008/09 is presented in Table 2, which provides an overview and description of research thrusts and programmes.

TABLE 2

Overview and description of thrusts and programmes

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Programme 1:
**Water-efficient production methods
 in relation to soils, crops and
 technology in rain-fed and irrigated
 agriculture**

Scope: Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.

Programme 2:
**Fitness-for-use of water for crop
 production, livestock watering and
 aquaculture**

Scope: Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Programme 1:
**Water-efficient production methods
 and systems in agro-forestry,
 woodlands and forestry plantations**

In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Programme 1:
**Sustainable water-based agricultural
 activities in rural communities**

Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities.

Programme 2:
**Integrated water management for
 profitable farming systems**

Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

Programme 1:
**Sustainable water resource use on
irrigation schemes and within river
catchments**

With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.

Programme 2:
**Impact assessment and
environmental management of
agricultural production**

Agricultural decisions to use land and to conserve rainfall or to withdraw water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface water and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

KSA alignment with DWAF's objectives

The research thrusts and programmes in KSA 4 have been purposefully designed and structured to achieve mainly:

- Efficient use of water in rain-fed and irrigated agriculture including forestry
- Reducing poverty levels amongst households in rural communities
- Promoting the protection and reclamation of water resources

Consequently there are a range of projects in the KSA 4 research portfolio that directly contribute to the objectives of DWAF's Strategic Plan for 2007/08 to 2009/10. This can be illustrated by highlighting key projects under the relevant DWAF strategic objectives and KSA research thrusts and programmes.



TABLE 3
KSA alignment with DWAF's objectives

DWAF objectives	WRC thrusts/programmes	WRC projects (examples)
Promote social-economic growth through development of the forestry sector	Water utilisation for fuelwood and timber production • <i>Programme: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations</i>	• Water use in relation to biomass of indigenous tree species in woodland and forest conditions • Agro-forestry systems for improved food production through the efficient use of water • The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services
Ensure reliable and equitable supply of water for sustainable economic and social development including the eradication of poverty	Water utilisation for poverty reduction and wealth creation in agriculture • <i>Programme: Sustainable water-based agricultural activities in rural communities</i> • <i>Programme: Integrated water management for profitable farming systems</i>	• Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods • Nutritional value and water use of indigenous crops for improved rural livelihoods • Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities • Development of a comprehensive learning package for education on the application of water harvesting and conservation • Participatory development of provincial aquaculture programmes for improved rural food security and livelihood alternatives • The development of training material for extension in irrigation water management • Assessment of the contribution of water use to value chains in agriculture • Technology transfer on the technical aspects and cost-estimating procedures of surface and sub-surface drip irrigation systems
Ensure the protection of water resources	Water utilisation for food and fibre production • <i>Programme: Fitness-for-use of water for crop production, livestock watering and aquaculture</i> Water resource protection and reclamation in agriculture • <i>Programme: Impact assessment and environmental management of agriculture production</i>	• Guidelines for sustainable use of greywater in small-scale agriculture and gardens in South Africa • A quantitative investigation into the link between irrigation water quality and food safety • Modelling non-point source (NPS) pollution in agriculture from field to catchment scale • The impacts of unpaved access roads on runoff, sediment fluxes and soil water movement within timber plantations
Water conservation and water demand management	Water utilisation for food and fibre production • <i>Programme: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture</i> Water utilisation for poverty reduction and wealth creation in agriculture • <i>Programme: Integrated water management for profitable farming systems</i>	• Standards and guidelines for improved efficiency of irrigation water use from dam wall release to root zone application • Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement • The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile catchment

Research Projects for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Real-time irrigation advice for small-scale sugarcane production using a crop model, weather data and cellular communication

South African Sugarcane Research Institute (SASRI)

No. 1576

Water-use efficiency in irrigated sugarcane agriculture is very low and could improve dramatically if farmers implement established scheduling methods. The challenge therefore is to provide simple, practical and useful advice to farmers using state-of-the-art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. To address this problem the South African Sugarcane Research Institute (SASRI) developed the **MyCanesim** system. The system provides farmers with access to the power of modern technological advances without the need to learn how they operate. The system was implemented fully on

the Pongola small-scale irrigation scheme. Subscription to the service grew from 10% in 2005 to 87% in 2008. The study showed that significant direct (monetary) benefits are possible, provided the specific prerequisites are in place. An advisory service that provides real-time irrigation scheduling advice based on weather data could be implemented on other sugarcane irrigation schemes, provided that the specific constraints are addressed. The report provides recommendations for the successful implementation of the system.

Cost: R256 000
Term: 2005 - 2008

Integrating and upgrading of SAPWAT and PLANWAT to create a powerful and user-friendly irrigation planning tool PICWAT

No. 1578

SAPWAT3 is essentially an enhanced and improved version of SAPWAT, the program that is extensively applied in South Africa and was developed to establish a decision-making procedure for the estimation of crop irrigation requirements by irrigation engineers, planners and agriculturalists. SAPWAT3 has included in its installed database comprehensive weather data that is immediately available to the user. SAPWAT3 makes provision for the introduction of enterprise budgets as part of the irrigation water requirement planning process. In addition, it provides a rainwater harvesting module aimed at small areas, typically small farms or household gardens. SAPWAT has become the accepted methodology for estimating crop irrigation requirements in a number of aspects of water management and it is foreseen that SAPWAT3 will continue in this role of macro planning; water pricing strategy, registration of water use and verification of legal water use; water demand management strategy; planning and management of small-scale farmer irrigation schemes; planning and management of household and community gardens; support for irrigation scheduling and irrigation system design.

Cost: R537 500
Term: 2005 - 2008

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams

University of Stellenbosch (Division of Aquaculture)

No. 1461

This project investigated the suitability of on-farm irrigation dams for aquaculture fish production and the effect this would have on the quality of the water for irrigation purposes. A study of irrigation dams in the Western Cape and the Makhathini Flats canal system in KwaZulu-Natal indicated that water exchange rate and inflow water quality are main factors in determining the suitability of water bodies for fish production. While the water chemistry did not show effects of aquaculture or differences between production and control sites, the phytoplankton composition and biomass did. Especially during the winter dam turnover, overall biomass of phytoplankton was higher at all production sites. The additional clogging of filters as a result of changes in phytoplankton biomass was the most significant

impact of aquaculture on the quality of water for irrigation. It was further found that a significant portion of the fertiliser requirements of the crops irrigated from the dams would become available because of aquaculture activities.

Cost: R1 000 000
Term: 2003 - 2008

Scoping study to determine the potential impact of agricultural chemicals (pesticides) with endocrine disruptor properties on the water resources of South Africa

AEC Burger (Private Consultant)

No. 1774

Endocrine-disrupting chemicals (EDCs) are defined as chemicals that interfere with the structure or function of hormone-receptor complexes that can cause endocrine disruptive effects at exposure levels up to a million times lower than carcinogen exposure levels of concern. Concern has been expressed that some of the pesticides used in agricultural practice may pollute rivers and dams and cause endocrine disruptor (ED) effects in animals and humans. It is, however, not clear what the impact of these chemicals is on the resources. The main objective of this study was to gather information in order to determine whether a larger study is justified. In this project, the focus is on chemicals (pesticides and drugs for domestic animal production) with ED properties used in crop production and animal husbandry activities to gather information in order to determine whether a larger study is justified. Other spraying programmes using pesticides are included in the report. The results indicated that a more comprehensive study is needed to determine the impact of agricultural pesticides with ED properties on South African water resources. However, it must be realized that ED activity in water resources is not only due to the presence of agricultural pesticides; therefore to determine the impact of only agricultural pesticides will be a difficult and complex exercise.

Cost: R250 000
Term: 2007 - 2008

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water use in relation to biomass of indigenous tree species in woodland, forest and /or plantation conditions

CSIR

No. 1462

The aim of this solicited research project was to investigate rates of growth and water-use by a wide selection of indigenous tree production systems, and to make economic and hydrological comparisons to current commercial forestry systems. Several models were used to gain insights into growth and evaporation processes, and for extrapolating daily ET from limited periods of measurement to whole years or longer. Different models were found to be required for different sites and species. Modelling experience during the course of the project has led to improved recognition of the important features of different forests, and the advantages and disadvantages of various models. Economic analyses have clearly shown that volume growth is not a major

criterion affecting the economic viability of forests. Timber value may be far higher for certain indigenous hardwood species than for commercial forest species. Low management costs also play a role in increasing the economic viability of new forms of forestry based on indigenous species. The water use efficiency (WUE) of indigenous species of trees appears to be generally lower than for commercial forest species. Transpiration remains relatively low in comparison to the more productive commercial species, particularly *Eucalyptus grandis*. Results therefore confirm the observation that indigenous species in general appear to possess an advantage over commercial species in productive sites in their lower water-use and lower streamflow reduction impact.

Cost: R2 249 616
Term: 2003 - 2008

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Integrating floodplain livelihoods into a diverse rural economy by enhancing co-operative management: A case study of the Pongolo floodplain system, South Africa
University of KwaZulu-Natal (Centre for Environment, Agriculture and Development)
No. 1299

The approach to integrating livelihoods into a diverse rural economy was understood through stakeholder dialogue workshops. The outcome from these studies was then linked to knowledge from literature reviews underpinning certain aspects of the ecological, social and economic thinking in order to not only illustrate the 'agriculture, water and the environment debate' within a 'water and society' context but also to identify knowledge gaps requiring further research. Consideration of all the stakeholder interests, including interests within floodplain communities, showed clearly that despite the scientific knowledge and technical skills required to manage the delivery of flows of water from the Pongolapoort Dam, which can sustain a diverse socio-economy, the management system has strengthened some sectors at the expense of others. The causes of the current inequitable situation are centred in the failure to implement integrated rural development on a catchment/regional scale through co-operative community-based approaches; failure to apply scientific knowledge; and inability to effect corrective action with commitment, in response to evidence of inequity and a move away from the ecologically desired state for the system.

Cost: R880 000
Term: 2002 - 2008

Indigenous water harvesting and conservation practices: Historical context, cases and implications
Umhlaba Consulting Group
No. 1777

Indigenous rainwater harvesting and conservation practices are the product of accumulated knowledge, practices and traditions which have evolved over many generations of experimentation

and adaptation. This scoping study identified 13 practices across the breadth of South Africa and reported in detail on ten of these: one distinctly indigenous (Gelesha practice), five indigenised (in that they are the product of local and external influences) and four more which are essentially contemporary-scientific methods. The techniques that were documented in detail (written report and DVD) covered scales varying from tens of thousands of hectares (Saidamme) to micro-catchments of a few square metres in size. The study concluded that while there is substantial anecdotal evidence of agricultural water-use in South Africa since the stone-age, indigenous rainwater harvesting and conservation technologies have not evolved to the same extent as in the more arid areas of North Africa. This is explained by historical settlement in the wetter eastern half of South Africa and a cattle-based culture.

Cost: R250 000
Term: 2007 - 2008

Current Projects

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Standards and guidelines for improved efficiency of irrigation water use from dam-wall release to root zone application
ARC (Institute for Agricultural Engineering)
No. 1482

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The levels of efficiency of water use which are currently attained will be scrutinised and particular attention will have to be given to the management of water use. Broadly defined, management of water use starts at dam wall releases, through river or canal conveyance, on-farm storage and distribution, in-field application up to root zone storage. However, the problem is that at present there is no standardised terminology, comparable benchmarks or generally acceptable guidelines to improve water use and irrigation efficiency. These issues must be urgently addressed in order to provide consistent management advice and comply with the requirements of the National Water Act of 1998 regarding compulsory licensing and periodic review of licences. For the purposes of planning, design and operation of water supply systems, definitions of various efficiency terms need to be clearly stated, understood and accepted by all stakeholders. The site-specific criteria and tools which will be used to measure efficiency and practically achievable bench-marks need to be established. In order to achieve this, the proposed research project must be undertaken on a representative number of irrigation schemes which should include but are not limited to the following: Loskop; Tabana; Middle Letaba; Crocodile/Komati; Pongola; Makhatini; Gamtoos; Sundays; Orange-Riet; Vaalharts; Breede; Hex; Hartbeespoort.

Estimated cost: R5 742 128 (incl. leverage)
Expected term: 2004 - 2009

Adapting the Wetting Front Detector to the needs of small-scale furrow irrigators and providing a basis for the interpretation of salt and nutrient measurements from the water sample

University of Pretoria (Department of Plant Production and Soil Science)

No. 1574

The Wetting Front Detector was developed by Australian scientist Richard Stirzaker following a number of years work at the Tompi Seleka College of Agriculture in the Limpopo Province. The WRC funded a project (WRC **Report No. TT 230/04** entitled **Building Capacity in Irrigation Management with Wetting Front Detectors**) between June 2000 and December 2003 to continue the development of the Detector and introduce the technology to irrigation farmers in South Africa. Early results from field trials and feedback from farmers were sufficient to convince an irrigation agronomist from a South African Irrigation Manufacturer, Agriplas (Pty.) Ltd., to consider developing the detector into a commercial product. The project was nominated by SANCID as contender for the WATSAVE award and won the international prize for 'Outstanding Contribution to Water Saving and Water Conservation in Agriculture' presented by the International Commission of Irrigation and Drainage in France in 2003. However, the Detector, which strives to make more efficient irrigation accessible to the majority of farmers, is in its infancy. In particular, there is a lack of understanding of how to deploy the device for furrow irrigation and how to interpret the salt and nutrient concentrations measured from solution captured by the detector. Most of the current requests for information and support arise from these applications; furrow irrigation and solution sampling. Ninety-five percent of the research work on the Detector has been carried out on drip, micro-jet, and sprinkler systems. Most of the small-scale farmers, a key target audience, use furrow irrigation. The WRC **Report No. TT 230/04** provides conflicting evidence on the usefulness of detectors for furrow irrigation. Pilot studies carried out in Australia have demonstrated that monitoring of salt and nitrate can provide very useful information to farmers. In South Africa, 54 people using Detectors were asked in a survey why they were interested in the technology and 20% replied that their interest lay in monitoring electrical conductivity and nutrients in the soil water sample collected by the Detector. As soon as the Detector becomes widely available, numerous enquiries about which solutes to monitor, what techniques to use and how to interpret the results are anticipated. Therefore, there is an urgent need to do the underpinning science in order to provide reliable information.

Estimated cost: R1 402 000
Expected term: 2005 - 2009

Increasing water-use efficiency of irrigated sugarcane production by means of good agronomic practices

South African Sugarcane Research Institute

No. 1577

Low irrigation water-use efficiency (IWUE) has been identified as a major problem in irrigated areas and this is even more important when the source of water is limited. Results reported by Olivier and Singels (2003) indicate that IWUEs of between 12 to 18 t cane/100 mm irrigation are possible as compared to 6t cane/100 mm averaged in the Onderberg at present. Agronomic practices such as the use of a trash (plant residues) blanket,

growing suitable varieties, reduced row spacing and appropriate irrigation scheduling could increase the IWUE by saving water and/or increasing yield. Thorburn et al. (1999) have indicated that a trash blanket can reduce soil evaporation by an amount equal to 16% of annual rainfall. However, a trash blanket could also have a negative effect on the crop by slowing down initial growth, tillering and radiation interception and creating problems with trash worm and *Eldana*. Recent plant crop results by Olivier and Singels (2003) have shown that yields of a drip-irrigated plant crop can be increased by 10% and IWUE by 6% when changing row spacing from the standard single row spaced at 1.5 m to dual rows spaced at 1.8 m. The response to trash blanketing and high density planting depends on variety. According to Singels and Smit (2003) the very large yield responses to row spacing (53% per 1 m reduction) reported in Australia are the result of certain varieties having a low tiller production potential in the plant crop and therefore performing poorly in wide rows. It is believed that IWUE could be increased considerably by providing farmers with custom-made irrigation scheduling strategies for specific trash blanket, variety and row spacing combinations. Simple and easy-to-use irrigation calendars (with appropriate cycle and stand times) will be generated for areas with overhead irrigation by applying an accurate crop model to historic climate data. The outcomes of this research will include recommendations on best management practices (BMP, combinations of trash blanket, variety, row spacing, and irrigation scheduling strategy) for efficient and profitable use of irrigation water. Information will be available for the development of a trash blanket algorithm for the *Canesim* simulation model.

Estimated cost: R236 200
Expected term: 2005 - 2009

Guidelines for irrigation management in pasture production CSIR (Natural Resources and the Environment) No. 1650

It is estimated that the total area utilised for irrigated pasture production is approximately 16% of the total area under irrigation. The returns generated from these enterprises make pastures one of the higher value crops produced under irrigation in this country. However, the management of the water requirements of pastures is not easy. They are often established on heavy and shallow soils that would not normally be considered for irrigation. Limited rooting depths and the need to integrate irrigation and grazing management further aggravate the position. Judicious management of irrigation is essential not only to utilise labour and water resources effectively and maintain production and profitability, but also to prevent serious degradation of land. Although management of dairy farming has now attained unprecedented levels of technology due largely to the availability of practical equipment and methods for planning, managing and monitoring most facets of dairy farming, this does not apply to the irrigation of pastures. That still tends to rely on experience and tradition despite the increasing role of pastures in milk production.

It appears likely that it will be possible to develop a model or models that can be used to integrate the factors that must be taken into account when planning irrigation strategies and methods. It should also be possible to develop practical on-farm equipment and methods for recording and monitoring performance. There is, however, a dearth of reliable information and data pertaining to pasture water requirements to facilitate these developments. Alternate methods to address this problem

therefore need to be investigated and applied in practice in order to increase water use efficiency at farm level. This will be done initially by assessing the application of the main irrigation methods in conjunction with accepted grazing and irrigation management strategies and identifying opportunities for improvement. The 2nd phase would target the development of databases on the fodder crops and their characteristics, climate, soils, irrigation and on the development of methodologies for measurement and monitoring. The validity and practicality of the material and equipment developed would finally be assessed in conjunction with the industry.

Estimated cost: R2 117 600

Expected term: 2006 - 2011

Water use of fruit tree/orchard crops

CSIR (Natural Resources and the Environment)

No. 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently-published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate, soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water-use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, sub-tropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectareage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R4 350 000 (incl. leverage)

Expected term: 2007 - 2013

Water use of drought-tolerant food crops

University of KwaZulu-Natal (Crop Science)

No. 1771

A significant proportion of the South African population experiences food insecurity and malnutrition (micronutrient deficiency) despite living in a country that is a net exporter of food. One of the main food security challenges facing the country

is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. About 14.3 million people are vulnerable to food insecurity, particularly women, children and the elderly. There is therefore a need to increase the content of the South African food basket particularly for the poorest households living in rural areas. However, drought is one of the major hurdles facing agriculture in Sub-Saharan Africa. South Africa, like many countries in the region, is prone to severe water shortages which seriously impacts on the availability of food. One way to combat inadequate availability of water is to develop or select crops that are more tolerant to water stress. Indigenous edible plants that are resilient have sustained rural populations in developing countries for centuries. These traditional crops are native to specific localities and are therefore better adapted to the local environmental conditions and cultivated without the need for much external inputs such as agrochemicals or a high water requirement. However, information on the utilization of indigenous crops in South Africa is not well documented. Moreover, no comprehensive overview of the spectrum of food crops available for food production in South Africa in relation to drought tolerance, crop adaptability, economic importance and water use characteristics has been conducted. This project seeks to understand the water use characteristics of drought-tolerant crops through the use of empirical measurement and crop growth models. The parameters needed for modelling will guide the empirical research.

Estimated cost: R4 350 000 (incl. leverage)

Expected term: 2007 - 2013

Scoping study on water use of crops/trees for biofuels

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1772

Biofuels such as bio-ethanol and bio-diesel have been widely publicized as the means to sustainably meet South Africa's future energy needs. The establishment of an economically-viable biofuels industry is increasingly becoming an attainable prospect due to: technological advances; high oil prices; global commitment to limit greenhouse gases and to reduce global warming; the requirement to diversify energy supply and the enormous potential for local job creation, particularly in the agricultural sector. Various government departments including Minerals and Energy, Agriculture and Science and Technology are to begin an initiative to explore biofuels as an important component of the energy mix. Biofuels are renewable liquid fuels derived from, among other sources, the sustainable agricultural production of field crops and tree crops. South Africa is a water-scarce country whose rainfall is below the world average and whose rainfall distribution is, temporally and spatially, unreliable. Furthermore, the country has limited supply of water for irrigation. Therefore, the prudent selection of crops that will ensure the efficient and sustainable use of limited water resources will be essential. This project is addressing the suitability of various agriculturally-based products. It focuses on identifying the most suitable crops for biofuel production and establishing the available knowledge on water use of these crops. It will determine the water requirements of crops where information on water use is lacking but crop parameters are available by applying appropriate models.

Estimated cost: R250 000

Expected term: 2007 - 2008

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Guidelines for sustainable use of grey-water in small-scale agriculture and gardens in South Africa

University of KwaZulu-Natal (School of Biological and Conservation Sciences)

No. 1639

The *White Paper on Agriculture* emphasises food security. Since household and urban food gardens form part of the spectrum of production systems and processes that can contribute to food security, they are supported by government. However, a shortage of water to supplement rainfall often limits the application potential of these systems. The use of grey-water may overcome this limitation by providing a dependable water source that is under the control of the household gardener. Grey-water is the untreated household effluent that is produced from baths, showers, kitchen and hand-wash basins as well as washing machines. More than half of the indoor household water use is normally used for these purposes and can thus potentially be intercepted by the householder for additional uses. Initial indications from a scoping study to evaluate the fitness-for-use of grey-water in urban and peri-urban agriculture are that there is considerable potential to use this largely untapped source to augment household food security. However, there are also risks involved with the practice that need to be better assessed and quantified under controlled conditions. These risks are largely associated with factors that affect the sustained productivity of the irrigated soil and health considerations. A workshop is planned to prioritise these risks and finalise the appropriate experimental approach to address them before finalising the terms of reference and soliciting project proposals

Expected cost: R1 670 000

Estimated term: 2005 - 2009

A quantitative investigation into the link between irrigation water quality and food safety

University of Stellenbosch (Department of Food Science)

No. 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in, e.g., informal settlements, and failing water treatment in, e.g., non-operating sewage works. This water is often used for irrigation and there is a direct relationship between irrigation water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers, while there is also an increase in the susceptible individuals. A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and internationally. The problem of contamination of irrigation water and

food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets. Biomonitoring of irrigation water quality is currently fragmented and not regularly published. Little is therefore known on a national level regarding the contribution of irrigation water and the associated potentially-contaminated raw produce to the burden of disease. Consequently little action is taken to remedy the situation. A clearer understanding of the problem is urgently required to make inputs for policy formulation and regulation to reduce contamination of irrigation water. This project will investigate the links between irrigation water quality (microbial and nutrient chemistry) and food safety in commercial as well as subsistence agriculture and give guidance towards treatment options of irrigation water to ensure food safety. This research project will therefore evaluate the extent of the problem regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two and provide recommendations on the way forward in terms of treatment of irrigation water. To achieve this, the main tasks include a baseline study on the extent (types and quantities) of contamination found in irrigation water as well as contamination found on the irrigated raw produce (fruit and vegetables) before and after harvest at the selected sites. The final report will document the extent of contamination found in irrigation water and on the irrigated raw produce; the links between contamination on raw produce and irrigation water applied; and make recommendations for further research in respect of validation of results and treatment options.

Estimated cost: R5 232 500 (incl. leverage)

Expected term: 2007 - 2012

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Agro-forestry systems for improved food production through the efficient use of water

CSIR (Natural Resources and the Environment)

No. 1480

Less than 15% of land area in South Africa is arable. This implies that there is very limited scope for conventional food production, both on irrigated and dry-land. In addition to limited arable land, South Africa is a water-scarce country. Its rainfall is below the world average, and its distribution is somewhat unreliable. The relatively low rainfall and limited arable land make it imperative to effectively and efficiently use these natural resources for food and fibre production. This is even more important for emerging and subsistence farmers who often lack access to information and use of production technologies.

Smallholder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have

been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands. In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor. This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally. Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment

Estimated cost: R3 250 000

Expected term: 2004 - 2009

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

The effect of the introduction of agroforestry species on the soil moisture regime of traditional cropping systems in rural areas. Phase II: On-farm trials of alternative agro-forestry systems

CSIR (Natural Resources and the Environment)

No. 1351

One of the major constraints in rural farming systems of the Upper Thukela is the shortage of adequate and good quality grazing during the dry winter season. Unfortunately, supplementation of feed using commercial supplements is difficult because the supplements are expensive and not easily available in remote areas. Provision of alternative sources of fodder such as tree leaves and pods can increase production. The introduction of tree species for fodder should decrease the grazing pressure on the existing grassland. This will result

in improved basal cover, decreased soil erosion and promote greater water infiltration. The project aims are:

- To determine the effect of different agro-forestry systems on increasing fodder production in rural farming systems
- To determine the effect of agro-forestry practices on soil water availability to traditional crops (e.g. maize)
- To determine whether the inclusion of trees in traditional cropping systems can enhance the infiltration of rainfall and prevent soil loss
- To compare the water use of an indigenous fodder tree (*Acacia karoo*) and an exotic fodder tree (*Morus albus*), in order to test the hypothesis that indigenous fodder trees are more conservative water users than exotic tree species.

Estimated cost: R2 400 000 (incl. leverage)

Expected term: 2002 - 2011

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province

Zakhe Agricultural College

No. 1465

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exerts even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention should be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods should be analysed.

Estimated cost: R3 000 000

Expected term: 2003 - 2009

Best management practices for smallholder farming on 2 irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research

University of Fort Hare

No. 1477

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology

transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. The research project on 'best management practices for small-scale subsistence farming' therefore requires commitment and co-operation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000
Expected term: 2004 - 2009

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province
University of Fort Hare
No. 1478

Approximately 74% of South Africa's rain-water is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 200 000
Expected term: 2004 - 2010

Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods

Rural Integrated Engineering (Pty.) Ltd.
No. 1575

The rural landscape of South Africa is characterized by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location, ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the Government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Expected cost: R2 750 000
Estimated term: 2005 - 2009

Nutritional value and water use of indigenous crops for improved rural livelihoods
University of Pretoria (Centre for Nutrition)
No. 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (**WRC Report No. 944/1/04**). It is also important to determine the nutritional value and water requirements of these crops. The best combination, between indigenous crops and a range of home-grown vegetables and other foodstuffs, to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (**WRC Report No. 1267/1/04**). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosha, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of

food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households. An interim report on the outcomes of this project has been published: **WRC Report No. TT 362/P/08, Nutritional Status of South Africans: Links to Agriculture and Water.**

Expected cost: R5 700 000 (incl. leverage)
Estimated term: 2005 - 2010

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities

University of the Free State (Department of Agricultural Economics)

No. 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on biophysical aspects of in particular infield RWH&C has been done (see **WRC Report No. 1176/1/03**). A start has also been made to evaluate the social acceptability and economic viability of this technique (see **WRC Report No. 1267/1/04**). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the United Nations Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R3 100 000 (incl. leverage)
Expected term: 2006 - 2011

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa

ARC (Institute for Soil, Climate and Water)

No. 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorized as ultra-poor. Although the country is self-sufficient in food production, about 14 million people are reported to be vulnerable to food insecurity and 43% of households suffer from food poverty. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas. Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned but used communally by farmers for grazing domestic livestock and harvesting natural products such as fuelwood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterized by abandoned croplands that are infested by weeds and grasses. In communal areas, where individuals share land and water resources, understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is dependent upon the functioning of the institutional arrangements. Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop lands in communal areas will be produced.

Estimated cost: R4 728 500 (incl. leverage)
Expected term: 2007 - 2013

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)

Umhlaba Consulting Group

No. 1776

Water harvesting and conservation practices have been tested and demonstrated to be sustainable and contribute to food security. Many of these techniques and practices have been documented in the form of research reports and information material for public interest, but not packaged as training material for the end user. In addition, advisors and farmer support personnel such as extension services are often ill-informed and inadequately trained in agricultural water management including water harvesting and conservation. High illiteracy, particularly among the rural population, limits the ability of farmers to access information and utilise new technologies. There is, therefore, a need for accredited yet appropriate training material for certified trainers and learners (farmers). Training, education and skills development will need to follow a broad-based approach that is aligned to government initiatives such as the Joint Initiative on Priority Skills Acquisition (JIPSA) and grounded on Outcomes Based Education (OBE) and Adult Basic Education and Training (ABET) principles. This project will develop a comprehensive learning package for the application of WH&C for household food production and poverty alleviation in rural areas. It will identify the existing unit standards for training in WH&C and fill the gaps in learning material by adopting and adapting available material and developing a comprehensive

package (NQF level 4/5 facilitators guide for trainers, ABET levels 1 and 2 learning material for learners and assessment guide). The learning package will be tested in the field with trainers, facilitators and learners.

Estimated cost: R1 950 000

Expected term: 2007 - 2012

Programme 2: Integrated water management for profitable farming systems

Water resource management for profitable small-scale farming along the banks of the Orange River

University of the Free State (Department of Agricultural Economics)

No. 1354

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment. The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa. Sub-aims are to:

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land

Estimated cost: R970 000

Expected term: 2002 - 2008

Revitalisation of provincial fish hatcheries and training facilities to promote profitable aquaculture

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1580

A baseline study on the *Contribution of Aquaculture to Rural Livelihoods in South Africa* has been done by Rhodes University (WRC Report No. TT 235/04). This study showed that the present factors constraining aquaculture in rural areas were mainly a consequence of a lack of policy and institutional capacity and that the development of rural aquaculture will depend principally on a public sector led intervention, inclusive of technical support

and fingerling supply. The study revealed that there are many state-owned hatcheries and training facilities falling under various government departments that are unproductive, privatised, or defunct. Though not assessed these assets are worth millions of rand. Based on the survey results it was further agreed that the involvement of the private sector in rural aquaculture would be essential for sustainable growth. As policy issues were being addressed by the National Department of Agriculture, it was suggested that the WRC should support the undertaking of workshops in preparation for participatory action research (PAR) with the various public and private sector stakeholders to appraise the potential role of these hatcheries in the light of emerging policy, and where applicable to develop a framework for a community private public partnership (CPPP) to revitalise government hatcheries that are currently under-utilised. The workshops have been completed and the PAR can now proceed. The PAR is a process which includes research and implementing goals and objectives. Stakeholders in the Limpopo, Mpumalanga and Eastern Cape Provinces will be engaged and an end-point will be identified (for example, through CPPP revitalising a specific government hatchery). Once the end-point has been identified, the role of the PAR implementers would be to actively facilitate and record the process, so that it is successful and repeatable elsewhere.

Expected cost: R4 500 000 (incl. leverage)

Estimated term: 2005 - 2010

Development of training material for extension in irrigation water management

University of Pretoria (Department of Agricultural Economics, Extension and Rural Development)

No. 1649

The revitalisation of irrigation schemes and irrigation management transfer is accepted policy in South Africa (Department of Agriculture, 2003). Implementation of this policy can, however, not succeed without extension support. In the process of integrated development planning (IDP), extension services are also the essential link between government and rural communities who are dependent on agriculture. In both cases extensionists therefore perform an important function to promote agricultural development, which in turn leads to community development. It is generally recognised that extensionists provide the link between research output and solving the perceived problems which farmers experience. All types of farmers, but specifically emerging farmers, are dependent on extension services as a source of information and knowledge. This has been confirmed by a survey amongst emerging irrigation farmers (WRC, 2003). Discussion forums organised by the WRC in all provinces between 2000 and 2003, in which a wide range of farmers participated, have highlighted that the extension link has deteriorated in recent years and has become less effective. Presently information is available on various biophysical and socio-economic aspects of irrigation management. Irrigation-related courses are also presented by universities and colleges. However, this information is not presented in the required format and the courses are not specifically targeted to be useful for extensionists in their work environment. Extensionists therefore do not have the appropriate knowledge base and skills to do their work. In many cases this results in a lack of confidence amongst extensionists, decline in their credibility and withdrawal from the community which they must serve. There is an urgent need to restore the

self-esteem of individuals and improve the service delivery of the extension profession. Extensionists require in-service training on all aspects of irrigation management, to meet the demands of subsistence, emerging and commercial smallholder farmers. Training material must be developed or adapted for this purpose. This will enable extensionists to become more effective, with the benefits not being limited to farmers only, but having a positive impact on the community in which extensionists and farmers live.

Estimated cost: R2 370 000 (incl. leverage)
Expected term: 2006 - 2011

Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement

WSM Leshika (Pty.) Ltd.

No. 1778

According to the National Water Resource Strategy of 2004, national water conservation and demand management (WC & DM) strategies are being developed. The strategy for irrigated agriculture provides a framework of regulatory support and incentives to improve efficiency, with a plan of action towards delivering amongst others the following outputs:

- Implement measures that reduce wastage
- Convince users to progressively modernise their water conveyance infrastructure and irrigation equipment.

The recently-published Water Conservation and Water Demand Management Conditions for Water Use Sector Authorisation (DWAF, 2006) imposes a duty to measure, record aspects of water use and requires that 'the licensee shall measure the amount of water supplied to each farm or user on a monthly basis using an appropriate flow measurement device'. The WRC has published reports and guidelines for the direct and indirect measurement of water on irrigation schemes in response to the practical need to measure and manage water effectively and efficiently. However, in most cases the water management system currently in operation does not incentivise water measurement, and consequently measurement of water use and volumetric charging is not widely practised. This project will facilitate a process towards effective implementation of water measurement at river, irrigation scheme and farm level in South Africa. In order to achieve this, end users of water measurement technology will be made aware and convinced to adopt the technology. Specific attention will be given to technical constraints and financial justification for implementation of the technologies for water measurement. This will require purposeful capacity building and training of end-users such as farmers while using the model of 'train-the-trainer', which has been found to be most successful. In this process a common understanding of the practical requirements of water measurement by water users, water managers and regulators will have to be reached. Therefore it is necessary to obtain support of the DoA and DWAF on training for adoption of water measurement. Since water user associations (WUAs) will increasingly provide an advisory role, the managers of WUAs and leader farmers whom they serve, will be targeted in order to achieve sustainable implementation of water measurement. The intention is to interact with these stakeholders as part of the preparatory phase; determine the incentives for water measurement as part of the analysis phase; and practically demonstrate how to undertake effective water management in the implementation phase. The final output of

this technology transfer project will be an overarching report that documents the implementation process, the lessons learned and guidelines towards general implementation of water measurement.

Estimated cost: R1 400 000
Expected term: 2007 - 2011

Assessment of the contribution of water use to value chains in agriculture

University of the Free State (Department of Agricultural Economics)

No. 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the Agriculture Sector Plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-ranging programme is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises: how can emerging producers be included in the mainstream of the economy? Only by obtaining access to available resources or assets in agriculture, can an impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically-beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the economy. It will investigate whether emerging farmers, who are producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development. The main outputs will be: firstly, a conceptual framework based on the literature review of the value chain analysis with specific reference to water utilisation and competitiveness in agriculture; secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticultural and field crop industries; thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain, optimisation of water use in the whole value chain, mainstreaming of marginalised participants in the economy by integration in the value chain, employment creation and poverty reduction through the value chain, and improving competitiveness in the value chain.

Estimated cost: R2 430 000
Expected term: 2007 - 2012

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Managing salinity associated with irrigation in selected areas in South Africa

University of the Free State (Department of Soil, Crop and Climate Sciences)

No. 1647

Because crops use water consumptively it is an inevitable consequence of irrigation that the salts in irrigation water are being concentrated in the soil. Since crop yield, in turn, is reduced at high soil salinity levels, it is a prerequisite for sustainable irrigation (and to protect the soil resource base) that soil salinity be managed to remain at levels that support acceptable crop yield. Current practice is to achieve this by applying water in excess of crop requirement, whereby some of the accumulating salt is leached from the root zone. The practice to leach salt from soil, which ensures the sustainability of irrigation from an agricultural perspective, has the undesirable side-effect of salinisation of ground and surface waters. The negative impact irrigation return flows have on water quality is observed in practically all irrigation schemes. Because of the negative impact that 'irrigation wastewater' (leachate and drainage water) has on other water resources, there is an increasing range of initiatives that are being investigated both locally and internationally to improve the way in which to manage this impact at both farm and scheme level.

Even though there is concern about the environmental impact of irrigation, the need for increased agricultural production and assurance of supply seem to necessitate the continued expansion of irrigation on a global basis. In view of the increasing demand for water resources and irrigation's relative inability to compete with other sectors for high quality water sources, it is foreseen that in the case of South Africa the future expansion in irrigation area will increasingly have to rely on poorer quality water. By making use of poorer quality (waste) water, irrigation would also be able to free up better quality water for other productive uses. However, such a move will make even greater demands on the ability of irrigators and water managers to manage salinity and its effects on crops and environment. It is thus clear that the sustainability of irrigated agriculture will to a large extent be determined by our collective ability to manage the problems associated with salinity. Much of the success of such management strategies will depend on the success with which the 'wastewater' can be utilised within irrigated agriculture. Although much in this regard has already been learnt locally and internationally, the practical application of these lessons is lagging behind. It is thus envisaged to conduct a project that would synthesise current knowledge and select the appropriate practices for application and testing in a number of case study areas with existing problems. It is anticipated that this evaluation would enable the development of specific guidelines for the management of the case study areas with as aim to bridge the gap between existing knowledge and its application, the formulation of generalised recommendations about the implementation of sustainable solutions to the management of salinity on irrigation schemes, the identification of incentives that can be applied to modify the behaviour of water managers at farm and scheme level and the identification of research or knowledge gaps.

Estimated cost: R2 480 000
Expected term: 2006 - 2010

Programme 2: Impact assessment and environmental management of agricultural production

Modelling non-point source (NPS) pollution in agriculture from field to catchment scale

Sigma Beta Consulting

No. 1516

It is increasingly recognised that non-point source (NPS), or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore increasingly accepted that it is unfeasible to properly manage water quality without addressing the contribution from non-point-sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. Since most of the land area is utilised for agricultural activities, agriculture has both locally and internationally been implicated as a major source of NPS pollution. It is therefore necessary to assess the contribution that the different agricultural activities make to the different manifestations of NPS pollution, to devise the means through which these can be controlled and to determine and predict the effect that control measures will have to reduce NPS pollution. Understanding the production, delivery, transport and use components of agriculture-derived NPS loadings of water resources and having a predictive ability about the fate of agriculture-related NPS constituents are discrete research themes that will enhance the usefulness of the existing guidelines in the agricultural domain. The contribution of irrigation activities towards the salinisation of water resources has been studied for quite some time and is currently still receiving attention. Other water quality issues of concern that are potentially aggravated by agricultural activities are eutrophication (through fertiliser leaching and wash-off from human settlements), sediments (as a result of erosion), pathogens (from intensive animal production units), pesticides (through the application of insecticides, fungicides and herbicides) and some heavy metals. Although agricultural activities that give rise to the latter water quality issues have been the subject of previous studies, the present level of knowledge concerning them is not as advanced as for irrigation-induced salinisation of water resources. The project will address those issues that require priority attention, with regard to NPS pollution.

Estimated cost: R5 000 000
Expected term: 2004 - 2009

Applications of rainfall forecasts for agricultural-related decision making in selected catchments

University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)

No. 1646

The South African climate is highly variable over short and longer periods. This inter- and intra-seasonal variability is likely to be amplified by the global change in climate. Agricultural production is intrinsically linked to climate variability. Many agricultural decisions are made based on climate (short, medium and longer term) information and assumptions. Farmers need information to help them plan for planting, irrigation and harvesting of their crops. Weather forecasting can aid users to make more informed decisions and assist in planning activities. They have the potential to reduce risk in the long term and

improve water-use efficiency. Forecasting involves computer models, observation and knowledge of trends and patterns. Using such tools, meteorologists can reasonably forecast weather conditions up to 5 days in advance. Longer lead-time forecasts (weeks, months) are referred to as climate forecasts. Such forecasts, usually made in terms of categories (above, near and below normal) and probabilities, are becoming more skilful as research progresses. However, gaps exist between the weather and climate forecasts and linking them to agro-hydrology and applications in agricultural decision-making. The project aims to develop techniques and models for translating forecasts of up to 1 year in advance into applications for decision support.

The WRC has funded several projects over almost 2 decades on research on climate variability with a focus on forecasting, modelling and database development. These include *inter alia*:

- **Development of a Raster Database of Annual, Monthly and Daily Rainfall for Southern Africa (WRC Report No. 1156/1/04)**
- **A Flood Nowcasting System for the eThekweni Metro: Volume 1 and 2 (WRC Report No. 1217/1/04 and 1217/2/04)**
- **Spatial interpolation and Mapping of Rainfall (Simar): Volume 1 – 3 (WRC Report No. 1151/1/04; 1152/1/04 and 1153/1/04)**
- **Regional Model Development for Simulating Atmospheric Behaviour and Rainfall over Southern Africa (WRC Report No. 1261/1/05)**
- **Dynamic Modelling of the Present and Future Climate System (WRC Report No. 1154/1/04)**

These and other projects have resulted in more comprehensive datasets and a better understanding of weather and climate variability and refined forecasting tools. It is therefore in the interest of the WRC to see this research utilised. The 2001 Strategic Plan for South African Agriculture states that one 'component of the comprehensive risk management strategy is an early-warning system that includes adequate access to and utilization of timely, accurate, relevant, and free information about the weather'. Since the end of 2002, the National Department of Agriculture has been advising farmers on climate conditions and practices to follow, based on a long-term climate outlook. It is envisaged that this project will develop an early warning system with different lead-times that could reduce farmers' susceptibility to adverse weather conditions. Although the project will focus on 2 or 3 critical catchments, the findings of this study will be extrapolated to other catchments.

Estimated cost: R5 700 000 (incl. leverage)
Expected term: 2006 - 2011

New Projects

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact

University of Stellenbosch (Division of Aquaculture)
No. 1802

This project will investigate the feasibility and practical implications of using on-farm irrigation water storage dams for aquacultural fish production. A recently-completed WRC **Project (No. 1461)** found that although this dual use of water is mostly beneficial, it can also impact on water quality. This is a follow-on project that will continue with monitoring the effects of aquaculture at a number of sites, follow-up on the environmental concerns (especially enrichment or eutrophication of dam water) and investigate management and other measures aimed at reducing the enriching effects associated with intensive cage aquaculture.

Estimated cost: R1 680 000
Expected term: 2008 - 2012

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services

ASSET Research; University of Stellenbosch; CSIR
No. 1803

Large parts of the South African landscape, especially the former homelands, are heavily degraded and denuded due to, amongst other factors, historical over-population, mismanagement and exploitation of natural resources. While the country does have a limited history of restoring natural capital, i.e. rangelands and grassland catchments, woodlands and natural landscapes, few comprehensive analyses have been done to assess the ecological, hydrological and socio-economic impacts of rehabilitation across a range of contrasted sites and contexts. Very few investigations have been conducted to determine the tangible contributions restoration has made and can make to rural landscapes and local economic development. This study will assess the ecological, hydrological and socio-economic impact of improving degraded landscapes across the country at a number of contrasted sites in an integrative and dynamic systems approach. This will be done using a carefully selected assemblage of parameters to study how restoration specifically improves water flow, water quality, land productivity and in some instances carbon sequestration as well as generally improving the agricultural potential of the land. In addition, the socio-economic benefits of restoring natural capital will be assessed by investigating the contribution to employment creation and income generation. The economic quantification of restoration is likely to provide critical data needed for the implementation of payment for environmental services. A model will be developed based on information gathered by this study to assist in predicting the impact of future restoration projects on complex and dynamic socio-economic and ecological rural landscapes. This model will be used to consider the most effective and best ways to embark on future restoration projects. This decision support tool will be very valuable to national programmes and projects such as *Working for Water*, *Working for Wetlands*, *Working for Woodlands* and the land-care project.

Estimated cost: R3 000 000
Expected term: 2008 - 2013

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo

Province

Tshwane University of Technology; Agricultural Research Council (Institute for Agricultural Engineering)

No. 1804

Livelihoods of plot-holder homesteads on small-scale canal irrigation schemes in South Africa are diverse and dynamic and the importance of irrigated farming in the livelihood portfolio of these homesteads also varies. Typically, the objectives of plot-holders on small-scale irrigation schemes range from production of food solely for own consumption to fully market-oriented production. While market-oriented farmers seek to expand the scale of their enterprise, subsistence farmers (food producers for own consumption) tend to have excess land. Most of the smallholder farmers on irrigation schemes require technical improvements to the prevailing production systems to enhance the financial viability of plot enterprises and increase the efficiency of water and land use. Effective management of shared resources such as water is essential to all farmers on the irrigation schemes and is dependent on collective action. Despite the multi-faceted challenges facing smallholder irrigation schemes, very little research has been successfully conducted on integrated production systems on these schemes. At this stage these schemes are also not included in RESIS of Limpopo Province, except if farmers are prepared to switch to sprinkler irrigation. Changing to sprinkler irrigation will not necessarily increase water-use efficiency, particularly if it is done without participation by farmers. This project seeks to enhance plot-holder scheme productivity and to strengthen collective action by improving the availability of irrigation water to farmers. It will seek to enhance the establishment of robust community-based institutional systems that reduce uncertainty and risk in land-exchange contracts. It will also endeavour to integrate crop and animal production in order to contribute substantially to local resource use, value-adding and market access on smallholder irrigation schemes. In order to achieve these objectives, the project will adopt a participatory learning and action approach to collectively analyse the existing behavioural and communication patterns. It will employ both plot and field experiments in an effort to encourage the efficient use of water and improve plot-holder productivity. The final output of this project will be a comprehensive report that documents the holistic approach followed in addressing the challenges facing smallholder irrigation farmers and lessons learnt as well as practical crop and animal production manuals for smallholder farmers and their advisers. These outputs will contribute to national programmes of high priority that address issues of poverty alleviation and food security.

Estimated cost: R1 890 000
Expected term: 2008 - 2012

Programme 2: Integrated water management for profitable farming systems

The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile Catchment

CPH Water; South African Sugarcane Research Institute; University of the Free State

No. 1805

Numerous options are being considered to address the over-allocation of water in catchments. This ranges from improvements in the efficiency with which water is used and managed, to the reduction of alien invasive plants in catchments, to the building of new dams or transfer schemes. However, even though the measures listed above will help address the over-allocation to some extent, it is likely that existing lawful users may need to be curtailed (i.e. have their water use licences reduced) in order to address the over-allocation. The general aim of the project is to evaluate the impact of curtailment of existing lawful water use on the economic and financial feasibility of irrigation farming. In the selected catchment of the Crocodile River in Mpumalanga Province, the current water situation will be assessed to determine the causes of water stress in the catchment. This will be done by reviewing available documents and reports and through discussions with DWAF and the CMA. The ACURU and Mike Basin models will be configured to represent the current water users, water resources and operating rules in the catchment. This component can be described as catchment-scale hydrological modelling. The SKELETON model will be further developed to link with the Mike Basin irrigation module. In particular the influence of the variable availability of water on optimum crop combinations and farming viability will have to be determined. This part of the modelling can be described as the farm-scale economic modelling. The integrated ACURU/Mike Basin/SKELETON model will be applied to evaluate the outcome of various curtailment scenarios. A report will be produced to document the findings for the Crocodile River specifying the potential impact of curtailments and changes in operating rules to support sustainable irrigation farming in future.

Estimated cost: R1 790 000
Expected term: 2008 - 2011

Technology transfer on the technical aspects and cost-estimating procedures of surface and sub-surface drip-irrigation systems

ARC (Institute of Agricultural Engineering); NB Systems; University of the Free State

No. 1806

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The National Water Act of South Africa (Act 36 of 1998) requires equitable, efficient and sustainable use of available water by all user sectors. Drip-irrigation is considered to be the most efficient method of irrigation. The increasing application of drip-irrigation systems necessitates the correct economic analysis and choice of not only the dripper, but also the filtration equipment to ensure that the water is used efficiently.

The WRC has published 4 different reports on drip-irrigation. The results of these reports created useful information for the cost analysis, choice, operation and maintenance of drippers and filtration equipment. It is of the utmost importance that the results of these projects are disseminated by means of technology transfers and training sessions with designers and farmers. The main aim of the technology transfer project is to facilitate a process towards effective implementation and usage of surface- and subsurface drip irrigation systems in terms of technical and economic principles. To achieve this aim, the project will be undertaken in 5 distinct phases of preparation; testing and analysis; compilation of guidelines; technology transfer and a process of knowledge dissemination. The technology transfer phase will consist of organising courses for designers to train them in the selection and usage of surface- and subsurface drip irrigation systems with respect to the technical and economic principles and organising of field days for farmers, irrigation managers and trainers to present the principles of economics, operation and maintenance of drip and filtration systems and to practically demonstrate it to participants. The output of the project will be a manual with guidelines for costing, selecting, operating and maintaining surface and sub-surface drip-irrigation systems.

Estimated cost: R1 485 400
Expected term: 2008 - 2011

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

The impacts of unpaved access roads on runoff, sediment fluxes and soil water movement within timber plantations

Aquagreen Consulting; University of KwaZulu-Natal
No. 1807

Despite wide acceptance that access roads in timber plantations are important hydrological pathways that affect the volume and distribution of overland flow and corresponding sediment fluxes, there is little quantitative information to account for this process in South African catchments. Water flowing unrestricted on unpaved road surfaces directly to the stream network is effectively lost to forestry compartments and potential uptake by tree roots, which in turn has a bearing on timber production. The main aim of the project is to evaluate the direct contribution of unpaved forestry access roads as a potentially ready source of runoff and sediment through physical on-site measurements and modelling at the plot and road segment scale. Based on field assessments done in close co-operation with the forestry industry, 2 catchments will be targeted for further monitoring and detailed modelling. Each of the catchments will represent a different bioclimatic zone, have varying ages of timber stands and have different soil types. Once the target catchments have been identified a detailed geographic information (GIS) coverage of the soils, topography, age, species and size of forestry compartments, extent of the riparian zone and the stream and road networks will be sourced or developed. Based on the findings of the modelling, verified by actual measurements, a research report will be produced on the feasibility of redirecting runoff from access roads to down-

slope forestry compartments and practical strategies that could be used by the industry to accomplish this.

Estimated cost: R1 700 000
Expected term: 2008 - 2011

Definition of process zones and connectivity in catchment-scale NPS processes

University of KwaZulu-Natal; ARC; University of Pretoria; Sigma Beta

No. 1808

Non-point source (NPS) pollution makes a significant contribution to the water quality degradation being experienced in South Africa. Several research initiatives are underway to obtain a better understanding of the processes that are operating and to improve predictive abilities under local conditions. Specific process zones have been identified to play a dominant role in determining the magnitude of non-point source pollutants within a landscape. This project will use an existing experimental site at Wartburg to study process zones, NPS migration dynamics and connectivity so as to gain an improved understanding of the processes. This in turn will lead to the development of generalised methodologies for estimating the influence of these features on NPS loads at catchment scale.

Estimated cost: R722 540
Expected term: 2008 - 2010

Contact persons

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Dr Andrew Sanewe

E-mail: andrews@wrc.org.za
Tel: +27 12 330 9047

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Dr Andrew Sanewe

E-mail: andrews@wrc.org.za
Tel: +27 12 330 9047

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Dr Andrew Sanewe

E-mail: andrews@wrc.org.za
Tel: +27 12 330 9047

Programme 2: Dr Gerhard Backeberg

E-mail: gerhardb@wrc.org.za
Tel: +27 12 330 9043

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Dr Gerhard Backeberg

E-mail: gerhardb@wrc.org.za
Tel: +27 12 330 9043

KSA 5: Water-Centred Knowledge



Dr Heidi Snyman: Director

Scope

The culture of knowledge management forms the basis of the WRC mission and is the focus of the WRC vision, i.e., becoming a true knowledge hub. The **Water-Centred Knowledge** KSA strives to meet this objective by focusing on the development and protection of internal and external knowledge resources. The knowledge resources are both explicit, documented knowledge and tacit (subjective) knowledge. Management of knowledge in the WRC therefore entails all of the processes associated with the identification, sharing and creation of knowledge. This requires systems for the creation and maintenance of knowledge repositories, and for supporting the cultivation and facilitation of knowledge sharing and organisational learning. For the WRC to succeed in knowledge management it has to view knowledge as an asset and develop organisational norms, which support the creation and sharing of knowledge, both internally and externally.

This KSA will continue to develop knowledge management capabilities, in terms of technology and fundamental business processes in order to contribute to the effectiveness of the WRC. The recent focus has been on the basic building blocks necessary to support the knowledge management objective of the WRC. The development and improvement of the Fund Management System (FMS) is one of these building blocks. The KSA also strives to package information in a format that is understood by a broader audience including our major stakeholders. The development of technical and management project briefing notes is an example of an innovative knowledge-dissemination tool implemented over the past year.

Driven by external needs, the WRC strives to improve its position as the dynamic hub for water-centred knowledge, innovation and intellectual capital in South Africa, Africa and the developing world. Therefore, this KSA will focus on deriving value from its intangible assets, e.g. full utilisation of information systems to manage data, information and knowledge; full utilisation of a system that tracks who is using our knowledge products (technical reports); increasing the circulation of our publications; improving document and information management internally; and the management and/or administration of research projects.

The scope of this KSA will be threefold, i.e. it will address:

- Internal needs of the WRC regarding knowledge management, through the optimal use of internally-available tools such as information and communication technology - enabling systems and tools; e-business; the Intranet; and developing a culture of sharing, support and community of practice (achieving higher quality by sharing knowledge)

- Internal/external interface, e.g. supporting the core process of funding (creation of new knowledge) by improving the use of support systems, evaluation tools, building research information databases and networks, and supporting information regarding research on research
- External leadership role at a national/global level and increasing public understanding of water-related issues

Objectives

The broad objectives include:

- To provide a strategic support function to the WRC as a whole and ensure effective knowledge management internally and externally
- To actively support the water sector in its strategic knowledge-dissemination initiatives
- To manage the WRC-related intellectual property, media relationship and public relations/communication

The specific objectives of the KSA have been expanded as follows:

Internally-focused objectives:

- To enhance the core processes of research support and management
- To improve access to relevant information
- To support the emergence of the culture of knowledge management
- To develop and maintain consistent data architecture to enable the flow of content through an FMS to support the core business of the organisation
- To support innovation and commercialisation through proper management and protection of the WRC's intellectual property portfolio

Externally-focused objectives:

- To participate and lead knowledge-dissemination initiatives including sharing and networking supported by functional, user-friendly research and water information systems
- To build and strengthen knowledge links with Africa and globally
- To continuously improve knowledge transfer and dissemination through feedback from users, dissemination of reports, guides, scientific and popular-scientific journals, and by providing support to other technology-transfer initiatives
- To develop state-of-the-art communications systems, to enable quick, meaningful contact between the WRC and the water sector/stakeholders

- To continuously develop better and more efficient knowledge-dissemination tools and channels, especially to DWAF and Local Government
- To promote the WRC by engaging with all stakeholders and customers, either directly or through the media, and providing them with information about the WRC's activities, products and accomplishments

Thrusts and Programmes

The achievement of the above objectives will be supported by a structure or a framework of a number of thrusts (which form a number of management areas/functional groups). The thrust structure (management areas) as described in the previous year's plan was reviewed and will remain unchanged:

THRUST 1: RESEARCH COORDINATION AND STRATEGIC RESEARCH ADVICE

Scope: The core business of the WRC is to invest in developing the water knowledge base in South Africa. This is primarily done through investing in water research on a priority basis through 3rd party agreements. The focus of this thrust will be to coordinate the research cycle in the WRC and provide strategic research advice through facilitation, feedback and review. An FMS has been developed to facilitate the coordination of the research cycle in the WRC. Consequently the functions will entail:

- Overseeing the further development of the FMS
- Driving the content and population of the FMS
- Producing management reports from the FMS for the Chief Executive Officer (CEO) and WRC Executive
- Overseeing the annual call for research proposals cycle and preparing the necessary documentation
- Reviewing project and finalisation reports and submitting consolidated reports to WRC Executive

The WRC is a knowledge organisation and hence the fundamental processes are knowledge-based, thereby creating value for the WRC and its stakeholders. Thus the WRC is well positioned to offer strategic research advice on water-related issues to a range of stakeholders. This function will involve:

- Provision of independent expert research advice to key stakeholders such as the Portfolio Committee on Water Affairs and Forestry and DWAF
- Technology prospecting and foresight

THRUST 2: KNOWLEDGE DISSEMINATION AND PROMOTION

Scope: The focus of this thrust will be to develop knowledge-sharing and knowledge-dissemination instruments to support the objectives of the WRC (of being a knowledge hub) in its knowledge-creation and learning activities and the core process of knowledge generation. It will develop a culture based on the understanding that 'knowledge resides in the user and not in the collection of information.' Thus there will be a need to develop a clear link between this KSA and the other water KSAs, who will be at the core of the knowledge management activities. Further, this thrust will oversee that the WRC maintains access to the necessary information to make appropriate decisions internally as well as externally. This management area will also act as a resource centre to meet information requirements of the WRC and the water sector in general and will lead and participate in other knowledge-sharing and knowledge-dissemination activities. It will also strengthen the WRC's ability

to exchange information and data on developments around water management issues, while continuing to disseminate technical reports and technology transfer documents. This KSA also acknowledges that the knowledge base must remain dynamic, and globally relevant. In pursuing this goal, there will be increased focus to collaborate with other countries and/or researchers in the international arena. Such initiatives will be pursued while leveraging the WRC's funding for these initiatives. This thrust will also focus on promoting the WRC through engaging with all stakeholders, especially DWAF and customers, either directly or through the media, and providing them with information about the WRC's activities, products and accomplishments. The purpose of promoting the WRC in this way is to realise crucial benefits for both the WRC and its stakeholders/customers.

THRUST 3: PUBLICATIONS

Scope: This thrust focuses on the WRC publications and internal library and the management of these publications, including the maintenance of library and information services. The key focus is on dissemination of knowledge created via the support of the WRC as well as other sources (originating from the national and international arena) through publication of an internationally-rated journal (*Water SA*) as well as a popular-science magazine (*The Water Wheel*), and the ongoing publication of research reports and technology transfer (TT) documents. Working with

Thrust 2 (see above), there will be an effort to support proper packaging for better sharing of knowledge. The KSA will strive for continual improvement in the quality of the reports and other knowledge-dissemination media.

THRUST 4: INTELLECTUAL PROPERTY MANAGEMENT

Scope: In order to encourage successful invention and subsequent solid patents and commercialisation, the WRC will continue to address the creative needs of the researchers and foster an environment that encourages innovation within the research area and engage with the researchers at all levels. By supporting the creation and protection of technological developments the WRC strives to further improve knowledge transfer (utilisation and commercialisation) of its research results (in collaboration with its research providers and the water sector at large), where and when applicable.

THRUST 5: BUSINESS SYSTEMS

Scope: This thrust will continue ensuring effective communication between service providers and the WRC and between users of WRC knowledge products and the WRC. The creation of virtual communities of users and customers is among the key priorities of our vertical portals that are to be developed. The challenge of walking the tightrope between adopting the latest technologies and remaining up-to-speed with ongoing business and technology developments is becoming more acute. These systems will be developed by KSA 7 with KSA 5 support.

Core Strategy

Strategic context

Through its research KSAs the WRC generates a vast array of water-related information products which contribute to addressing the critical water problems that South Africa experiences. The challenge is the explicit and systematic

management of this vital information along with its associated processes of gathering, organising, diffusing, using and exploiting that information.

The value of research generated by the WRC is increasingly being measured by how readily the research results are translated into useful products and services. This requires knowledge management systems (KMSs) that effectively link the information generated by the WRC research portfolio to the knowledge users (those who ultimately take action or make decisions that initiate action), such as national and local government officials, farmers, community-based organisations, politicians and researchers.

The **Water-Centred Knowledge KSA** will support the other KSA's processes by producing instruments or tools that will support the knowledge process within the WRC. This includes communication, translation, conversion, filtering, rendering and protection of research results. The capability to offer strategic research advice will also be further developed within the KSA.

A major task is to effectively manage knowledge repositories within the WRC to capture and distribute information throughout the water sector and support the implementation processes of DWAF. A critical aspect is also to use the information, communication and technology (ICT) infrastructure that is provided for the efficient functioning of the organisation as a knowledge hub.

Needs analysis

Developing a proper understanding of the knowledge users and their needs is the main determinant of how information should be packaged. The **Water-Centred Knowledge KSA** has both internal and external customers. Previous stakeholder consultations through a knowledge-dissemination survey have demonstrated the need to improve knowledge dissemination via the electronic media. In the year under review the KSA undertook to address the need to improve the efficiency of searching, location and downloading of information from the WRC Website, and to improve ease of access to information.

Internal customers

The focus in 2008/09 was on improving the FMS to facilitate decision-making, especially with respect to research project management. Staff members need to be able to access the information base of the organisation and be empowered to take decisive action. The KSA shall continue in the belief that the overarching need is to develop one seamless system for employees to conduct its business.

External customers

External stakeholders are Government departments, private service providers, decision-makers and policy-makers. At every stage of knowledge accumulation, the above-mentioned category of knowledge users is almost always the main target group. It is important that the 'knowledge workers' in this sector make their decisions by increasing the amount of relevant information they have access to, introducing the elements of expertise and experience through collaboration capabilities and shortening the time that it takes to make better decisions.

The level of knowledge of water-centred knowledge management in the broader community was a priority. The following issues were considered high priority for 2008/09:

- Media education
- Improvement of public understanding of water issues
- Effective dissemination and sharing of information
- Being the real hub for water information

- Improving the efficiency of searching and downloading information from the WRC's Webpage in close collaboration with KSA 7

Other stakeholders and user communities

These include water boards, municipalities, community associations, development groups, consultants, etc. Encouraging free flow of information fosters innovation, and in today's information-driven economy, organisations may uncover the most opportunities, and ultimately derive most value from intellectual assets. Knowledge sharing must serve as the foundation for collaboration.

Researchers and service providers

The ongoing reassessment of key assumptions, renewal of existing knowledge, creation of new knowledge and its application, requires that the knowledge available is readily available and accessible.

Public understanding of science

South Africa cannot change to sustainable water management without the co-operation of the public and the latter cannot co-operate if they do not have sufficient knowledge to contribute meaningfully. The basis for understanding is knowledge. The water sector in general also faces the challenge of being able to link up and work globally and regionally.

Overview of technological trends

The WRC has embarked on a business process re-engineering process through the development of the WRC FMS. The FMS will serve as a complete project management system internally and engages to a certain extent with the researchers (contractors). The FMS does not provide a platform for knowledge dissemination or overall document management. This was the focus for 2008/09. In order to achieve its objective as a knowledge dissemination hub, the WRC should be a leader in knowledge dissemination as well as document processing and handling. Innovative solutions were explored, in close collaboration with KSA 7, to achieve this objective, including:

- Index servers – servers that automatically generate an index
- Interactive trigger mechanisms – send an SMS to key stakeholders for alerts
- Web pages that open in a smaller version on mobile units
- Blogs and discussion platforms
- Repositories for *Water SA*, reports, publications, project briefing notes, *The Water Wheel*, WRC patents, etc.
- Interactive, user-friendly templates
- Interactive FMS system – automatic alerts for deliverables that have been deposited
- Mass data sending devices

Key stakeholders

Creation, transfer and dissemination of knowledge require an appropriate knowledge user base which includes water-related experts, practitioners, academics, science councils, all spheres of government and research organisations. The WRC has to be able to effectively translate needs into research ideas and further transfer research results and new technologies to end-users or end-user representatives and communities.

Other key stakeholders include DWAF, the water sector, service providers, user communities and the general public.



Strategic Initiatives

National initiatives

- KSA 5 and Sci-Bono continue to work together developing and supporting various mechanisms of knowledge transfer through providing water-related materials to school learners
- KSA 5 is supporting DWAF in drafting a water sector research and development strategy for South Africa. A 1st draft was produced for wider comment and input. The WRC will continue to assist the Department in the implementation of the National Water R&D Strategy.
- A comprehensive stakeholder map was developed for the WRC with the support of KSA 5. The stakeholder map for each KSA and the WRC as a whole includes the level of interaction and defines the relationship, the stakeholders' needs and expectations, as well as the planned communication and relationship plan.
- Memorandum of Understanding (MoU) with the Water Institute of Southern Africa (WISA). KSA 5 developed a draft MoU which is in an advanced stage of negotiation. The purpose is to formalise a partnership for the dissemination of water knowledge and for advancing the knowledge economy of the South African water sector and in the African continent.

Leadership positions

- The KSA 5 director and a KSA 3 research manager are leading the establishment of a joint IWA-SA/WISA Young Water Professionals Forum. This forum will address the needs of the young water professionals in terms of professional growth and building a track record and of the water sector through attracting and retaining professional scientists and engineers in the water industry.
- The director of the KSA participates in the Water Sector Leadership Group chaired by the DWAF Director-General
- The director of the KSA was elected as the President of the Water Institute of Southern Africa (WISA).
- The KSA 5 director led the development of the technical programme of the flagship event of WISA, the *WISA Biennial Conference* held at Sun City in May 2008. This contributed to a successful event and effective knowledge dissemination for 1 249 delegates who could participate in or attend 9 parallel sessions, presenting 164 technical papers (at least 50% informed by WRC projects), and 26 workshops.

African leadership

- NEPAD Centres of Excellence. The KSA represented the WRC when, in association with IRD (the French Institute of Research for Development), it was appointed as the implementing agent by the NEPAD Office of Science and Technology for the establishment of the African Network of Centres of Excellence in Water Science and Technology. This initiative falls under water S&T flagship programmes of the African Ministerial Council of Science and Technology (AMCOST) in association with the African Ministerial Council of Water (AMCOW). The centres will address critical water-related issues, conduct research programmes, train new researchers, trainers and professionals, and promote technology transfer. The network of centres of excellence is expected to overcome the fragmentation regarding water-related policies and S&T. A call for proposals was sent out to all possible water-related institutes. Twelve applications were received. It was resolved that 2 centres of excellence will be established while keeping the call

for proposals open to all other regions. The WRC and IRD submitted a comprehensive report with recommendations to the NEPAD-OST and will assist in the establishment of the Southern African Centre of Excellence next year.

- Memorandum of Understanding with Kenya Water Institute (KEWI). The KSA was instrumental to the WRC signing a MoU with the Kenya Water Institute (KEWI) in Nairobi on 12 August 2008. KEWI is a Kenyan statutory body and has a recognized mandate in sustainable capacity building in the water sector in the Republic of Kenya. The Institute is mandated to offer training services in the water sector, consultancy and research and development on a commercial basis. Its functions include providing hands-on experience and quality training to assist in transforming the Kenyan water sector institutions and individuals, acting as a training ground for technologies and research findings, and supporting capacity development of water sector institutions. The KEWI research mandate includes areas such as water resource management and environment, water and sanitation services, and appropriate technology in the water sector. The goal of the MoU is for the WRC and KEWI to collaborate where appropriate, and to:
 - Undertake scientific and applied research, and database development, in order to promote planning, management, development and institutional reforms in the water sector in their respective countries
 - Develop scientific and technological innovations in the water sector in their respective countries
 - Promote sustainable capacity building in the water sector in their respective countries
 - Facilitate knowledge exchange and information dissemination

International player

This KSA supports many global initiatives managed by other KSAs. Examples include media support and exhibitions for international events. KSA 5 also assists with logistics for international delegations visiting South Africa.

In addition, the KSA played a leading role in various international activities:

- The KSA director was invited by the Minister of Water Affairs and Forestry to accompany her to the international water expo held in Zaragoza, Spain. The self-proclaimed 'biggest water festival on earth', *Zaragoza 2008 International Expo 'Water and Sustainable Development'* ran from 14 June to 14 September 2008. The Expo attracted thousands of people daily from governments, academia, civil society and the private sector. A key component of the Expo was the Water Tribune, which had been created to stimulate reflection, debate and a search for solutions in relation to water and sustainability. It brought together the most relevant international water professionals to discuss sustainable initiatives and solutions on water management. The Water Tribune was organised in 9 thematic weeks, and attracted about 700 specialists per day throughout the duration of the Expo. The director was one of 3 South African women scientists who accompanied the Minister to Zaragoza and attended the South African National Day on 5 August 2008, the Ministers' Keynote address at the Water Tribune on 6 August and participated in discussions with key international organisations such as the World Bank. The WRC also assisted DWAF with the technical content for the South African stand in the Africa Pavilion.

- The WRC authored the South African contribution to the *Global Atlas of Excreta, Wastewater Sludge, and Biosolids Management: Moving Forward the Sustainable and Welcome Uses of a Global Resource*, published by the Greater Moncton Sewerage Commission and UN-HABITAT
- The KSA director participated in, and presented a poster entitled 'Management of wastewater sludge in South Africa – Overview of legislative trends', at the *IWA World Water Congress & Exhibition* in Vienna, September 2008
- The KSA director represented the WRC at the *5th World Water Forum* – held in Istanbul, Turkey, in March 2009 – in the session entitled: 'Collaborative and problem-solving research in the WASH sector: achieving greater use and impact of research through the learning alliance approach (and other multi-stakeholder approaches)'
- The WRC is a strategic partner assisting DWAF in their bid to host the *6th World Water Forum* in 2012

Innovation

The WRC supports knowledge creation which in turn may lead to innovative methods and technologies. While many of these innovations are public goods and are readily available for use, some technologies, processes and products require commercial involvement in order to make them publicly available.

Currently, the WRC has licence agreements with reputable South African companies. These include one royalty-earning innovation, i.e. **The Secondary Metabolites**, a cluster of 13 patents, currently licensed to Synexa-Life Sciences; the WRC has been receiving royalties since 2006. Two other licensed innovations are currently undergoing further development: the **BioSURE™ Process**, a cluster of 36 patents which is licensed to ERWAT, and the **Ambient Temperature Ferrite Process (ATFP)** for removing iron from acid mine drainage, which is currently licensed to Environmental Technology Agencies (ETA). Further development is often required to allow the technology to function reliably at a large scale. Business related to another innovation that was licensed out last year is rapidly progressing. This is an invention that will allow the provision of clean water at a small scale and could effectively provide drinking water for small rural communities. The **Capillary Ultra-Filtration Membrane Technology (CUF)**, a cluster of 5 patents, was licensed to Ikusasa Chemicals in January 2008.

The **Olive Wastewater Treatment Technology** was assigned to the University of Cape Town (UCT) and a benefit-sharing agreement was concluded. Following the aforementioned benefit-sharing agreement, an option agreement was concluded whereby Dr Garcin was granted an exclusive option to enter into a licensing agreement for commercial development and public utilisation should its evaluation so warrant. The option agreement has lapsed and Dr Garcin is currently negotiating with UCT with the view to extend the agreement as the technology is still undergoing further development.

The WRC has launched patent applications for 2 new innovations:

- **Process for treating sulphate-containing effluent** – The object of this invention is to provide a process for treating sulphate-containing effluent in a bioreactor. The process involves introducing the sulphate-containing effluent into the bioreactor along with a metabolisable carbon energy source, such that the metabolisable carbon energy source is present in an amount in excess of that required for the biological reduction of the sulphate in the effluent to sulphide. This will be followed by a step in which the

sulphate in the effluent is biologically reduced to sulphide, simultaneously biologically producing methane from the carbon energy source, and removing the sulphide from the effluent.

- **Treatment of wastewaters using dual-stage membrane bioreactors** – This invention is a wastewater treatment process. The process includes steps providing a discrete acclimation bioreactor system for developing a desired micro-organism inoculum, with the system being in selectively interruptible fluid flow connection with an effluent hydrolysis system. This allows the flow of desired micro-organisms from the bioreactor system to the effluent hydrolysis system to be regulated independently from the effluent feed flow through the hydrolysis system, leading to greater flow-through and system efficiencies.

Marketing local water innovation

Marketing the WRC's technologies remains a continuous process. Our technologies are now listed on one international IP-marketing website, *The Place to go for IP*, hosted by Technology Transfer Tactics, an American-based company. In 2008/09 the WRC completed the development of the *WRC IP Booklet* and developed the WRC IP website which was launched on 6 March 2009.

Growing the Knowledge Base

Capacity-building initiatives

KSA 5 provided support for a number of capacity-building initiatives undertaken by the research KSAs. The FMS capability necessary to capture all the required fields of student data is fully developed and commenced operation on 1 April 2009. The existing FMS capacity-building reports capture all the student information on the proposals as and when they are submitted. In February 2009, a new capacity-building module was commissioned that will enable the on-line capture and update of student information, including the student's country of origin. A primary objective is to ensure the capture and ongoing update of capacity-building data on all ongoing projects.

KSA 5 supported the research KSAs (1-4) in many workshop activities. The following specific workshops were championed:

- The WRC, DWAF and UNESCO co-hosted the *African Regional Workshop on Water Education*, 24-25 February 2009, as a side event of the IEWA Conference in Port Elizabeth. This workshop was aimed at identifying gaps in water education in order to prepare an appropriate response to regional needs and to achieve the objectives foreseen in the strategic plan for the 7th phase of the International Hydrological Programme in the context of the UN Decade on Education for Sustainable Development. Fifty participants (25 international) attended the workshop.
- The WRC launched its Technology Transfer Office on 6 March 2009. The launch was held in conjunction with a consultative workshop regarding the WRC's standard research contract and an information session on the administrative aspects of a typical research project at the WRC. Representatives from the IP office and research support offices of our contractors attended. The workshop was well-attended (50 delegates), attracted the targeted stakeholders, and was well received.
- *WISA 2008, Sun City, 18-22 May 2008. Workshop on WISA Young Professionals: Creating a Forum for Postgraduate Students & Young Professionals*. The aim of this workshop was to inform

participants of the WISA Young Professionals Programme that began in 2007 and to establish the needs of the group. The workshop was well-attended and has since led to the Young Professionals developing a business plan presented to the WISA council.

- Book launch: *Rivers and Wetlands of Cape Town: Caring For Our Rich Aquatic Heritage*, 10 March 2009, Cape Town. The project that led to this book arose from a successful unsolicited funding proposal submitted to the WRC in June 2005. The CEO of the WRC, Dr Kfir, presented a copy of the book to the Chairperson of the Parliamentary Portfolio Committee on Water Affairs and Forestry, Ms Connie September.

Knowledge dissemination

Open days

- The Open Day celebrating the theme Knowledge for Growth and Development, was held on 2 December 2008, Montana Park, Pretoria. The WRC invited the water sector leaders and academia to this prestigious event to celebrate Knowledge for Growth and Development. The keynote speaker was Prof. B O'Connell, Vice-Chancellor of the University of the Western Cape.

Exhibitions

- *WISA Conference*, 18-22 May 2008, Sun City. The *Knowledge Café* concept presented by the WRC exhibit was met with resounding success, culminating in the WRC receiving 2nd prize in the Designer Exhibition Stand Category. Delegates were offered an array of reports that related to the conference themes and could order these reports at the exhibition stand. Research managers and directors were present at the stand to answer questions and address queries.
- *Public Health Association of South Africa, (PHASA) Conference*, 2-4 June 2008, Cape Town. The WRC exhibit focused on 'Water and Health' and enabled delegates to view the work of the WRC, meet experts in respective fields and discuss issues pertaining to research, thus providing a platform for network and the formation of alliances and collaborations. Approximately 300 delegates attended the Conference.
- *International Congress of Entomology (ICE 2008)*, 6-12 July 2008, Durban. ICE 2008 provided a forum for over 2 000 scientists, researchers, technicians and officials, from academic, government, industry and commercial organisations, to share their expertise in their specific fields of interest, discuss applications, and/or present their products. The WRC exhibited at this event with a main focus on freshwater invertebrates.
- *International Water Distribution System Analysis Conference (WDSA 2008)*, 17-20 August 2008, Kruger National Park. The WRC exhibited at the 10th WDSA Conference (WDSA 2008), which was attended by approximately 210 delegates.
- *Municipal Indaba*, 11-12 September 2008, Gauteng. The main objectives of the Indaba, attended by approximately 850 delegates, were: to identify the key challenges affecting municipalities with regards to water sanitation services; to discuss and agree on solutions and joint actions to be embarked on when dealing with these challenges; to prepare municipalities for future compliance and enforcement of departmental directives; to share international experiences on an integrated approach to the management of water resources and water services; to

solicit input from the municipalities on the proposed Water For Growth And Development Strategy; and to exhibit technologies that can be used in the water value chain. The WRC reports and publications proved to be popular.

- *2008 Professor Humphrey Memorial Lecture & Postgraduate Colloquium*, 16 September 2008 University of Pretoria. The memorial lecture was organised in honour of the late Prof. Godfred Humphrey, the first Dean of the College after the UNISA merging process. The topic of the lecture was 'The impact of global warming on food security, human and environmental health and safety'. The WRC displayed research reports on the above topics.
- *3rd International Seminar on Mine Closure*, Johannesburg, 13-17 October 2008. The theme of *Mine Closure 2008* was, 'From Waste to Resource: Revaluation of Mining Operations, Land and Residue Deposits in a Changing World'. It was also an opportunity to exhibit the work of the WRC to delegates. Approximately 300 delegates attended the conference.
- *Implementing Environmental Water Allocations (IEWA)*, 23-26 February 2009, Port Elizabeth. The theme of this conference was to promote the sustainable use of rivers, wetlands, estuaries and groundwater. The main objectives were to identify and critique global trends in the implementation of environmental water allocations, and to share knowledge and skills. Representatives of municipal, provincial and national water departments, water engineers and managers, water and social scientists, resource economists, representatives of water boards, policy-makers, stakeholders and relevant NGOs attended the conference. The WRC exhibited at this event attended by approximately 300 delegates.
- *Climate Change Summit 2009*, 3-6 March 2009, Midrand. The purpose of the *Climate Change Summit 2009* was to provide all stakeholders with an update on the most recent climate change research and other current South African initiatives and interventions, and to provide a platform for stakeholders to discuss and agree on a framework for a National Climate Change Response Policy. The DST hosted a 'climate change science' exhibition space and invited the WRC to share the stand with them.

Enhancing access to WRC publications

Continuous improvement of the way in which the WRC publications are disseminated is of the utmost importance. In the 2008/09 financial year a few new ways were developed and implemented to advertise the WRC reports:

- The *WRC Knowledge Toolbox* was developed and launched at WISA 2008. The Toolbox is in the format of a file encompassing the WRC briefs. The idea is that future briefs can be added to this file by the owners through downloading and printing from the WRC website. The plan is that all registered participants will be prompted to download the latest information.
- A series of topic-based brochures was initiated, of which 3 have been completed: *Drinking Water, Sanitation and Groundwater*. This initiative will continue.
- A new feature article entitled 'New from the WRC' has been included in *The Water Wheel*. These articles give a short summary of the latest WRC publications and information on how to order them.
- The 1st phase of the new Electronic Water Knowledge Hub was started and the concept design has now been completed. In the next financial year, the website will be fully developed, with all WRC publications properly tagged

and searchable. This will greatly enhance the accessibility of WRC products.

Thirty-five **briefs** (32 technical and 3 policy) were developed and printed in 2008/09:

TECHNICAL BRIEFS

- *Jatropha curcas*: Measuring the impact of large-scale planting on water resources
- Water quality use allocation
- Rehabilitating degraded catchments
- Selecting suitable small water treatment systems
- Monitoring residual poly-electrolytes in drinking water
- Rapid detection of faecal contamination
- Negotiated environmental agreements
- Substrate maintenance in cobble and boulder bed rivers
- Estuary management as part of integrated development plans (IDPs)
- Using human excreta as fertiliser
- Fate and transport of dense non-aqueous phase liquids (DNAPLs)
- Guidelines for the planning, design and operation of fishways
- Quantifying groundwater's contribution to baseflow
- Setting resource directed measures for groundwater
- The contribution of geothermal studies to research of the TMG aquifer
- Groundwater licensing guide
- Groundwater supplies for municipalities
- National microbial monitoring programme for groundwater
- Estimating recharge of the Table Mountain Group aquifer system
- Constructed wetlands for treatment of winery effluent
- Solid waste in the minerals extraction industry
- Microorganisms in paper mill water systems
- Communities and integrated water resource management
- An improved soil survey technique for in-field rainwater harvesting (IRWH)
- In-field rainwater harvesting (IRWH) adoption on small farm plots
- Developing hydraulic modelling tools for ecological studies
- Prevalence of organic pollutants in South African sludge
- Biosensors for eco-toxicity testing of water sources
- Eutrophication
- A cost-benefit analysis manual
- Nanotechnology for the treatment of water and wastewater
- Guidelines for effective use of ozone 3

POLICY BRIEFS

- Guidelines for the planning, design and operation of fishways
- Focus on estuary management
- EDCs and drinking water – reducing the risk

A number of **strategic press releases** were made to highlight WRC activities and research outputs:

- Mfabeni Mire – a wetland case study (April 2008)
- Yellowfish Telemetry Study (May 2008)
- WRC emerges as winner at WISA (May 2008)
- Desalination at tip of Africa (May 2008)

- Thumbs-up for *Water SA* and open-source publishing (web only) (June 2008)
- WRC leads EU-SA Summit water side event (web only) (July 2009)
- WRC poster presentation in Poland (web only) (July 2008)
- WRC represents SA at Zaragoza (web only) (August 2008)
- Guidelines for improved disinfection of small water treatment plants (September 2008)
- Specialists unite to save Olifants River system after massive croc kill (November 2008)
- Workshop on identification of aquatic beetles (web only) (November 2008)
- Hurting river systems leads to leaner wallets (November 2008)
- Symposium offering special training on best practice guidelines for water resource protection in mining industry (December 2008)
- Local research creates viable membrane industry (February 2009)

Effective interaction with the media

Several WRC initiatives have been reported on in the media over the past year. KSA 5 acts as facilitator to the rest of the WRC to ensure that adequate media exposure is achieved. Some examples include:

- The KSA director, in her capacity as WISA President, was interviewed several times on radio, and participated in a televised debate on SABC 1 (*Asikhulume*) on 8 March 2009. The panel consisted of Dr Snyman (WISA President), Dr Chris Herold (South African Institute of Civil Engineering), Lindiwe Hendricks (Minister of Water Affairs and Forestry) and Sicelo Shiceka (Minister of Provincial and Local Government). The KSA director has also written 5 articles for *Water and Sanitation Africa*.
- The WRC handled all the media-related activities on behalf of the sector at the *WISA 2008 Conference* in May 2008
- *Delivery* magazine (August/October 2008), reported on the WRC Open Day demonstrating the new small-scale water treatment system using membrane technology (Struisbaai, Western Cape)
- SABC TV recorded interviews with WRC-funded researchers at the Mfabeni wetland in St. Lucia, KZN. The story was aired in the 7pm TV *News Bulletin* on SABC 3 and in *Morning Live* on SABC 2.
- A director was interviewed on SABC TV on 10 April 2008 in connection with the Elands River Yellowfish Conservation Area
- A director was quoted in the *Pretoria News*, 26 August 2008, with regard to the growth of water hyacinth under the highly-polluted conditions of Roodeplaat Dam, Pretoria
- WRC-funded research projects featured in the organisation's public water research and development magazine, *The Water Wheel*, have been well-received. The March/April 2008 and May/June 2008 editions, featuring articles on the National EDC Research Programme led by the WRC, proved particularly popular. Good feedback was also received on the articles detailing WRC funding towards the improvement of basic sanitation, published in May/June. The edition also featured an article on the new water law compendium published by the WRC. Comment from several sectors has been received on the July/August 2008 cover article describing WRC-funded research on the state of plumbing in South Africa. Every issue also introduces newly published reports available from the WRC.



- Extremely good press was received following the launch of CROC (Consortium for the Restoration of the Olifants Catchment), of which the WRC forms part. The initiative was formed to address extreme pollution which has led to massive crocodile die-offs in the catchment, including at least 160 mortalities in the Olifants gorge, in the Kruger National Park. Articles were published in, amongst others, *Beeld*, *Business Day*, *The Star*, *Cape Times*, and *The Herald*, while radio stations such as RSG and 702 Talk Radio also covered the news.
- An article on WRC's sanitation-related research appeared in the December 2008 edition of *Achiever* magazine
- A director had an interview on Metro FM on 8 December 2008 on topical water issues, including South Africa's water quality and quantity challenges
- In December 2008, French television production company La Compagnie des Taxi-Brousse documented WRC-funded projects at North-West University focusing on the use of membrane technology to bring clean drinking water to rural communities
- A research manager was interviewed by PhalaPhala Radio on environmental water and its link to food safety in November 2008. Several articles had been written and published in different publications and websites on the *International Conference on Implementing Environmental Allocations*, and PhalaPhala Radio subsequently wanted to know more about the conference and its importance in connection with environmental (water) and food challenges.

TABLE 1
WRC reports distributed to stakeholders in 2008/09

FWR (Foundation for Water Research, UK)	196
Institutes	2 971
Municipalities	945
Private	10 881
Schools	206
NLSA (National Library of South Africa)	624
Universities of Technology	1 330
Universities	2 526
WRC	1 370
WRC Board	149
TOTAL	21 198

TABLE 2
Most popular reports distributed during 2008/09

Report	Title	KSA	Total
TT 305/07	<i>A Manual for Cost Benefit Analysis in SA with Specific Reference to Water Resource Development: Second Edition (Updated and Revised)</i>	KSA 4 for KSA 1	184
KV 207/08	<i>Towards Defining the WRC Research Portfolio on Climate Change for 2008-2013</i>	KSA 1	205
TT 129/00	<i>Quality of Domestic Water Supplies Vol 3: Analysis Guide</i>	KSA 3	208
TT 319/07	<i>Guidebook for the Selection of Small Water Treatment Systems for Potable Water Supply to Small Communities.</i>	KSA 3	206
TT 313/07	<i>On-farm Application of In-Field Rainwater Harvesting Techniques on Small Plots in the Central Region of South Africa Vol 1: Main Report</i>	KSA 4	235
TT 117/00	<i>Quality of Domestic Water Supplies Vol 2: Sampling Guide</i>	KSA 3	235
TT 101/98	<i>Quality of Domestic Water Supplies Vol 1: Assessment Guide</i>	KSA 3	236
TT 247/04	<i>An Illustrated Guide to Basic Sewage Purification Operations</i>	KSA 3	251
TT 265/06	<i>Handbook for the Operation of Water Treatment Works</i>	KSA 3	254
TT 314/07	<i>On-farm Application of In-Field Rainwater, Harvesting Techniques on Small Plots in the Central Region of South Africa Vol 2: Extension Manual</i>	KSA 4	259

Contact Persons

THRUST 1: RESEARCH COORDINATION AND STRATEGIC RESEARCH ADVICE

Dr Heidi Snyman (Director: KSA 5)

E-mail: heidis@wrc.org.za

FMS:

Mr Pieter Smit

E-mail: pieters@wrc.org.za

THRUST 2: KNOWLEDGE DISSEMINATION AND PROMOTION

Ms Hlengiwe Cele (PR)

E-mail: hlengiwe@wrc.org.za

Ms Zagry Scholtz (PR events coordinator)

E-mail: zagrys@wrc.org.za

THRUST 3: PUBLICATIONS

REPORTS:

Ms Rina Winter

Mr Judas Sindana

E-mail: orders@wrc.org.za

REPORT QUALITY CONTROL:

Mr Reg Sutton

E-mail: regs@wrc.org.za

LAYOUT AND DESIGN:

Ms Drinie van Rensburg

E-mail: driniev@wrc.org.za

WATER SA:

Ms Ingrid Buchan

Ms Tamsyn Sherwill

E-mail: watersa@wrc.org.za

THE WATER WHEEL:

Ms Lani van Vuuren

E-mail: laniv@wrc.org.za

SUBSCRIPTIONS:

Ms Mmatsie Masekwa

E-mail: subs@wrc.org.za

Tel: +27 12 330 9009

THRUST 4: INTELLECTUAL PROPERTY MANAGEMENT

Mr Lawrence Baloyi

E-mail: lawrenceb@wrc.org.za

Impact Areas

Introduction

The core strategy of the WRC requires a number of key crosscutting issues of national importance to be addressed. Each of the KSAs, through its own portfolio of thrusts and programmes, makes an important contribution to addressing these issues. However, to ensure that the WRC research portfolio as a whole achieves the desired impact with regard to each of these key strategic issues, they are dealt with specifically in four Impact Areas established purposely to provide for the necessary integration and leadership roles and functions. The 4 Impact Areas are directly linked to DWAF's overarching objective of economic growth and sustainability. The areas address the principles for Water for Sustainable Growth and Development. Apart from being of national importance, the issues addressed by the Impact Areas are of regional and international priority, as the agendas of major events and movements such as the WSSD, successive meetings of the World Water Forum as well as NEPAD have clearly shown.

The integrating function of the Impact Areas entails drawing together programmes and projects which address the relevant crosscutting issues and which are under way within the portfolios of each of the KSAs. Leadership and support is also provided for new KSA initiatives which can further knowledge with regard to Impact Area-related strategic thrusts. The Impact Areas may also drive specific programmes/projects that are overarching and relate to all KSAs in a general manner.

The Impact Areas address the following key issues:

- Water and Society
- Water and the Economy
- Water and the Environment
- Water and Health

Water and Society



Dr Andrew Sanewe: Head

Scope

The impact area of Water and Society seeks to build understanding of the social aspects and dynamics of water in society and the role that water can play in achieving social transformation and justice. It does so in the context of deepening democratic practices, the extension of water services and redressing of the wrongs of the past, as well as a commitment to ecological sustainability while facing growing pressure on water resources, the effects of climate change, HIV/AIDS and the daily realities of households living in poverty. It ensures that a social perspective is brought to bear on all aspects of water research. This focus is sensitive to multiple perspectives, including those of gender, class, disability, urban or rural, culture and religion, and aims to integrate a variety of methodologies to provide a holistic view. It emphasizes respect for people's rights and encourages participation in monitoring and decision making as entrenched in the country's constitution.

Objectives

This impact area will support research which:

- Develops a greater understanding of social dynamics in the water sector, and people's needs for and views of water; encourages people's participation in water management and decisions about water
- Searches for ways of using water for transformation and social justice
- Enables water users at all scales and in different localities to meet the challenges of utilising water as a shared and scarce resource in a sustainable way
- Provides water services which are socially acceptable, affordable and available to all
- Ensures ready access to water for the poor and disadvantaged members of society

Thrusts and Programmes

THRUST 1: CO-OPERATIVE GOVERNANCE

Scope: In the context of a growing confidence in the instruments of democracy and participation, this thrust focuses on strengthening and encouraging relevant and affected stakeholders in the water sector to agree and work towards achieving common goals. It promotes a governance system that includes all sectors of society, namely government organisations, non-government organisations, private sector and civil society.

It focuses on developing an understanding of the opportunities for citizens to participate and influence decisions about water management. It assesses how the roles and participation of different stakeholders in water planning, the regulation of the water sector, monitoring and evaluation of the impact of service delivery can be strengthened and encouraged.

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

Scope: South Africa's water policy and legislation reflects a deep commitment to social transformation and justice. This thrust will investigate possibilities for using water to redress the injustices of the past and bring about a more just society. It will study the options for the reallocation of water, both on national and community scales. It will also investigate the extent to which gender, age and physical disability influence access to water resources.

THRUST 3: SUSTAINABLE USE OF WATER AS A SCARCE AND SHARED RESOURCE

Scope: This thrust develops an understanding of different aspects of water scarcity in the context of enhancing ecological sustainability of water systems. It will focus on investigating hydro-political issues at a local, national and regional scale. It addresses the dimensions and causes of scarcity of water in our society which include the inter-sectoral and transboundary sharing of water, water scarcity in relation to demand, water quality, and the roles of water in various economic and societal sectors. It investigates the social impacts of climate change on water resources and water supply systems. Appropriate research initiatives will aim at alleviating impacts of scarcity and degraded water quality on society and the water environment, thereby reducing potential for conflict, and promoting healthy co-operation with regard to integrated, sustainable management. Research in this thrust will support policy and decision-making regarding the allocation of water (over and above the Reserve) between competing groups, namely domestic, industrial and agricultural.

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

Scope: The focus of this thrust remains on analysing and understanding society's needs for water services. This will lead to guidelines aimed at enhancing utilisation of limited water resources and finance in sustainable service provision. Such understanding will ensure that the real needs of society are known and addressed in a flexible and socially acceptable manner. Issues around institutional arrangements, hygiene and sanitation will be investigated.

THRUST 5: POVERTY ALLEVIATION

Scope: The focus of research within this thrust remains the linkages between water and poverty. This will lead to effective strategies for using water resources to improve livelihoods, break the cycle of poverty and promote food security. The thrust seeks practical ways of better aligning water provision with the expectations and needs of water users, especially the poor.

Research Portfolio for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: CO-OPERATIVE GOVERNANCE

Enriching freshwater conservation

CSIR (Natural Resources and the Environment)

No. 1678

The project was aimed at advancing understanding of the relationships between freshwater conservation planning and the social, economic and political landscape within which freshwater conservation goals are being implemented. It is proposed that once this relationship is more deeply understood freshwater conservation goals and objectives will be more robust because they will reflect wider agreement about the desired and expected delivery of human benefits from freshwater ecosystems, and hence implementation of freshwater conservation will be more effective and successful. The project examined ways in which the systematic conservation process could be augmented by re-defining ecosystems as social-ecological systems, by promoting co-operation across overlapping mandates and an adaptive learning process, and by categorising societal groups and attitudes that can be targeted through different strategies to encourage freshwater conservation ideals and practices. A research strategy, which contextualises future research needs in this field of research, was developed and a proposal to continue research in this field, based on the work undertaken in this project that was focused on how the conservation process is influenced by different categories of actor clusters (that do not know, care and/or act when it comes to freshwater conservation) was written and implemented.

Cost: R450 000 (KSA 2)

Term: 2006 - 2008

The development of a framework for the involvement of local government in water resource management linked to water service provision

Rhodes University

No. 1688

The main aim is to investigate the possibility and abilities for integrated water resource management (IWRM) at local government level in a small-to-medium Category B municipality using Makana Municipality as a case study. The next aim was to develop a framework of recommendations for action in order

to achieve IWRM at local government level by defining the links between (integrated) water resource management and water services provision. As a water service authority (WSA) and water service provider (WSP), Makana Municipality has to incorporate water resource protection into their planning, development and maintenance of services including the effects of land use. It is in this area where the integrative aspects of IWRM are so valuable. The third aim is also part of the IWRM protocols, namely, increased community awareness of water supply issues through a dedicated programme aimed at school learners within Grahamstown.

Cost: R550 000 (KSA 1)

Term: 2006 - 2008

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa

Palmer Development Group (Cape Town Office)

No. 1713

The purpose of this research was to assess whether being a member of a large consumer unit, defined as more than 8 people sharing a stand, results in inhibited access to water and sanitation services, and whether large consumer units find water and sanitation services to be unaffordable. This research suggests that large consumer units cannot be viewed simply as a homogenous group. Different types of consumer units, and different households making up those consumer units, face different challenges with respect to water and sanitation. Nuanced policy approaches will be necessary to help to alleviate these differing challenges. Such policy approaches might include: considering programmes to upgrade backyard accommodation, and metering such accommodation separately; increases in the amount of Free Basic Water allocated to large consumer units; revisions to the rising block tariff structures, or consideration of alternative tariff approaches; and education programmes around the wise use of water. Indigent policies should also be reviewed to take large consumer unit size into consideration.

Cost: R390 550 (KSA 3)

Term: 2007-2008

THRUST 5: POVERTY ALLEVIATION

Real-time irrigation advice for small-scale sugarcane production using a crop model, weather data and cellular communication

South African Sugarcane Research Institute (SASRI)

No. 1576

Water-use efficiency in irrigated sugarcane agriculture is very low and could improve dramatically if farmers implement established scheduling methods. The challenge therefore is to provide simple, practical and useful advice to farmers using state-of-the-art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. To address this problem the South Africans Sugarcane Research Institute (SASRI) developed the *MyCanesim* system. The system provides farmers with access to the power of modern technological advances without the need

to learn how they operate. The system was implemented fully on the Pongola small-scale irrigation scheme. Subscription to the service grew from 10% in 2005 to 87% in 2008. The study showed that significant direct (monetary) benefits are possible, provided the specific prerequisites are in place. An advisory service that provides real-time irrigation scheduling advice based on weather data could be implemented on other sugarcane irrigation schemes, provided that the specific constraints are addressed. The report provides recommendations for the successful implementation of the system.

Cost: R256 000 (KSA 4)

Term: 2005 - 2008

Current Projects

THRUST 1: CO-OPERATIVE GOVERNANCE

Development of the AWARE model for the Inkomati CMA

University of KwaZulu-Natal

No. 1935

RISKOMAN, a joint project with UNESCO-IHE, aims to develop a policy tool that: (a) can optimise water allocation in multi-purpose multi-reservoir systems in water scarce environments, based on economic values and socio-political preferences; that (b) can continuously adjust these allocation policies based on seasonal flow forecasts and knowledge of their uncertainties; and that (c) can hedge against inflow risks using adaptive, risk dynamic, management and operation strategies. This project adds 2 extra components to the RISKOMAN research: i.e. (a) The development of an interactive multi-level information system in which information will be provided to different levels of basin water resources stakeholders, with an emphasis on providing the integrated information from RISKOMAN to the level of CMA Board members; (b) improved understanding of the hydrological functioning of the Inkomati Basin through focused research on the spatial and temporal variability of hydrological drivers in the catchment with the use of remote-sensing methodologies and the application of these within the RISKOMAN project as a whole.

Estimated cost: R1 800 000 (KSA 1)

Expected term: 2007 - 2013

A philosophy and strategy enabling learning for good ecosystem governance

CSIR

No. 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users and to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. In addition, the aim is also to develop a strategy and implement it using the above principles in pilot areas. As a new, emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200 (KSA 1)

Expected term: 2006 - 2009

Institutional dimensions of water resource management in South Africa: Socio-cultural perspectives

University of Cape Town

No. 1698

This project seeks to analyse, monitor and evaluate the new water management institutional arrangements by focusing on the role of socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices in determining water management outcomes. Some of the long-term benefits of the research include enhancing public participation in water management and the voices of local people, and alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400 (KSA 1)

Expected term: 2006 - 2009

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity

CSIR (Natural Resources and the Environment)

No. 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision-making in a situation of varying levels of certainty and of potential conflict. Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820 (KSA 2)

Expected term: 2007 - 2009

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector

Council for Geoscience

No. 1612

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made? This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralisation of services. Are these new arrangements supporting gender mainstreaming?

Estimated cost: R600 000 (KSA 3)

Expected term: 2005 - 2009

The criteria necessary for the success of women in the water sector

Palmer Development Group

No. 1762

A number of successful women can be found in the political, corporate and business worlds in South Africa. Whether their success can be attributed to positive family endowments such as well-defined gender roles at the home and/or community level, the enabling legislation in support of gender parity, etc., or a combination of all the above, might explain why still only few women manage to make it to the top echelons. The project will seek to personalise the success by investigating real-life examples to draw out the criteria necessary for the success of women in the water sector. The intention is to uplift those feeling disempowered and to identify gaps if any hindering the progress of women in the water arena.

Estimated cost: R712 320 (KSA 1)

Expected term: 2007 - 2010

THRUST 3: SUSTAINABLE USE OF WATER AS A SCARCE AND SHARED RESOURCE

The Shared Rivers Initiative Phase 1: Part A - Contextual profiles of the shared rivers of the Kruger National Park

Association for Water and Rural Development (AWARD); SANParks (Kruger National Park); University of the Witwatersrand; CSIR; Tlou & Mallory (Pty.) Ltd.

No. 1711

Research undertaken during this project will address a recently-identified gap in the governance process of water resources, in that a formal route of response to the red flag raised when a Threshold of Probable Concern is exceeded during the Strategic Adaptive Management process needs to be defined.

There is growing concern among scientists, managers and the general public in South Africa about the continuing decline in the integrity of the river systems of South Africa's north-east Lowveld in spite of an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management. The Lowveld river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland). Each has to achieve their own important resource management and water supply priorities within their portions of these basins. Each neighbour faces a similar set of needs and challenges in its attempts to balance social development imperatives with management for resource sustainability. There is a clear need to harmonize management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery.

This project aims to explore water policy implementation as a complex social-ecological process and initiate an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management. During this process, an understanding will be developed towards managing the Lowveld rivers following a cooperative, international and basin-wide approach.

Estimated cost: R1 500 000 (KSA 2)

Expected term: 2007 - 2009

Review of the involvements of national water institutions and civil society in international agreements in South Africa

Pegasys Strategic Management

No. 1758

Water management institutional reform is taking place within most of the SADC countries, and new local catchment councils and/or agencies are already in existence in the respective countries. At higher interstate levels, Shared River Commissions are established in accordance with the SADC protocol on shared rivers. To date, little or no attention has been paid to the interaction and integration of local actors vs. international bodies and the quest to separate the governance and implementation/management dimensions in internationally shared rivers for effective management and long-term sustainable use of such resources. This project could look at some examples such as the Inko-Maputo Agreement and the roles and responsibilities of the different local and international role players to ensure effective implementation. Other examples can also be considered.

Estimated cost: R3 000 000 (KSA 1)

Expected term: 2007 - 2010

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas

CSIR

No. 1610

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and proven, which would then allow piloting and implementation to be much more attractive. The concepts will contribute to wider participation of small-scale entrepreneurs in the management of water services.

Estimated cost: R600 000 (KSA 3)

Expected term: 2005 - 2009

Sustainable options for community level management of grey-water in settlements without on-site waterborne sanitation

University of Cape Town (Department of Civil Engineering)

No. 1654

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects which influence the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be applicable for extension to the rest of South Africa. This will be supported by preparation of educational material for community-level training concerning grey-water management options and techniques.

Estimated cost: R750 000 (KSA 3)
Expected term: 2006 - 2009

Review of regulatory aspects of the water services sector
African Centre for Water Research
No. 1667

The changing water services institutional and legislative environment in South Africa has indicated the need for a strong and competent regulatory component to oversee the activities of the sector, such that objectives of sustainability, equity and efficiency are achieved and maintained. There have been many debates and discussions on this topic, as to whether the regulatory function should be an independent function or whether the sector can afford a regulatory function and who will finance such an initiative, e.g. DWAF has commissioned a number of studies in this regard. However, the subject area is very new to the sector and there is a great deal of information required to support decision making and input is required to support this regulatory function. The area also poses many challenges in its implementation. The study aims to support and build on national initiatives to find optimum models and mechanisms for effective regulation of the water services sector. The study will cover:

- Review of international models for water services sector regulation and highlight pros and cons of the different regulatory models
- Assessment of institutional and human capacity required to implement sector regulation
- Evaluation of the cost implication of sector regulation on municipalities
- Exploration of the feasibility of using incentives to regulate the water services sector
- Investigation of international best practice on proper regulation, identifying institutional, financial and operating procedures of relevance to South Africa
- Investigation and evaluation of case studies of independent regulation and central regulation, capturing lessons and experiences of relevance to the South African situation
- Investigation of water sector and consumer opinion on independent versus central regulation and aspects that should be addressed
- Determination of the scope of water services regulation and the linkage/integration with water resource management
- Identification of the capacity and competency requirements to facilitate regulation across the sector
- Evaluation of the cost implications of water sector regulation and its impact on tariffs/chain of costs
- Exploration of the feasibility of using incentives to regulate the water services sector

Estimated cost: R800 000 (KSA 3)
Expected term: 2006 - 2009

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa
Tshwane University of Technology
No. 1700

Over the years, the government has spent billions of rand to meet the backlogs in water supply and sanitation services in South Africa, and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that

improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental).

Estimated cost: R1 200 000 (KSA 3)
Expected term: 2006 - 2009

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities
Cape Peninsula University of Technology
No. 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services. Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty-alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324 (KSA 3)
Expected term: 2007 - 2009

Development of a framework and model to regulate the competencies and training of managers and technicians in the provision of water services
University of the Witwatersrand
No. 1715

Currently there is a lack of an understanding of the appropriate generic approaches to qualifications, competence and skills in a technical sector such as water services. Reviewing the water services and related (municipal, health, construction, electricity) legislation and regulations, it is evident that there is a huge gap in identifying current institutional arrangements for regulating qualifications, competencies, training and development. Furthermore, this is compounded by a lack of a conceptual framework and model for the qualifications competencies and skills required for effective provision of

water services. This study aims, on the basis of engagement with stakeholders, to develop an appropriate framework for competencies and skills in water services. It will develop an understanding of the specific qualifications, competencies and skills that are required for the effective provision of water services in South Africa. It will also clarify options and propose mechanisms that can be used to ensure that necessary qualifications, competencies and skills are available to all water services authorities and providers.

Estimated cost: R350 000 (KSA 3)
Expected term: 2007 - 2009

Examine the understanding and interpretation of sanitation policy and programmes

Hlathi Development Services

No. 1741

South Africa is faced with a sanitation backlog that has to be redressed by 2010, and at present policy and strategy focus on delivery, rather than on sustainability of the sanitation services provided. The 2010 targets have been set by National Government as being a basic level of sanitation because all effective sanitation must focus on people and not only the infrastructure. The primary focus of the policy is on the services provided by the Water Service Authority, but also highlights that the end-user households share responsibility for good sanitation and effective sanitation practices. The Water Service Authority is given the responsibility of monitoring and desludging on-site facilities, and/or relocation of on-site toilets when pits fill. There are, however, no existing policies or strategies that set out the detail of how this process is to be implemented. This implies that the operation and maintenance of rural sanitation systems are less than optimum, leaving the user with a level of service that is below the national average. This has numerous implications for the user and national Government. Amongst the implications are health and cost factors.

Estimated cost: R400 000 (KSA 3)
Expected term: 2007 - 2009

Free basic sanitation – is it possible?

Hlathi Development Services

No. 1742

The South African Government has made a commitment to provide free basic water and sanitation services to the poor households. A review of progress in the implementation of the free basic water policy showed that the 3 poorest provinces are lagging behind with regard to the provision of free basic water (KZN, Limpopo and EC). More than 60% of the people without access to basic sanitation services are found in these 3 provinces. From this analysis, it is clear that the objective of providing free basic water and sanitation services to the poor households is proving to be difficult to achieve. The implementation of the free basic sanitation policy is more complex than water provision because of the different sanitation technologies that are used; e.g., for poor households with full waterborne sanitation, it is unclear whether the water for flushing or the cost of treating sewage should be subsidised. Should the municipalities be responsible for providing O&M for on-site sanitation? There is currently no policy for funding relocation of superstructure for full

toilets or construction of new ones where relocation is not feasible. Thus, there is a need to identify successful and cost-effective approaches of implementing sanitation subsidies for sanitation infrastructure in order to achieve the 2010 sanitation target. Financial models and innovative strategies are required for assisting municipalities to provide sustainable free basic sanitation services to the poor household and to pay for ongoing O&M for these services. Good practice must be identified and scaled-up where possible.

Estimated cost: R700 000 (KSA 3)
Expected term: 2007 - 2009

What do we do to accelerate sanitation?

Hlathi Development Services

No. 1743

The need to accelerate the provision of safe and hygienic sanitation to the approximately 8 million South Africans who still lack it is an urgent priority. Safe sanitation and improved hygiene practices can save thousands of children's lives every year. The dignity and quality of life of mainly poor people can be considerably enhanced. Government has accorded sanitation a very high priority and has committed itself to eliminating the backlog by 2010. However, at the current pace of delivery, this target will not be achieved. There is thus an urgent need to find ways to accelerate the pace of delivery, and to do so in such a way that the sustainability of the facilities provided and behaviour changes achieved are sustainable. The bottlenecks to faster delivery need to be identified and analysed, examples of how they have been successfully overcome documented, and tools and guidelines produced to help municipalities to achieve the required rate of sustainable service delivery. Ways also have to be found to reduce the cost of sanitation delivery to urban areas, and informal settlements in particular.

Estimated cost: R549 600 (KSA 3)
Expected term: 2007 - 2009

THRUST 5: POVERTY ALLEVIATION

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province

Zakhe Agricultural College

No. 1465

Approximately 74% of South Africa's rainwater is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exerts even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often

overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention should be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods should be analysed.

Estimated cost: R3 000 000 (KSA 4)
Expected term: 2003 - 2009

Best management practices for smallholder farming on 2 irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research

University of Fort Hare
No. 1477

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. The research project on 'best management practices for small-scale subsistence farming' therefore requires commitment and co-operation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000 (KSA 4)
Expected term: 2004 - 2009

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province

University of Fort Hare
No. 1478

Approximately 74% of South Africa's rain-water is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in

particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 000 000 (KSA 4)
Expected term: 2004 - 2009

Agro-forestry systems for improved food production through the efficient use of water

CSIR (Natural Resources and the Environment)
No. 1480

Less than 15% of land area in South Africa is arable. This implies that there is very limited scope for conventional food production, both on irrigated and dry-land. In addition to limited arable land, South Africa is a water-scarce country. Its rainfall is below the world average, and its distribution is somewhat unreliable. The relatively low rainfall and limited arable land make it imperative to effectively and efficiently use these natural resources for food and fibre production. This is even more important for emerging and subsistence farmers who often lack access to information and use of production technologies.

Smallholder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands. In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor. This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally. Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within

South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment

Estimated cost: R3 250 000 (KSA 4)

Expected term: 2004 - 2009

Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods

Rural Integrated Engineering (Pty.) Ltd.

No. 1575

The rural landscape of South Africa is characterized by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location, ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the Government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Expected cost: R2 750 000 (KSA 4)

Estimated term: 2005 - 2009

Nutritional value and water use of indigenous crops for improved rural livelihoods

University of Pretoria (Centre for Nutrition)

No. 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (*WRC Report No. 944/1/04*). It is also important to determine the nutritional value and water requirements of these crops. The best combination, between indigenous crops and a range of home-grown vegetables and other foodstuffs, to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (*WRC Report No. 1267/1/04*). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosa, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households.

Expected cost: R2 850 000 (KSA 4)

Estimated term: 2005 - 2010

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities

University of the Free State (Department of Agricultural Economics)

No. 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on biophysical aspects of in particular infield RWH&C has been done (see *WRC Report No. 1176/1/03*). A start has also been made to evaluate the social acceptability and economic viability of this technique (see *WRC Report No. 1267/1/04*). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high- and low-rainfall areas. Priority attention must be given to low-potential areas, which

are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000 (KSA 4)
Expected term: 2006 - 2011

Productive use of domestic water for sustainable livelihoods

Nemai Consulting

No. 1666

Poor communities in both rural and urban areas use water for various purposes other than merely domestic use. The source of this supply can vary from traditional sources to improved water supplies, and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor in these additional requirements of water for poor communities to be able to sustain their livelihoods. Further, the general approach and thinking about productive uses is limited to small-scale agriculture; however, in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities, and also what levels of supply will be adequate for this purpose. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000 (KSA 3)
Expected term: 2006 - 2009

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa

ARC (Institute for Soil, Climate and Water)

No. 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorized as ultra-poor. Although the country is self-sufficient in food production, about 14 million people are reported to be vulnerable to food insecurity and 43% of households suffer from food poverty. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas. Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned but used

communally by farmers for grazing domestic livestock and harvesting natural products such as fuelwood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterized by abandoned croplands that are infested by weeds and grasses. In communal areas, where individuals share land and water resources, understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is dependent upon the functioning of the institutional arrangements. Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop lands in communal areas will be produced.

Estimated cost: R3 200 000 (KSA 4)
Expected term: 2007 - 2013

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)

Umhlaba Consulting Group

No. 1776

Water harvesting and conservation practices have been tested and demonstrated to be sustainable and contribute to food security. Many of these techniques and practices have been documented in the form of research reports and information material for public interest, but not packaged as training material for the end user. In addition, advisors and farmer support personnel such as extension services are often ill-informed and inadequately trained in agricultural water management including water harvesting and conservation. High illiteracy, particularly among the rural population, limits the ability of farmers to access information and utilise new technologies. There is, therefore, a need for accredited yet appropriate training material for certified trainers and learners (farmers). Training, education and skills development will need to follow a broad-based approach that is aligned to government initiatives such as the Joint Initiative on Priority Skills Acquisition (JIPSA) and grounded on Outcomes Based Education (OBE) and Adult Basic Education and Training (ABET) principles. This project will develop a comprehensive learning package for the application of WH&C for household food production and poverty alleviation in rural areas. It will identify the existing unit standards for training in WH&C and fill the gaps in learning material by adopting and adapting available material and developing a comprehensive package (NQF level 4/5 facilitators guide for trainers, ABET levels 1 and 2 learning material for learners and assessment guide). The learning package will be tested in the field with trainers, facilitators and learners.

Estimated cost: R1 950 000 (KSA 4)
Expected term: 2007 - 2012

New Projects

THRUST 1: CO-OPERATIVE GOVERNANCE

Exploring the lowest appropriate level of water governance in South Africa

University of the Western Cape; University of Botswana
No. 1837

This project aims to develop an unambiguous conception of the management-governance relationship. Clarify the resource management responsibilities and concomitant governance responsibilities of each type of water organisation as intended by government and other stakeholders. Investigate the execution of the governance responsibility of each organisation type within a water management area and advise on possible reforms. The project aims to derive the most appropriate structure of water governance, particularly at local level, based on local experience in comparison with international practice.

Estimated cost: R1 000 000 (KSA 1)
Expected term: 2008 - 2010

The water sector institutional landscape by 2025

CSIR; Barbara Heinzen (independent consultant); HSRC
No. 1841

The implementation of institutional reforms in South Africa is moving ahead despite a number of challenges and an environment that is changing constantly. The purpose of this investment is to project to the future and paint a futuristic picture of the organisational landscape for both the management of water resources and for the provision of services. A good set of scenarios should leave the reader wondering which one is more likely or more probable. That forces the reader to think more, and that is the whole point of a scenario – to learn more about alternative futures, so that one can make better choices today. In this exercise, the scenario building must be conducted in a participatory and inclusive manner, and very systematically so that it could make a major contribution to refining the future outcomes in institutional rationing and to build new capacities in the country.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2008 - 2011

THRUST 2: WATER FOR TRANSFORMATION AND EQUITY

The impact of IWRM on the lives of women and the poor in South Africa

Ninham Shand; University of the Western Cape; Groundwater Africa; North-West University; Rand Water; The Rural Action Committee; Mbumba Development Services; Umhlaba Consulting Group; FAO; Gavin Quibell (independent consultant); Roger Short (independent consultant); DANIDA/DWAF; PLAAS (Institute for Poverty, Land and Agrarian Studies, UWC)
No. 1839

This project aims to: conduct a comprehensive literature review of how IWRM has been conceived and applied both in international literature and in selected national legislation and policy; to develop indicators for assessing how IWRM will impact on the lives of women and the poor and to apply these

indicators to South African case studies; and to build research capacity locally and internationally on approaches to implement and monitor IWRM.

Estimated cost: R1 000 000 (KSA 1)
Expected term: 2008 - 2010

Water allocation reform, instruments and processes for achieving equity and gender balance

Sinelwati Scientific cc; Scientific and Technical Services Institution
No. 1855

This project aims to interrogate and derive lessons from international (regional) experiences with respect to sustainable use of water to meet the needs of historically-disadvantaged individuals and the poor; to evaluate immediate past interventions designed to achieve redress, establish reasons for success or failures and derive lessons; to evaluate each of the current processes and instruments for water allocation reform and investigate the conditions under which they can meaningfully redress race and gender inequities; to develop discussion documents and guidelines to inform and improve future implementation of the water allocation reform processes and instruments; to participate and share lessons with the department as the water allocation reform is implemented; and to develop a learning journey manual for the water allocation reform experience in South Africa

Estimated cost: R1 050 000 (KSA 1)
Expected term: 2008 - 2010

THRUST 3: SUSTAINABLE USE OF WATER AS A SCARCE AND SHARED RESOURCE

The Shared Rivers Initiative Phase I: Communication and fundraising

CSIR (Natural Resources and the Environment); AWARD; SANParks (Kruger National Park); University of the Witwatersrand
No. 1783

There is growing concern about the continuing decline in the integrity of the Lowveld river systems despite an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management. These river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland) and each has to achieve their own resource and supply priorities within their portions of these basins. There is a clear need to harmonize management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery. This must be done within the constraints of seasonal and longer term variability of the water resources. River systems are complex, comprising interrelated social and ecological sub-systems, which make addressing issues of implementation and compliance difficult within an international river context. Recognising the Lowveld rivers as complex social-ecological systems has many implications in the way they are/should be managed. This project (Phase 1 of a larger initiative) aims to understand and effect change in the implementation of policies and legislations relevant to the wise use of the Lowveld river systems by exploring water policy implementation as a complex social-ecological problem from a theoretical perspective, initiating an action research programme that combines research, learning and implementation to secure

institutional and operational competency in river management and to improve broad stakeholder awareness and compliance that leads to the implementation of real solutions to real problems, the outcome of which delivers the river ecosystem goods and services upon which people depend. Research in the other countries with which South Africa shares these basins will depend on funding from sources other than the WRC. Thus, it is important that, during this phase, other funders are recruited to broaden the geographical scope of the research.

Estimated cost: R548 000 (KSA 2)
Expected term: 2008 - 2010

Knowing, caring, and acting: making use of socio-cultural perspectives to understand and improve conservation

CSIR (Natural Resources and the Environment)

No. 1800

This project is an extension of **Enriching Freshwater Conservation (K5/1678)** and will focus on issues that make society more aware of the value of a healthy environment for the wellbeing of both current and future generations, i.e. will focus on increasing the success rate of the implementation of conservation. A WRC study entitled Enriching Freshwater Conservation (K5/1678) identified 4 potential 'actor clusters' which feel and act differently towards the environment. In order to understand some of the nuances of the implementation crisis facing freshwater conservation initiatives, one needs to interrogate the 'knowing, caring and acting' sequence. But, the expectation that society should be influenced by, and should adjust their knowledge systems, their values and behaviours in greater support of conservation, is an enormous challenge. This is especially true in the context of freshwater ecosystems where, apart from water, the ecosystem benefits to society are sometimes hidden and typically not felt in a commercial or market-oriented fashion. The overall aim of the project is to develop a conceptual understanding of how the conservation process is influenced by the 'knowing, caring and acting' dynamic.

Estimated cost: R500 000 (KSA 2)
Expected term: 2008 - 2011

An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments

University of KwaZulu-Natal (School of Agricultural Sciences and Agribusiness); University of Cape Town; Swedish Meteorological and Hydrological Institute (SMHI); DWAF; Government of Queensland; German Development Institute (GDI)

No. 1843

Much effort has been expended to improve predictions of how global change will impact on primary biophysical changes such as rainfall and temperature, and the secondary effects on crop production, water resources and ecosystems. However, to date practically no effort has been made to integrate the causal relationships of global change to determine or assess its higher level socio-economic impacts. These impacts can be disastrous on a regional scale and its knock-on effect may have serious implications for the national economy. Vulnerable communities may be most seriously affected. On the other hand, socio-economic activities mostly display remarkable adaptive ability and thus resilience to change. This project will be undertaken to assess how sensitive socio-economic activities are to expected climate change in 4 divergent areas of South Africa.

Estimated cost: R2 500 000 (KSA 1)
Expected term: 2008 - 2011

THRUST 4: SOCIAL REQUIREMENTS FOR SUSTAINABLE WATER SERVICES

Situational analysis of water services provision in South Africa - establishing future strategies for consideration by municipalities

PD Naidoo & Associates (Pty.) Ltd.

No. 1812

To date centralised service provision has been the norm in the development of many cities and towns. The attraction towards centralised systems is based on established experience and practice of the benefits obtained from the economies of scale offered. Questions of efficiency, vulnerability, long-term technology decisions which prevent application of new technology, etc., are all new constraints which are questioning current approaches. This is further compounded by the fact that as cities and areas within cities get established it becomes more challenging to replace and rehabilitate existing infrastructure. These approaches come with pros and cons; however, the new and future challenges are different from those which influenced centralised approaches, from both new developments, operation and maintenance, energy constraints/costs and the availability of new technology. Similarly, decentralised systems also have their pros and cons. There is good evidence of the challenges faced in managing stand-alone and dispersed schemes, with the contributing factors being capacity and competency constraints. Thus this study will contribute to the growing understanding of the operational realities of decentralised and centralised water and sanitation systems. An analysis and review of the approaches required will assist the sector to plan smarter for the future and shape our growing cities/towns/villages to support sustainable water services.

Estimated cost: R600 000 (KSA 3)
Expected term: 2008 - 2010

Development of people-centred programmes

Mvula Trust

No. 1815

The challenges in developing good operations and maintenance (O&M) practice are perhaps greatest in remote rural areas with stand-alone schemes. There are no economies of scale for this kind of infrastructure provision as there are vast distances between the location of WSA/WSP and where human settlements are scattered. Given this geographical reality, innovative solutions are required to ensure the sustainability of infrastructure in these areas. International and South African experience has shown that community-based approaches yield sustainable results in the field of service delivery. Several factors, however, have contributed to the decline of community-based (or people-centred) approaches in South Africa. The main reason seems to be that water services authorities (WSAs), have neither the experience nor the tools to apply people-centred approaches. From the viewpoint of service delivery sustainability and the rights of communities, this research will try to close this gap.

Estimated cost: R800 000 (KSA 3)
Expected term: 2008 - 2009



THRUST 5: POVERTY ALLEVIATION

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services

ASSET Research; University of Stellenbosch; CSIR
No. 1803

Large parts of the South African landscape, especially the former homelands, are heavily degraded and denuded due to, amongst other factors, historical over-population, mismanagement and exploitation of natural resources. While the country does have a limited history of restoring natural capital, i.e. rangelands and grassland catchments, woodlands and natural landscapes, few comprehensive analyses have been done to assess the ecological, hydrological and socio-economic impacts of rehabilitation across a range of contrasted sites and contexts. Very few investigations have been conducted to determine the tangible contributions restoration has made and can make to rural landscapes and local economic development. This study will assess the ecological, hydrological and socio-economic impact of improving degraded landscapes across the country at a number of contrasted sites in an integrative and dynamic systems approach. This will be done using a carefully selected assemblage of parameters to study how restoration specifically improves water flow, water quality, land productivity and in some instances carbon sequestration as well as generally improving the agricultural potential of the land. In addition, the socio-economic benefits of restoring natural capital will be assessed by investigating the contribution to employment creation and income generation. The economic quantification of restoration is likely to provide critical data needed for the implementation of payment for environmental services. A model will be developed based on information gathered by this study to assist in predicting the impact of future restoration projects on complex and dynamic socio-economic and ecological rural landscapes. This model will be used to consider the most effective and best ways to embark on future restoration projects. This decision support tool will be very valuable to national programmes and projects such as *Working for Water*, *Working for Wetlands*, *Working for Woodlands* and the land-care project.

Estimated cost: R3 000 000 (KSA 4)
Expected term: 2008 - 2013

Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province

Tshwane University of Technology; Agricultural Research Council (Institute for Agricultural Engineering)
No. 1804

Livelihoods of plot-holder homesteads on small-scale canal irrigation schemes in South Africa are diverse and dynamic and

the importance of irrigated farming in the livelihood portfolio of these homesteads also varies. Typically, the objectives of plot-holders on small-scale irrigation schemes range from production of food solely for own consumption to fully market-oriented production. While market-oriented farmers seek to expand the scale of their enterprise, subsistence farmers (food producers for own consumption) tend to have excess land. Most of the smallholder farmers on irrigation schemes require technical improvements to the prevailing production systems to enhance the financial viability of plot enterprises and increase the efficiency of water and land use. Effective management of shared resources such as water is essential to all farmers on the irrigation schemes and is dependent on collective action. Despite the multi-faceted challenges facing smallholder irrigation schemes, very little research has been successfully conducted on integrated production systems on these schemes. At this stage these schemes are also not included in RESIS of Limpopo Province, except if farmers are prepared to switch to sprinkler irrigation. Changing to sprinkler irrigation will not necessarily increase water-use efficiency, particularly if it is done without participation by farmers. This project seeks to enhance plot-holder scheme productivity and to strengthen collective action by improving the availability of irrigation water to farmers. It will seek to enhance the establishment of robust community-based institutional systems that reduce uncertainty and risk in land-exchange contracts. It will also endeavour to integrate crop and animal production in order to contribute substantially to local resource use, value-adding and market access on smallholder irrigation schemes. In order to achieve these objectives, the project will adopt a participatory learning and action approach to collectively analyse the existing behavioural and communication patterns. It will employ both plot and field experiments in an effort to encourage the efficient use of water and improve plot-holder productivity. The final output of this project will be a comprehensive report that documents the holistic approach followed in addressing the challenges facing smallholder irrigation farmers and lessons learnt as well as practical crop and animal production manuals for smallholder farmers and their advisers. These outputs will contribute to national programmes of high priority that address issues of poverty alleviation and food security.

Estimated cost: R1 890 000 (KSA 4)
Expected term: 2008 - 2012

Contact Person

Dr Andrew J Sanewe

E-mail: andrews@wrc.org.za
Tel: +27 12 330 9047



Mr Meiring du Plessis: Head
(until 31 May 2009)

Water and the Economy

Scope

Following an investigation launched during 2006 to review the Research Framework and Strategic Plan for future water-related economic research, some changes to the Research Framework were implemented in 2007. However, the scope of research addressed by this impact area in 2008/09 remained largely unchanged from previous years.

In the South African context water is first and foremost treated as a common (social) good. Water is recognised as being essential for sustaining life and is a commodity to which people and the aquatic environment have a legally-protected right. However, water is also recognised as an economic good, the use of which has a major impact on the creation of wealth and the well-being of people. Almost without exception, there is increasing interest in assessing the economic value of water, using water as a catalyst for the generation of wealth and prosperity, and using economic instruments to increase efficiency and effect desired behavioural change among water users. Examples of management options that are being implemented include: the use of water tariffs to effect changes in water consumption; the use of waste discharge charges to internalise pollution costs and, in so doing, effect pollution reduction and desirable improvements in water quality; and the sale of water use licences under specific circumstances. There is also recognition of the need to deal with complex water-economy systems such as catchments in an integrated manner, and to determine the sensitivity of socio-economic activities and their associated values to the impacts of extreme events such as floods or droughts, as well as to gradual changes over the longer term, such as global climate change.

This impact area will continue to integrate the economic aspects of water-related investigations funded by the KSAs. It will also identify overarching issues that need to be addressed at a higher level of integration. Projects and activities under this impact area will determine the role of water in economic development, the use of economic instruments for improved water management and the economics of dealing with complex systems at the appropriate micro-, regional and national levels.

Objectives

This impact area aims to be instrumental in integrating the economic aspects of water-related investigations that are under way within the WRC's KSAs, and in identifying and initiating further important investigations that may be needed in this impact area, **Water and the Economy**.

The primary aim of the research portfolio facilitated through this impact area is to demonstrate the applicability of economic principles in the water field and to provide convincing evidence as well as sound knowledge and support to water management institutions and implementing authorities. The legal framework is already reasonably accommodating and stakeholders are therefore expected to be receptive to the knowledge generated.

Secondary objectives are to:

- Assess the role of water in economic development
- Use economic instruments for improved management of water
- Deal with complex water-economy systems

This impact area thus serves to integrate the contributions made by WRC research in support of the governmental imperative to promote social and economic development as embodied in the DWAF initiative to promote the use of Water for Growth and Development.

Thrusts and Programmes

Following the completion of the *Strategic Investment Framework for Water-Related Economic Research: 2007-2010*, in the beginning of 2007, new thrust areas were outlined as follows:

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

Scope: The ever-mounting scarcity of freshwater in South Africa, within the context of an expanding economy and thus increasing demand, will need informed choices on water allocation between competing needs. In general there are 2 options to address this problem; increase supply or reduce demand.

- With a renewed focus on public infrastructure development in South Africa the question needs to be answered as to what the best possible economic allocation of scarce resources to, or costs and benefits of alternative shorter and longer term water management options is, including the options of enhancing supply and managing demand. Such analysis must also assist decision-makers to determine and communicate the trade-offs resulting from water allocation decisions.
- A 2nd and related question is whether South Africa's water resources are sufficient to support planned economic

developments (such as those proposed in the ASGISA document), and what the sensitivity of such economic development plans is to changing assurances of supply, changing water prices and implementation of water conservation regulations and technologies. This requires an analysis of whether water, as a specific resource, is a constraining factor in economic development in the first place.

- A 3rd question is the role of water in the alleviation of poverty. Although the WRC has a separate research focus on Water and Society, specific issues remain that are relevant to the Water and Economy impact area. One example is the impacts of water redistribution on economic growth as well as broad-based black economic empowerment, 2 key objectives of government policy. Another example is evaluation of the economic viability of emerging and small business in the water sector, such as small-scale farmers and contractors.
- A 4th question in this key strategic focus area is to evaluate the economics of water service delivery, including water supply and sanitation, and to identify institutional bottlenecks hampering service delivery

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

Scope: The next key element of the strategic framework is the application of economic instruments in the management of water.

- The 1st question concerns the (volumetric) levels at which water prices should be set, and how sensitive water demand is to changes in water prices, moving beyond single-point estimates on water valuation (elasticity). Price and demand will have to be studied at various stages of the water supply chain and for different users, while testing the affordability to water users throughout the chain.
- The 2nd question is that non-market-related valuation techniques need to be applied to estimate the demand for those water-related ecosystem goods and services not traded in markets. Estimating the benefits of healthy water-related ecosystems and applying these to estimate the economics of the ecological Reserve are 2 topics in need of further research.
- A 3rd question is what benefits are provided by clean water and what costs are involved in addressing polluted water. To limit water pollution to a level that do not cause long-term damage while allowing room for development, research is needed on the damage and unit control costs for key pollutants and key polluting sectors.
- The 4th question focuses on the prerequisites for efficient water allocation, specifically the accurate and cost-effective measurement of water use, as well as the institutional economics of water rights and licences.
- The 5th question revolves around an economic evaluation of water policies and the application of economic policy instruments to water management. A regulatory impact assessment of the National Water Act (NWA) is proposed, as well as applied research on the feasibility of water markets and charges for water and wastewater discharge.
- Finally, the question of how the results of economic analysis can be better integrated into the policy-making process, needs specific research

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

Scope: The causal relationships within complex water-economy systems need to be explicitly recognized and their sensitivity to biophysical and socio-economic change tested. Cause-effect relationships within larger-scale complex systems such as catchments are not necessarily obvious. Water needs to be managed for multiple uses in a sustainable manner. Integrated assessment and multidisciplinary modelling approaches are needed to provide a system-wide perspective on the management of water resources. The sensitivity of socio-economic activities, and the value derived from them, to the impacts of extreme events and gradual changes needs to be tested. Integrated water-economic modelling at a catchment level is needed to inform appropriate catchment management strategies.

Research Portfolio for 2008/09

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

Effective demand for alternative sanitation options in peri-urban settlements

Sigodi Marah Martin (Pty.) Ltd.

No. 1664

The level and quality of the services that communities are to receive must be discussed with, and accepted by, the community members. Quite important also are the economic considerations of these principles, namely that services must be provided economically and efficiently in order to give citizens the maximum value for money. Experts have long noted the importance of determining the 'effective demand' for services such as sanitation as expressed by the willingness of users to pay for these services. Too often the solutions proposed are inappropriate in terms of what the people want. As a result sanitary facilities are misused, badly maintained or even vandalised. If they are too expensive, the bills will not be paid which may give rise to the discontinuation of services and consequently to riots and/or violence. If the solutions do not meet the social norms, they will not be used. Finding the right solution is therefore fundamental in our quest for sustainability. Through the use of the SHAPE model developed through this research, it was possible to show that peri-urban residents eagerly preferred waterborne sewerage systems, but when integrated affordability considerations started to play a part, about 30% of the participants chose to accept on-site sanitation options. Further, affordability affects choice, but there is not a close correlation between incomes and sanitation options chosen by the inhabitants of dense settlements. Whatever the reason may be, it proves that policies stipulating only certain sanitation options when new housing schemes are built are restrictive and not in line with the Batho Pele principles. The conclusion was drawn that many peri-urban residents are willing

to accept smaller houses in exchange for higher levels of water and sanitation services in their homes.

Cost: R630 000 (KSA 3)
Term: 2007 - 2008

The impact of large consumer unit size on access to and affordability of water services in lower income urban areas in South Africa

Palmer Development Group (Cape Town Office)

No. 1713

The purpose of this research was to assess whether being a member of a large consumer unit, defined as more than 8 people sharing a stand, results in inhibited access to water and sanitation services, and whether large consumer units find water and sanitation services to be unaffordable. This research suggests that large consumer units cannot be viewed simply as a homogenous group. Different types of consumer units, and different households making up those consumer units, face different challenges with respect to water and sanitation. Nuanced policy approaches will be necessary to help to alleviate these differing challenges. Such policy approaches might include: considering programmes to upgrade backyard accommodation, and metering such accommodation separately; increases in the amount of Free Basic Water allocated to large consumer units; revisions to the rising block tariff structures, or consideration of alternative tariff approaches; and education programmes around the wise use of water. Indigent policies should also be reviewed to take large consumer unit size into consideration.

Cost: R390 550 (KSA 3)
Term: 2007 - 2008

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

Towards the establishment of water market institutions for effective and efficient water allocation

CPH Water

No. 1569

A regulated water market enables the transfer of water-use rights between water users in a manner that ensures that the transactions do not bear with them undesired third-party effects. The transfer takes place on a voluntary basis between buyers and sellers for their mutual benefit. Implicit in the discussions on water markets is that the laws, rules and regulations are in place to permit it to happen. The National Water Policy sets the scene and the National Water Act of 1998 provides the conditions for water management to move from the previous legislative framework, largely based on 'command and control' methods, to a new system which is more decentralised and market-driven (while being regulated to minimise undesired third-party effects). In the case of water management, all the actors (such as water users, water management agencies and government entities) are influenced by incentives. These incentives are provided by the institutional arrangements applicable such as the conditions attached to water-use rights. The different parts of the institutional framework interact to achieve the stated objective, such as the efficient use of water that can be achieved by the transfer of water-use rights to higher value uses through a regulated water market. For such transfers to take place the

appropriate institutional arrangements need to be in place. On the technical side, water use (i.e. abstraction or diversion) and/or discharge needs to be measured and monitored, and water users must be informed of water-saving techniques and have the financial means to implement them. Water-use rights need to be well defined and transfer mechanisms need to be in place to allow water-use rights to move within and between sectors at acceptable costs of transacting. In addition water-use rights need to be appropriately priced to incentivise more efficient use.

Cost: R1 500 000 (KSA 1)
Term: 2005 - 2008

A pilot study into upstream cleaner production technologies for the petroleum-refining industry to meet the requirements of the Waste Discharge Charge System (WDCS)

Process Optimization and Resource Management

No. 1673

The implementation of the Waste Discharge Charge System (WDCS) is expected to have a significant impact on how industries conduct their business. The main drive of the WDCS is to address problems of excessive water pollution by encouraging efficient resource utilisation and promoting sustainable water use. In order to comply, industries tend to resort to end-of-pipe treatments which are expensive and specific to certain constituents. New developments suggest that upstream technologies could be more cost-effective and more efficient in removing the water quality constituents of concern which could result in a considerably downsized end-of-pipe system with a small footprint, including considerable investment savings. This project investigated this premise by focusing on the petroleum industry. In order to validate upstream technologies or cleaner production (CP) options, the project team solicited input from Chevron, which is the main refinery in the Western Cape.

A literature survey of international CP technologies identified the most appropriate technologies for each process unit in the petrochemical industry. The WDCS consists of an Incentive Charge, a Mitigation Charge and combinations of the two, the determination of which are dependent on the efficiency of CP techniques employed, as well as on realistic and accurate cost estimates of these techniques. The intention is to set the Incentive Charge at the minimum level required to serve as an incentive to dischargers to reduce their effluent loads at source, so that the RQOs in the catchment may be met. In order to effectively implement an Incentive Charge, a realistic set of cleaner production techniques first have to be developed so that appropriate costs may be calculated. Although Chevron is currently discharging to a marine outfall, a hypothetical scenario was constructed to compare the application of upstream CP technology with end-of-pipe treatment. It was calculated that the introduction of CP technology would have been able to achieve the same improvement in effluent quality as projected for the Chevron effluent treatment plant, at 30% lower cost. This project has thus confirmed the premise that upstream CP technologies could be more cost-effective and efficient than end-of-pipe systems in removing water quality constituents of concern. It also demonstrated that waste discharge charges can be calculated and set at levels that should provide an incentive to industries to introduce CP technologies and, in so doing, improve effluent and resource water quality.

Cost: R229 200 (KSA 3)
Term: 2006 - 2008

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

Integrating floodplain livelihoods into a diverse rural economy by enhancing co-operative management: A case study of the Pongolo floodplain system, South Africa

University of KwaZulu-Natal (Centre for Environment, Agriculture and Development)

No. 1299

The approach to integrating livelihoods into a diverse rural economy was understood through stakeholder dialogue workshops. The outcome from these studies was then linked to knowledge from literature reviews underpinning certain aspects of the ecological, social and economic thinking in order to not only illustrate the 'agriculture, water and the environment debate' within a 'water and society' context but also to identify knowledge gaps requiring further research. Consideration of all the stakeholder interests, including interests within floodplain communities, showed clearly that despite the scientific knowledge and technical skills required to manage the delivery of flows of water from the Pongolapoort Dam, which can sustain a diverse socio-economy, the management system has strengthened some sectors at the expense of others. The causes of the current inequitable situation are centred in the failure to implement integrated rural development on a catchment/regional scale through co-operative community-based approaches; failure to apply scientific knowledge; and inability to effect corrective action with commitment, in response to evidence of inequity and a move away from the ecologically desired state for the system.

Cost: R880 000 (KSA 4)

Term: 2002 - 2008

Current Projects

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

Water resource management for profitable small-scale farming along the banks of the Orange River

University of the Free State (Department of Agricultural Economics)

No. 1354

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment. The main aim of this project is to develop an appropriate methodology

to successfully establish small-scale irrigation farmers in South Africa. Sub-aims are to:

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000 (KSA 4)

Expected term: 2002 - 2009

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development

Conningarth Economist

No. 1570

Water being a limited resource, it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000 (KSA 1)

Expected term: 2005 - 2009

Revitalisation of provincial fish hatcheries and training facilities to promote profitable aquaculture

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1580

A baseline study on the *Contribution of Aquaculture to Rural Livelihoods in South Africa* has been done by Rhodes University (**WRC Report No. TT 235/04**). This study showed that the present factors constraining aquaculture in rural areas were mainly a consequence of a lack of policy and institutional capacity and that the development of rural aquaculture will depend principally on a public sector led intervention, inclusive of technical support and fingerling supply. The study revealed that there are many state-owned hatcheries and training facilities falling under various government departments that are unproductive, privatised, or defunct. Though not assessed these assets are worth millions of rand. Based on the survey results it was further agreed that the involvement of the private sector in rural aquaculture would be essential for sustainable growth. As policy issues were being addressed by the National Department of Agriculture, it was suggested that the WRC should support the undertaking of workshops in preparation for participatory action research (PAR) with the various public

and private sector stakeholders to appraise the potential role of these hatcheries in the light of emerging policy, and where applicable to develop a framework for a community private public partnership (CPPP) to revitalise government hatcheries that are currently under-utilised. The workshops have been completed and the PAR can now proceed. The PAR is a process which includes research and implementing goals and objectives. Stakeholders in the Limpopo, Mpumalanga and Eastern Cape Provinces will be engaged and an end-point will be identified (for example, through CPPP revitalising a specific government hatchery). Once the end-point has been identified, the role of the PAR implementers would be to actively facilitate and record the process, so that it is successful and repeatable elsewhere.

Expected cost: R2 250 000 (KSA 4)

Estimated term: 2005 - 2010

Financial sustainability of sanitation services

Partners in Development

No. 1632

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially-viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices:

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall cost strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best-practice case studies
- Exploration of credit finance options for household sanitation improvement programmes

Estimated cost: R600 000 (KSA 3)

Expected term: 2005 - 2009

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities

University of the Free State (Department of Agricultural Economics)

No. 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based

strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on biophysical aspects of in particular infield RWH&C has been done (see **WRC Report No. 1176/1/03**). A start has also been made to evaluate the social acceptability and economic viability of this technique (see **WRC Report No. 1267/1/04**). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the United Nations Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000 (KSA 4)

Expected term: 2006 - 2011

Productive use of domestic water for sustainable livelihoods

Nemai Consulting

No. 1666

Poor communities in both rural and urban areas use water for various purposes other than merely domestic use. The source of this supply can vary from traditional sources to improved water supplies, and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor in these additional requirements of water for poor communities to be able to sustain their livelihoods. Further, the general approach and thinking about productive uses is limited to small-scale agriculture; however, in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities, and also what levels of supply will be adequate for this purpose. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems.

Estimated cost: R700 000 (KSA 3)

Expected term: 2006 - 2009

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa

Tshwane University of Technology

No. 1700

Over the years, the government has spent billions of rand to meet the backlogs in water supply and sanitation services in South Africa, and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental).

Estimated cost: R1 200 000 (KSA 3)

Expected term: 2006 - 2009

Guidelines for the integration of community-based procurement for providing operations and maintenance services for basic water and sanitation provision by municipalities

Cape Peninsula University of Technology

No. 1714

The Strategic Framework for Water Services (2003) advocates that the provision of water and sanitation services has significant potential to help alleviate poverty through the creation of jobs, use of local resources, improvement of nutrition and health, development of skills, and provision of a long-term livelihood for many households through the provision of water supply and sanitation services. Traditionally, community-based procurement opportunities have been limited to labour-intensive facility construction during the implementation of water and sanitation programmes. These have primarily been short-term job creation opportunities with the emphasis on giving as many people as possible an opportunity to acquire the necessary skills and limited experience by rotating labour at short intervals. As municipalities are coming to terms with the scale of operation and maintenance requirements of basic services, more municipalities are considering integrating community-based procurement opportunities for the provision of operation and maintenance functions of basic water and sanitation services. This study will investigate the extent to which local municipalities have integrated poverty-alleviation opportunities into their operation and maintenance programmes for basic water and sanitation services, and how these opportunities have been integrated into the overall water service provider arrangements in each of the case study sites.

Estimated cost: R667 324 (KSA 3)

Expected term: 2007 - 2009

Assessment of the contribution of water use to value chains in agriculture

University of the Free State (Department of Agricultural Economics)

No. 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the Agriculture Sector Plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-ranging programme is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises: how can emerging producers be included in the mainstream of the economy? Only by obtaining access to available resources or assets in agriculture, can an impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically-beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the economy. It will investigate whether emerging farmers, who are producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development. The main outputs will be: firstly, a conceptual framework based on the literature review of the value chain analysis with specific reference to water utilisation and competitiveness in agriculture; secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticultural and field crop industries; thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain, optimisation of water use in the whole value chain, mainstreaming of marginalised participants in the economy by integration in the value chain, employment creation and poverty reduction through the value chain, and improving competitiveness in the value chain.

Estimated cost: R2 430 000 (KSA 4)

Expected term: 2007 - 2012

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

Valuing water for South African industries: A production function approach

CSIR (Natural Resources and the Environment)

No. 1366

The industrial sector in South Africa is one of the fastest-growing sectors and relies to varying degrees (ranging from wet to essentially dry industries) on water resources as an input to many production processes. Industrial water use currently comprises about 10% of the total water use in South Africa

(WSAM 2000) and is therefore a significant water-using (and effluent-generating) sector. Very little is, however, currently known about the responsiveness to water pricing within the industrial sector in South Africa, probably because of historically low pricing structures and the perception that industrial water use is better suited to engineering rather than economic analysis. International literature offers mixed results, with industrial price elasticities ranging from very inelastic to more elastic. In the context of the National Water Act and its emphasis on economic pricing, and the significance of industrial water use in South Africa, it is necessary to provide econometric tools to decision-makers. The project aims to quantify and characterise the role that water plays in various local industries and their responsiveness to price changes; and to develop a set of indicators and judgement criteria for policy-makers, decision-takers and other stakeholders to use economic analysis for appropriate water resource management. The project's overall aim is to determine the marginal value of industrial water in South Africa, in keeping with the National Water Act's objectives to price water correctly. The specific sub-goals are listed below:

- To assess the role that industries play in the overall water demand for South Africa, and to determine which industries are the most water-intensive industries and which industries are relatively 'dry'
- To determine price elasticities of demand for water for the respective industrial sectors within South Africa, and develop a set of indicators that can be used in existing models or to assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge

Estimated cost: R549 600 (KSA 3)
Expected term: 2002 - 2009

Valuation of estuary services in South Africa

Nelson Mandela Metropolitan University (Department of Economics)

No. 1413

Estuaries are delicate systems that are not only in high demand for development, but also deliver important goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological processes and functions, but does not adequately account for the values placed on estuaries by people. This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 170 000 (KSA 2)
Expected term: 2004 - 2009

Development of a model to assess the cost associated with eutrophication

The Institute of Natural Resources

No. 1568

Eutrophication and its accompanying effects is one of the intractable symptoms of water pollution associated with modern society. It diminishes the quality of our water resources for many uses and costly treatment is often required to overcome its negative effects. In the prevention vs. cure debate, it is important to not only know the cost of prevention, but also the cost associated with eutrophication when it occurs at various levels, in order to justify often expensive preventative measures. Knowledge of the cost associated with eutrophication will also help in determining and justifying the introduction of waste discharge charges. Similarly to a study that assessed the cost to users that can be associated with water salinity, a multidisciplinary team will conduct this project to determine the costs associated with eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2005 - 2009

Framework and manual for the valuation of goods and services of aquatic ecosystems for resource-directed measures

CIC International

No. 1644

The determination of the ecological Reserve for a particular catchment area requires the integration of the catchment area's management class, the related Reserve and the resource quality objectives. In addition, benefit trade-offs with other water users also have to be considered. The National Water Resource System (NWRS) recognises this by seeking to find a 'balance between protection and utilisation'. Therefore, in order to develop resource-directed measures (RDMs) that are technically sound, scientifically credible, practical and affordable, a framework and manual for the valuation of goods and services from aquatic ecosystems for the RDM are now required. The set of problems to be addressed here is therefore clear: in order to enable interpretation (and negotiation) of the likely consequences of changes in management class as embodied in the RDM procedures, the 'invaluable' aquatic ecosystem threshold must be determined, while trade-offs in ecological, social and economic benefits of the other management classes must be made transparent to users and other interested and affected parties. This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R750 000 (KSA 2)
Expected term: 2006 - 2009

Estuaries and economic empowerment

University of KwaZulu-Natal (Centre for Environment, Agriculture & Development)

No. 1705

Earlier phases of the Eastern Cape Estuaries Management Programme researched the estuarine systems with the long-term aim of enabling communities living alongside the estuaries to

generate income from the resource in a sustainable manner. Courseware was prepared and presented to local authorities (ranging from poorly- to well-resourced) on estuarine planning and management with a view to including the estuary in the Integrated Development Plan (IDP) of the local authority. This follow-up project will focus on subsistence livelihoods and will examine such issues as economic empowerment, institutional arrangements, participatory governance in the light of available opportunities, and will establish a framework where identified opportunities can be picked up in the IDP process. Principles developed during this suite of projects will be applicable to wetlands and other areas where natural resource-based enterprises may be developed.

Estimated cost: R1 500 000 (KSA 2)
Expected term: 2007 - 2010

What do we do to accelerate sanitation?

Hlathi Development Services

No. 1743

The need to accelerate the provision of safe and hygienic sanitation to the approximately 8 million South Africans who still lack it is an urgent priority. Safe sanitation and improved hygiene practices can save thousands of children's lives every year. The dignity and quality of life of mainly poor people can be considerably enhanced. Government has accorded sanitation a very high priority and has committed itself to eliminating the backlog by 2010. However, at the current pace of delivery, this target will not be achieved. There is thus an urgent need to find ways to accelerate the pace of delivery, and to do so in such a way that the sustainability of the facilities provided and behaviour changes achieved are sustainable. The bottlenecks to faster delivery need to be identified and analysed, examples of how they have been successfully overcome documented, and tools and guidelines produced to help municipalities to achieve the required rate of sustainable service delivery. Ways also have to be found to reduce the cost of sanitation delivery to urban areas, and informal settlements in particular.

Estimated cost: R549 600 (KSA 3)
Expected term: 2007 - 2009

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

Investigation of the positive and negative consequences associated with the introduction of low-P detergents

University of KwaZulu-Natal (Pietermaritzburg)

No. 1768

Eutrophication is rated as one of the major water quality problems being experienced by South Africa. Eutrophication, specifically the accumulation of phosphorus (P), gives rise to serious problems with the water quality management of South African dams. It is estimated that up to 50% of P in South African sewage comes from detergents. This project will investigate the positive and negative consequences that the introduction of detergents with lower P contents would have on the eutrophication of dams, users of detergents, water and wastewater treatment works and the waste discharge charges system.

Estimated cost: R689 200
Expected term: 2007 - 2009

New Projects

THRUST 1: THE ROLE OF WATER IN ECONOMIC DEVELOPMENT

An investigation into the water infrastructure development financial allocation pathways in municipalities

African Centre for Water Research; Pegasys Strategy and Development; Oscar Somers (independent consultant)

No. 1844

This project aims to describe and quantify the water and sanitation sector value chain; assess the impact of widely differing financial and institutional capacity of the sector actors on the financing of service delivery; describe and analyse financial decision-making in the value chain; identify constraints to financial effectiveness or to the use of any particular financial instruments in the pursuit of sector goals; and to develop scenarios and recommendations for improvements in the value chain.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2008 - 2010

THRUST 2: USING ECONOMIC INSTRUMENTS IN THE MANAGEMENT OF WATER

The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile Catchment

CPH Water; South African Sugarcane Research Institute; University of the Free State

No. 1805

Numerous options are being considered to address the over-allocation of water in catchments. This ranges from improvements in the efficiency with which water is used and managed, to the reduction of alien invasive plants in catchments, to the building of new dams or transfer schemes. However, even though the measures listed above will help address the over-allocation to some extent, it is likely that existing lawful users may need to be curtailed (i.e. have their water use licences reduced) in order to address the over-allocation. The general aim of the project is to evaluate the impact of curtailment of existing lawful water use on the economic and financial feasibility of irrigation farming. In the selected catchment of the Crocodile River in Mpumalanga Province, the current water situation will be assessed to determine the causes of water stress in the catchment. This will be done by reviewing available documents and reports and through discussions with DWAF and the catchment management agency (CMA). The ACRU and Mike Basin models will be configured to represent the current water users, water resources and operating rules in the catchment. This component can be described as catchment-scale hydrological modelling. The SKELETON model will be further developed to link with the Mike Basin irrigation module. In particular the influence of the variable availability of water on optimum crop combinations and farming viability will have to be determined. This part of the modelling can be described as the farm-scale economic modelling. The integrated ACRU/Mike Basin/SKELETON model will be applied to evaluate the outcome of various curtailment scenarios. A report will be produced to document the findings for the Crocodile River specifying the

potential impact of curtailments and changes in operating rules to support sustainable irrigation farming in future.

Estimated cost: R1 790 000 (KSA 4)
Expected term: 2008 - 2011

Technology transfer on the technical aspects and cost-estimating procedures of surface and sub-surface drip-irrigation systems

ARC (Institute of Agricultural Engineering); NB Systems; University of the Free State
No. 1806

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The National Water Act of South Africa (Act 36 of 1998) requires equitable, efficient and sustainable use of available water by all user sectors. Drip-irrigation is considered to be the most efficient method of irrigation. The increasing application of drip-irrigation systems necessitates the correct economic analysis and choice of not only the dripper, but also the filtration equipment to ensure that the water is used efficiently. The WRC has published 4 different reports on drip-irrigation. The results of these reports created useful information for the cost analysis, choice, operation and maintenance of drippers and filtration equipment. It is of the utmost importance that the results of these projects are disseminated by means of technology transfers and training sessions with designers and farmers. The main aim of the technology transfer project is to facilitate a process towards effective implementation and usage of surface- and subsurface drip irrigation systems in terms of technical and economic principles. To achieve this aim, the project will be undertaken in 5 distinct phases of preparation; testing and analysis; compilation of guidelines; technology transfer and a process of knowledge dissemination. The technology transfer phase will consist of organising courses for designers to train them in the selection and usage of surface- and subsurface drip irrigation systems with respect to the technical and economic principles and organising of field days for farmers, irrigation managers and trainers to present the principles of economics, operation and maintenance of drip and filtration systems and to practically demonstrate it to participants. The output of the project will be a manual with guidelines for costing, selecting, operating and maintaining surface and sub-surface drip-irrigation systems.

Estimated cost: R1 485 400 (KSA 4)
Expected term: 2008 - 2011

Guidelines on domestic water accounts - Towards a consistent approach in RSA

Sarah Slabbert Associates; Neilsen Company; Zitholele Consulting
No. 1810

In the endeavour to provide municipal financial services of the highest quality to its customers and businesses, in an efficient and progressive manner, while safeguarding assets and upholding the public trust, water bills or accounts play a key interface in educating and encouraging participation in water management. Customers' water accounts provide a significant opportunity to further engage customers in relation to water conservation, regulation, risk management as well as planning.

The water customers in South Africa are split along the lines of being literate and illiterate, rich and poor. Domestic water accounts form an integral part of many communities who receive improved water services. The standardisation of water accounts is an innovation aimed at building linkages between customer awareness, customer accountability, participation and regulation of water services. The objective of these guidelines is to identify the key elements that would make domestic customers' water accounts more informative.

Estimated cost: R500 000 (KSA 3)
Expected term: 2008 - 2010

Guidelines on pricing and debt management for municipalities

Arcus Gibb (Pty.) Ltd.
No. 1811

Poor debt management and pricing continue to be some of the elements which are resulting in municipalities not performing in a financially viable manner and the customers not receiving an affordable service. DWAF produced a document entitled *Model Credit Control and Debt Collection By-Laws* (DWAF, 2005), which sets a framework and rules around this subject. It was aimed at water services authorities who did not have any legal framework to introduce effective debt collections and credit control. Thus the by-laws were seen as model by-laws. Though the bylaws (DWAF, 2005) provided the necessary legal framework, not much has however been done with regards to the provision of guidelines, tools and strategies to assist water services institutions to give effect to the bylaws and its contents. In the complex environment of water services delivery and the growing gap of poor revenue collection, it is becoming apparent that very radical and innovative approaches are required with regard to debt control and credit control.

Estimated cost: R600 000 (KSA 3)
Expected term: 2008 - 2010

Technical guidelines for the implementation of cleaner production initiatives (for point sources of pollution) in support of determining an incentive charge for municipal effluent charges

Process Optimisation and Resource Management (PRO&RM)
No. 1832

This project surmises that the only realistic way to calculate an incentive charge to promote the implementation of cleaner production technologies by industries disposing of their effluent into municipal sewers is to determine the equivalent implementation cost of cleaner production initiatives. The imminent implementation of the Waste Discharge Charges System adds impetus to the need for such a study. The objective is to develop Technical Guidelines through which the insights gained in the study can be transferred to other applications.

Estimated cost: R570 619 (KSA 3)
Expected term: 2008 - 2010

A comparison of the costs associated with pollution-prevention measures to that required to treat polluted water resources

CSIR; University of Cape Town
No. 1845

It is widely assumed that prevention is better than cure. This project will determine whether or not this assumption holds when applied to cleaner production technology costs (prevention) compared to the cost of treatment of pollution and the external costs borne by downstream users (cure). Four of the most important water quality contaminants will be covered: namely, salinity, eutrophication, microbial pollution and sediments. Because of the differences in the sources of the contaminants to be investigated and in the levels of information available for each, a differential approach will be followed in conducting this project. Specific catchments where the specified pollutants are of concern will be identified and the study will be undertaken in the identified catchment, e.g. salinisation in the Vaal catchment and eutrophication in the Crocodile catchment.

Estimated cost: R2 000 000 (KSA 1)

Expected term: 2008 - 2011

THRUST 3: DEALING WITH COMPLEX WATER-ECONOMY SYSTEMS

An evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments

University of KwaZulu-Natal (School of Agricultural Sciences and Agribusiness); University of Cape Town; Swedish Meteorological and Hydrological Institute (SMHI); DWAF; Government of Queensland; German Development Institute (GDI)

No. 1843

Much effort has been expended to improve predictions of how global change will impact on primary biophysical changes such as rainfall and temperature, and the secondary effects on crop production, water resources and ecosystems. However, to date practically no effort has been made to integrate the causal relationships of global change to determine or assess its higher level socio-economic impacts. These impacts can be disastrous on a regional scale and its knock-on effect may have serious implications for the national economy. Vulnerable communities may be most seriously affected. On the other hand, socio-economic activities mostly display remarkable adaptive ability and thus resilience to change. This project will be undertaken to assess how sensitive socio-economic activities are to expected climate change in 4 divergent areas of South Africa.

Estimated cost: R2 500 000 (KSA 1)

Expected term: 2008 - 2011

Contact Person

Dr Gerhard Backeberg

E-mail: gerhardb@wrc.org.za

Tel: +27 12 330 9043



Dr Renias Dube: Head
(until 31 December 2008)

Water and the Environment

Scope

Research in this impact area continues to improve the understanding of linkages between the natural environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) within the hydrological cycle as well as how these link with the anthropogenic environmental components (developed infrastructure and other land uses). The research will also seek to establish and apply best practices in mitigation of damage to the water environment. This additional dimension of the research is expected to address environmental degradation through applied approaches which will rely on competent fundamental research.

This impact area promotes enhanced understanding of whole-ecosystem functioning in the context of the broader environment and its effects on water resources, and supports the development and application of good environmental governance systems. Activities within this impact area contribute to sustainable water resource management that meets the changing needs of society, by combining:

- Our understanding of good governance principles
- Our knowledge of environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) and processes within the hydrological cycle

The primary focus of the impact area will continue to be integrated into existing and new insights generated by research within and between the KSAs and by other institutions working in related fields. Although this Impact Area is characterised by integrating research at a high/ meta-data analysis level, it is recognised that such research is only possible on the assumption that we have a sound foundation of appropriate basic research (and data) in place

Objectives

The objective of the impact area is to contribute to achieving a situation where our governance systems and our understanding of environmental processes and the functioning within the hydrological cycle are aligned to support sustainable water management. This impact area is also set to contribute to the selection and application of sustainable techniques in water governance and water projects that are aimed at addressing human development needs.

Thrusts And Programmes

The thrusts are unchanged from those of the previous year, but with minor changes to the thrust objectives. This year the thrust objectives emphasized the advancement of knowledge in the techniques that are used or targeted for use in meeting human needs while enhancing sustainable environmental components in the hydrological cycle.

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

Scope: All environmental components and processes within the hydrological cycle depend on and are regulated by the structural, functional and compositional aspects of biodiversity. Environmental components and processes also respond to, and impact on, society's decisions and actions. Historically, research has been narrowly focused on separate environmental components within the hydrological cycle rather than the processes and relationships between them. This thrust focuses on understanding these relationships within the hydrological cycle, their role in maintaining flows of water-related goods and services to society, and their vulnerability to change in the broader environment.

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Scope: Internationally, good governance is based on principles such as inclusivity, representivity, accountability, efficiency and effectiveness, as well as social equity and justice. In turn, good environmental governance should reflect our best understanding of the structure, functions, processes and variability that typify natural systems. Although there has been considerable development within the field of public, corporate and natural resource governance, little attention has been paid to the development of good environmental governance systems. This thrust focuses on water-related governance within society and the design of systems that better anticipate, reflect and respond to changes in environmental components and processes within the hydrological cycle.

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

Scope: This thrust focuses on the generation, application and communication of higher-level knowledge and understanding of ecosystem approaches to water resource management and water use. The higher-level knowledge targeted should recognise and account for natural processes and human-induced

impacts that affect water resources. This is achieved through research and workshops which stimulate the generation of new insights and information, through:

- Synthesising outputs from relevant programmes and projects within the WRC's research portfolio
- Combining these with the findings of other relevant national and international research initiatives
- Influencing and initiating appropriate new research and other initiatives to address environmental issues that cut across various water-related subject areas
- Sharing knowledge and influencing government support to the incorporation in government practices of environmentally sustainable processes

THRUST 4: ENVIRONMENTAL DEGRADATION AND MITIGATION

Scope: This thrust will seek to maintain and enhance the benefits of water to the environment, mitigate environmental degradation and reverse the damage caused to the natural and the developed environment by water through anthropogenic activities. Water in its different characteristics in the hydrological cycle will go through retrospective and prospective research to develop practical solutions for mitigating and addressing environmental degradation as well as enhancing the environment. These practical solutions for mitigating and addressing environmental degradation will be applied in a way that enhances social, economic and ecological benefits. This thrust will tend to align the research in this impact area to more evident solutions that are expected to touch the lives of those people who are exposed to degraded environments. The thrust will package, expose and enhance the applied research dimension to the mostly fundamental research in the different KSAs. The research in this area will also target the promotion of clean water environments through community-based research.

Research Portfolio for 2008/09

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

Ecological and environmental impacts of large-scale groundwater development in TMG aquifer systems

CSIR; Umvoto Africa

No. 1327

The evidence from the Kogelberg field study indicates that TMG (Table Mountain Group) aquifer discharge directly contributes to flow in the Oudebos tributary and cryptic discharge from the mid-slope 'wetland' on a fault. It also indicates that indirect TMG discharge contributes to the valley bottom wetland (via surface water) and to the coastal wetland (via the surficial unconsolidated wetland). All the fynbos species tested showed very high vulnerability to xylem embolism formation, i.e. they were vulnerable to reduced water availability. However, they showed relatively low levels of experienced midday water stress even in

terrestrial off-seep settings, particularly the deep-rooted *Proteas* which are known to have root systems up to 10 m deep (within the maximum known depth of soil formation in the TMG terrain). Shallow-rooted restios showed the greatest degree of moisture stress. The Proteaceae appear to be tapping water in the deep soil horizons, the colluvium and weathered TMG. At the Kogelberg site the following ecosystems linked to TMG discharge were identified:

- Slope wetlands linked to TMG faults and fractures and lithological contacts
- A coastal wetland linked indirectly to TMG fractures
- Perennial river and riparian zone linked to TMG fractures and lithological structures
- Terrestrial fynbos and perched high wetlands linked to (non-aquifer) TMG jointing and micro-fractures

The field study in Purgatory revealed that seeps on the eastern slope of the catchment occur where permeability interfaces (lithological contacts in particular the shale band and Peninsula formation) are transected by the Purgatory fault. These systems constitute a combination of lithologically-controlled and fault-controlled wetlands where groundwater contribution from the confined Peninsula Aquifer via the fault structure is possible. Seepzones at or just below the Goudini-Cedarberg Shale contact appear to be lithological contact systems and not connected to the confined TMG aquifer. Groundwater discharge into the eastern tributary is clearly evident along the deeply incised gorges. This inflow maintains the perennial character of the eastern tributary. The groundwater contribution most probably originates from the Peninsula Aquifer and discharges along the cross faults. The 2 wetlands in the non-perennial drainage line of the western tributary show strong seasonality in water level fluctuation. However, it appears that the streamflow in the dry months slightly increases below the second instream wetland suggesting some groundwater inflow, contributing to maintaining the ecosystem but not sufficient to create a perennial stream. At the Purgatory field site the following groundwater-linked ecosystems were identified:

- Slope wetlands linked to lithological contact and TMG fracture discharge
- Riparian zone indirectly linked to TMG fault and fracture discharge
- Seasonal and perennial rivers linked to TMG faults and fractures

The key findings of the research carried out on the project can be summarised as follows:

- It was shown that monitoring boreholes can be drilled in ecologically-sensitive areas without significant disturbance, using an appropriate EMP and site supervision.
- It was confirmed that it is imperative to collect good quality, hard physical data, such as groundwater-level data in correctly-sited boreholes and piezometers located at groundwater discharge-linked ecosystems, to monitor the changing availability of groundwater.
- It was shown that Si, DOC and Rn radioactivity are useful tracers of groundwater discharge into the aquatic environment. SiO_2 and DOC are more conservative tracers with respect to changes once discharged, whereas Rn (with a half-life of 3.8 days) could be used to indicate points of discharge. Macro-ions did not prove useful tracers in this study.
- Temperature is a useful indicator of groundwater flow and is indicative of the depth of groundwater flow.
- Stable isotopes are useful to distinguish between different plant water sources, although the differences might be

more distinct along gradients where the effect of altitude is more significant.

- Aquatic and terrestrial species indicators for groundwater dependency were not evident at the 2 study sites. Assemblages of plant, invertebrate and diatom communities were very diverse and could not be linked statistically to areas of groundwater discharge.
- The study did not encounter any species (threatened or not threatened) that are solely dependent on groundwater discharge.
- Wood-anatomy based measures indicate that on- and off-seep fynbos plants are highly vulnerable to moisture stress. However, there is no marked difference in the degree of xylem embolism vulnerability shown by on-seep species and their analogues off-seep, showing that the plants are adapted to the currently available moist conditions, i.e. precipitation and mist. The monitoring period covered 1 slightly wet year (2004/05) and 2 dry years (2005/06 and 2006/07), compared to long-term average data.
- Deep-rooted plants, such as the Proteaceae, did not exhibit moisture stress, while shallow-rooted plants, such as restios, showed some degree of moisture stress during dry periods. The Proteaceae appear to be tapping water in the deep soil horizons, the colluvium and weathered TMG, which is generally found in the top 10 to maximum 20 m below ground. In general, most plant species access multiple sources of water, with groundwater as a dominant source during drier periods.
- Remote sensing can be a useful tool to identify perennial wetland ecosystems and can be utilised for long-term and routine monitoring over a wide area of interest, provided the algorithm is adapted to the study area based on field verification and the spatial scale of the imagery is sufficiently small to detect ecosystems of interest.
- Subsurface flow in TMG mountainous catchments follows multiple geologically-controlled flow paths. Groundwater discharge from the TMG aquifers occurs at springs or seepage zones that are usually linked to predictable structural, lithological and topographic hydrogeological settings that can be mapped with high degrees of certainty.

Cost: R2 320 000 (KSA 1)

Term: 2002 - 2008

Habitat, use and movement of freshwater fish species

University of Cape Town (Freshwater Research Unit)

No. 1483

Fragmentation of rivers by dams, weirs and other human interventions is a major threat to aquatic biodiversity. Three of the nine species of yellowfish which occur in South Africa are endemic to the South-Western Cape, and all 3 are on the Red Data list as a result of human activities. The study was conducted on a tributary of the Doring River that supports populations of both Clanwilliam Yellowfish and Sawfins and demonstrated that detailed knowledge of habitat requirements of fauna is essential for the successful implementation of environmental water allocations (including dam-operating procedures), and that monitoring programmes should specifically address the response of key species to these allocations. Particular aspects that needed to be addressed were education and awareness of people such as landowners; protection and rehabilitation of river reaches, particularly the reaches critical to early life stages; fish sanctuaries; law enforcement; monitoring; and the eradication of alien fish species.

Cost: R688 000 (KSA 2)

Term: 2004 - 2008

Refining tools for evaporation monitoring in support of water resource management

CSIR

No. 1567

In the hydrological cycle evaporation is generally a large component of the hydrological cycle which is only second to precipitation. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the transpiration of plants. The accurate measurement of water use as prescribed in the National Water Act (NWA) of 1998 calls for more accurate assessment of the water balance. Most variables in the water balance equation have been measured or estimated to a reasonably more accurate level when compared to evaporation. The evaporation measurement/estimation techniques that are currently applied for most water use calculations have been around since the late 1940s. New methods have started to come out in the last 20 years or so as technology (micro-electronics and computer hardware/software) enabled innovative developments such as scintillometry to be available for various uses. At the same time new opportunities for improved measurement, such as through the complementary use of ground-based and remote-sensing techniques (especially for larger-scale water-resource related applications), also need to be explored. In this project the researchers used a variety of case studies and applied selected methods for evaporation monitoring. The research investigated accurate and precise requirements relating to evaporation measurement/estimation for various water-resource management applications. In this research the appropriateness of evaporation measurement/estimation techniques for addressing a range of key water-resource management needs was evaluated. The evaporation monitoring techniques were compared for various land uses and water resource management scenarios which included various land-cover canopies and open water in Midmar Dam. This research resulted in the development and testing of an electronic guideline for the complementary use of measurement and estimation techniques in evaporation monitoring. The research produced guidelines to aid users in the selection of a suitable technique for estimating total evaporation from a specific surface. The guidelines also provide users with basic information on the selected technique(s). A simple electronic Decision Support System (DSS), in the Visual Mind™ software programme, supports interaction with the guidelines. With the tools developed in this project water managers and foresters are equipped to account for evaporation more accurately than in the past.

Cost: R1 600 000 (KSA 1)

Term: 2005 - 2008

A review of information on temporarily open/closed estuaries in the warm and cool temperate biogeographic regions of South Africa, with particular emphasis on the influence of river flow on these systems

South African Institute for Aquatic Biodiversity; Nelson Mandela Metropolitan University; University of KwaZulu-Natal

No. 1581

The aim of this project was to answer generic questions posed during the DWAF RDM Reserve-determination process for temporarily open/closed estuaries (TOCEs). There are

2 publications from this project. The first is a review of knowledge on TOCEs, and the second a report on the findings of the East Kleinemonde Intermediate Ecological Reserve Determination Study.

Along the Eastern Cape coast there are more than 80 temporarily open/closed estuaries (TOCEs) that fall within the warm temperate biogeographical region, and 5 in the cool temperate region of the Western Cape. TOCEs are predominantly regulated by the amount of river inflow received, the magnitude of which is governed primarily by catchment size and the regional climate that dictates rainfall patterns. The review focuses on the forces that govern hydrodynamic processes and mouth conditions in estuaries and to develop a conceptual model. The major forces that maintain open mouth conditions are river and tidal flow and the major closing forces are marine wave energy and sediment availability. In small and medium size estuaries (<150 ha) tidal flow can maintain open mouth conditions during spring tides but often closure occurs during neap tides. Within the coastal zone, there are a number of processes that can transport varying amounts of marine sediments to estuary mouths. River floods are the most important natural means of eroding and transporting sediments out of estuaries.

The Intermediate Ecological Reserve Determination Study was conducted on the East Kleinemonde Estuary, where a substantial expansion of the town is being planned. Four development scenarios were investigated. The study concluded that the estuary can accommodate the reduction in river flow necessary to meet the requirements of future housing development. However, it will not be able to support the additional non-flow related human disturbance pressures that will be associated with the planned residential developments. Therefore the approval of any future residential developments should be conditional on the following mitigation measures being implemented:

- No consumptive use (e.g. fishing or bait collection) should be allowed in the East Kleinemonde Estuary
- No power boating on the East and West Kleinemonde estuaries (only canoes and electric motors to be allowed)
- All new urban developments will have to be connected to a wastewater treatment works to eliminate the risk of seepage from septic tanks entering the estuary
- Stormwater runoff from newly-developed areas will have to be captured and diverted from the system to prevent hydrocarbons and other pollutants from entering the system

Cost: R1 753 000 (KSA 2)

Term: 2005 - 2008

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Enriching freshwater conservation

CSIR (Natural Resources and the Environment)

No. 1678

The project was aimed at advancing understanding of the relationships between freshwater conservation planning and the social, economic and political landscape within which freshwater conservation goals are being implemented. It is proposed that once this relationship is more deeply understood freshwater conservation goals and objectives will be more robust because they will reflect wider agreement about the desired and expected delivery of human benefits from freshwater ecosystems, and hence implementation of freshwater conservation will be more effective and successful. The project examined ways in which

the systematic conservation process could be augmented by re-defining ecosystems as social-ecological systems, by promoting co-operation across overlapping mandates and an adaptive learning process, and by categorising societal groups and attitudes that can be targeted through different strategies to encourage freshwater conservation ideals and practices. A research strategy, which contextualises future research needs in this field of research, was developed and a proposal to continue research in this field, based on the work undertaken in this project that was focused on how the conservation process is influenced by different categories of actor clusters (that do not know, care and/or act when it comes to freshwater conservation) was written and implemented.

Cost: R450 000 (KSA 2)

Term: 2006 - 2008

Current Projects

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

An investigation into the impact of landfill leachate on the physical, chemical and microbiological quality of the Soutpan Stream and its immediate surroundings

Tshwane University of Technology

No. 1341

The Soutpan Stream runs past a very poorly-managed landfill site which serves the local Soshanguve community. The landfill is used for dumping of domestic and industrial wastes. Visible leachate is observed on a regular basis running into the Soutpan Stream. The Soutpan Stream serves a huge informal settlement as sole water source and thus presents a health hazard. The community uses the water for household practices, gardening and for animals to drink. This project aims to improve the situation and make the water and the landfill practices acceptable according to set guidelines. This will serve as an upliftment project for the community as we will make use of their experience and knowledge. The research aims to:

- Conduct an environmental inventory and audit of the study area
- Obtain information on how the landfill site is managed, the hydrogeological conditions, attenuating factors, weather patterns, volume and type of waste dumped, the volume and characteristics of leachate produced
- Investigate the direct and indirect physical, chemical and microbiological impacts and consequences, over a defined range of temporal and spatial scales, of the leachate generated at the poorly-managed landfill site on the Soutpan Stream and its immediate surroundings
- Suggest measures which will help to minimise any adverse impacts on the environment and human health

Estimated cost: R386 000 (KSA 1)

Expected term: 2002 - 2009

Integrated management of water hyacinth in South Africa

University of the Witwatersrand (School of Animal, Plant & Environmental Sciences)

No. 1487

Water hyacinth is difficult to control and is a problem worldwide. Chemical control is expensive and ineffective in the long term.

Biological control has provided a sustainable and cost-effective control in certain conditions, but the harsh South African winters are more detrimental to the control agents than the weed, allowing the weed to regenerate in the spring of each year. This project will refine earlier work (**WRC Project No. K5/915**) to control this problem weed by low-dose levels of certain herbicides without unduly damaging the populations of the control agents.

Estimated cost: R1 655 600 (KSA 2)

Expected term: 2004 - 2009

Land-use impacts on salinity in Western Cape waters

University of Stellenbosch (Department of Soil Science)

No. 1503

The importance of dry-land salinity on water resources has been recognised for quite some time. Its importance is especially visible in the dryer parts of the country and in Western Cape rivers. Earlier research attributed the mobilisation of salt to ploughing of land, which increases infiltration and accelerates the mobilisation of salts contained in the underlying geologic strata. Another potential mechanism is that changes in land use from extensive pastoral use to intensive cropping over the last century or more may have triggered the same process of salt decantation being experienced in Australia. As the salinisation of some Western Cape dams is intimately linked to salinity releases from agricultural land it is important to gain a better understanding of the mechanisms that are operative. The central aim of this project is to develop a thorough understanding of soil water and salinity dynamics, salt sources and salt storage in dry-land profile and hill-slope transects, as well as corresponding groundwater salinity dynamics. This understanding should inform future large-scale modelling and enable the development of land-use practices that would reduce/prevent degradation of land and water resources.

The central objective of this project is to develop a thorough understanding of water and salinity dynamics in the regolith (soil plus vadose zone) of a small dry-land catchment representative of semi-arid conditions in the Berg River basin. The perspective will include both salt sources and storage, and groundwater fluxes and catchment runoff, in order to inform future large-scale modelling and to guide the development of land-use practices that would reduce the degradation of land and water resources. Subsidiary objectives include the following:

- Determine and map the spatial distribution of salts across the whole Berg River catchment
- Spatially relate salt distribution to salinity-generating factors (soils and soil-forming processes, geology, climate, topography, vegetation and land use) across the whole Berg River catchment
- Develop an improved understanding of how local tillage and other dry-land farming practices augment or reduce the mobilisation of salts
- Conduct mechanistic modelling of salinity dynamics
- Use the model to create small catchment-scale salt flux scenarios for various land use and water management practices that will serve to inform modelling of salt fluxes on a regional scale

Estimated cost: R2 347 068 (KSA 1)

Expected term: 2004 - 2009

Persistent organic pollutants (POPs) in the environment

North-West University

No. 1561

South Africa is a signatory to the Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research now needs to be taken further in order to:

- Assess with higher confidence the scale and significance of the occurrence of POPs in the water environment in South Africa, the potential short-term and long-term impacts on water resources and water-linked ecosystems and the associated threats to sustainability of water resources and water use
- Better identify and quantify the fate and effect of selected POPs in the water environment
- Guide and inform the development of appropriate policy and regulatory measures that will:
 - Support implementation of the requirements of the Stockholm Convention
 - Substantially contribute to the protection of water resources and water-linked ecosystems with regard to POPs.

Estimated cost: R1 500 000 (KSA 1)

Expected term: 2005 - 2009

Secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change

University of Cape Town

No. 1562

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality, water quality and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function, with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R2 500 000 (KSA 1)

Expected term: 2005 - 2009

Flow conceptualisation, recharge and storativity determination in Karoo aquifers (with special emphasis on the Eastern Cape (Mzimvubu to Keiskamma Water Management Area)

SRK (CE) Inc.

No. 1565

The Karoo rocks outcrop over almost three-quarters of South Africa and act as a host for important groundwater resources. Hundreds

of villages in the rural areas of the Eastern Cape and KwaZulu-Natal Provinces obtain their water supplies from boreholes adjacent to or within the area of influence of dolerite dykes and sills which have intruded the Karoo sediments. These conditions produce unique and complex hydrogeological systems, which complicates the development of groundwater resources. This project aims to:

- Conceptualise flow dynamics and groundwater flow paths
- Determine recharge-discharge and storativity and generate target maps for groundwater exploitation

Estimated cost: R3 400 000 (KSA 1)
Expected term: 2005 - 2009

National Wetland Rehabilitation Programme: Phase II - Wetland Health and Integrity

University of Cape Town (Freshwater Research Unit)
No. 1584

This is a solicited project, the second of three phases in the National Wetland Rehabilitation Programme, and focuses on the development of methods to assess the health and integrity of wetlands, as this assessment lags behind the assessment of rivers and estuaries, which poses a problem in the environmental water determination process. There is growing recognition of the important role of ecosystem services provided by wetlands. This project will develop a suite of assessment techniques, not only to assess the ecological condition of the wetland, but also the state of the services delivered, in addition to a protocol by which the loss of wetland function through degradation can be measured. Training courses and a communication programme will assist in the transfer of the technologies developed.

Estimated cost: R3 450 000 (KSA 2)
Expected term: 2005 - 2009

Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa

North-West University (Zoology Department)
No. 1586

Groundwater ecosystems are virtually unknown in South Africa. However, in Australia recent research has shown them to be highly diverse. Fundamentally, they are of interest because there are certainly organisms which will be new to science, and the physiology and food chain dynamics of the organisms inhabiting these areas is of interest. In terms of the new legislation on biodiversity it is necessary to protect the ecosystems. However, the introduction of the concept of a groundwater Reserve in the national water policy means that if we are to implement the policy effectively we need knowledge of the ecosystem that is to be protected. The objective of this study is to broadly characterise the ecosystem in which stygobiont amphipods occur, develop a sampling method and conceptualise a biomonitoring protocol for groundwater using stygobionts.

Estimated cost: R1 350 000 (KSA 2)
Expected term: 2006 - 2009

Environmental water requirements in non-perennial systems

University of the Free State (Centre for Environmental Management)
No. 1587

Methods for the determination of environmental flows for the Reserve have been developed and used for rivers with permanent flow. However, many rivers in the semi-arid west of the country are ephemeral. The NWA requires that the Reserve be determined before licences may be issued, and currently used methods have not been verified for ephemeral rivers. Verification needs to be done and, where necessary, new methods.

Estimated cost: R2 737 000 (KSA 2)
Expected term: 2005 - 2009

Biochemical processes in a groundwater-fed inter-tidal ecosystem: Biogeochemical controls on the plant biodiversity within a salt-marsh ecosystem in the West Coast National Park: Impact of saltwater-groundwater interaction on pore water chemistry and vegetation

University of Cape Town (Department of Geological Sciences)
No. 1591

The relationship between groundwater and surface water is poorly understood and the relationship between groundwater and the marine environment is even less well understood. However, the impact of poorly managed groundwater exploitation on the latter would have a severe impact on the ecology of the system. The groundwater – seawater mixing process impacts the salinity, anoxia and water movement, bioturbation and nutrient availability in the sub-surface coastal environment thereby controlling the distribution of halophytes and freshwater loving plants and any change in this balance will reverberate through the ecosystem. Over-exploitation of the groundwater resource will have this effect.

This project aims to investigate this relationship in the West Coast National Park, an area of low rainfall and permeable geology where the Langebaan Lagoon which is primarily a groundwater-fed estuary. The area is undergoing development and so the demand for exploitation of the groundwater is increasing. This research will refine the understanding of the groundwater discharge around Langebaan, generate water quality maps, and identify any relationship between plant species and geohydrological characteristics. It will also identify specific characteristics which may be used in a monitoring programme and make recommendations on environmental water requirements of the area.

Estimated cost: R397 400 (KSA 2)
Expected term: 2006 - 2009

The potential of food-web manipulation for the restoration of eutrophic South African impoundments

DH Environmental Consultants
No. 1643

The project will address the challenge of eutrophication through the application of food-web manipulation as a cost-effective management option for South Africa's indubitably most limiting natural resource – freshwater. Many South African waters subsist in an advanced state of eutrophication, viz. a plagio-climatic condition dominated by a few taxa of coarse phytoplankton and fish. Such systems are resilient to remediation and require shock treatments such as the rapid bulk removal of problematic fish to allow the system to reset. In South Africa, eradication of Common Carp was seen as the first step in rehabilitation of most dams with eutrophication problems because it is this alien fish that preys on zooplankton, feeds in open waters among

macrophytes, and contributes to sediment disturbance and water column turbidity. The project will develop a scientific understanding regarding the storage vessels (dams) that largely supply all water user sectors (industry, agriculture, and domestic supply). The aims of this study are to:

- Determine fish assemblages at a suite of impacted and control dams in the same eco-region, coupled with identification of trophic state and eutrophication impact assessment
- Determine harvesting requirements to reset the fishery to a desirable assemblage
- Determine harvesting requirements to sustain the desired assemblage
- Collect data on specific abiotic and biotic components (stable isotopes, phytoplankton and zooplankton assemblage)
- Compare and contrast commonalities of ecosystem response and degree of system (site) specificity
- Assess in broad terms, economic and financial implications of the recommended approach
- Identify constraints to the proposed rehabilitation methodology
- Evaluate the findings in terms of the potential of this approach as a method for impoundment rehabilitation, as well as for commercial opportunities

Estimated cost: R1 727 760 (KSA 2)

Expected term: 2007 - 2009

Conservation model for threatened fish species

University of Limpopo, (School of Agricultural and Environmental Sciences, Aquaculture Unit)

No. 1677

Freshwater ecosystems are recognised as the most threatened ecosystems world-wide, and in an inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of habitat, are generally more sensitive to disturbance than invertebrates. The 3 main threats are from habitat loss, impact of aliens and exploitation. The objective of this project is to develop a conservation model for threatened fish species using *Opsaridium peringueyi* as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170 (KSA 2)

Expected term: 2006 - 2009

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface- and groundwater

University of Pretoria

No. 1686

The adverse effects of endocrine disrupting chemicals (EDCs) in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In South Africa no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the

production cycle of the animal. In this study the presence/absence of veterinary drugs in the environment will be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources screened for oestrogenic and anti-androgenic activity, using a battery of bio-assays

Estimated cost: R1 900 000 (KSA 1)

Expected term: 2006 - 2009

To investigate the capability of the Mfabeni Mire (St Lucia) to respond to climatic and land-use stresses and its role in sustaining discharge to downstream and adjacent ecosystems

University of KwaZulu-Natal (School of Environmental Sciences)

No. 1704

The relationship between ground- and surface water is important and not well understood. The Mfabeni Peatland (at 1 250 ha one of South Africa's largest, and at ~45 000 years before present one of South Africa's oldest peatlands) is situated on the east shore of Lake St Lucia within the Greater St Lucia Wetland National Park. The water from this wetland flows into Lake St Lucia where it provides freshwater refugia for biota in times of drought. During times of climate change wetlands such as this will potentially become more important for maintaining the biodiversity of Lake St Lucia and other similar systems. The research undertaken during this project will quantify the water balance of the peatland, the contribution of fresh water to Lake St Lucia, and evaluate the effects of climate change and land use on the water flux. Principles drawn from this work will increase understanding of the relationship between ground- and surface water elsewhere and give guidance in managing this interface.

Estimated cost: R1 123 391 (KSA 2)

Expected term: 2007 - 2010

Influence of catchment development on peak urban runoff

University of Pretoria

No. 1752

Developments in urban and informal areas are regulated with regard to potential flooding by the National Water Act (No. 36 of 1998). The 1:100 year flood line is used to define the extent of the development. Furthermore it is required by the municipal authorities that all developers should create temporary storage if the development contributes to an increase in flood peaks. This study will provide a quantification of the influence of a catchment development on the flow rate and volume of runoff. The study will contribute to an effective stormwater drainage design and optimisation of costs for the upgrade of hydraulic infrastructures in targeted urban areas.

Estimated cost: R665 000 (KSA 1)

Expected term: 2007 - 2010

Land-water linkages: Agent-based modelling of land-use change and its impact on water resources in the Modder River basin

Central University of Technology

No. 1753

Changes in land use have profound impacts on water resources. This study applies agent-based modelling to investigate land-use

changes and how these have impacted on water resources in the Modder River basin. While previous studies of land-use changes have addressed simplistic representations of 2 or 3 driving forces, the agent-based modelling technique will involve several situation-specific interactions among a large number of factors at different spatial and temporal scales. The main objective of this research project is to analyse land-use changes and highlight the dynamic nature of coupled human-environment systems using agent-based modelling in relation to land-use change and its impact on water resources.

Estimated cost: R357 000 (KSA 1)
Expected term: 2007 - 2010

A national survey of mercury levels in South African resources

CSIR

No. 1754

Recent estimates indicate that Hg emissions from sources in South Africa, mostly coal combustion and gold mining, contribute more than 10% to the global Hg emissions, thereby ranking the country second after China on the list of major Hg polluters globally. Mercury (Hg) pollution is a world-wide problem that should be addressed at global, regional and national levels. Mercury is released into the atmosphere from anthropogenic sources both as elemental Hg (Hg⁰) and in the ionic oxidized form (HgII). The major concern with Hg⁰ is that once released into the atmosphere it is oxidized, contributing to the oxidized Hg pool. This HgII is very water-soluble, and is removed from the atmosphere by both wet and dry deposition and enters freshwater and marine resources, where it is rapidly converted into the more toxic methyl-mercury (CH₃Hg) form. This more toxic form bio-accumulates in the aquatic food chain and poses a serious health risk to humans who consume fish or other aquatic organisms that are contaminated with CH₃Hg. Anthropogenic activities, such as artisan gold-mining activities, industrial and small-scale coal combustion, as sources of Hg in the atmosphere, the deposit thereof into water resources, and its effects on water quality, are not well characterized in South Africa. Accordingly, as one important step towards such characterization, this project aims to carry out a national survey of Hg levels in South African water resources. This should provide a sound basis for establishing the extent to which Hg is currently a problem in South Africa. The aims of the study are to survey the levels and speciation of mercury in water, sediments and biota in priority South African water resources; to assess the degree of compliance of the measured mercury levels with national and international guidelines; to assess the degree to which mercury may be a problematic pollutant in South Africa; and to create local capacity relating to mercury sampling and analysis.

Estimated cost: R918 850 (KSA 1)
Expected term: 2007 - 2009

Water quality monitoring data and target users: Maximising value

CSIR

No. 1755

DWAF operates a vast water quality monitoring network. The information transfer which should form an integral part of the design of such networks is not functioning optimally at present.

Much of the value of water quality information is lost if it is not effectively conveyed to users. This project will aim to maximise the value of water quality monitoring programmes by optimising the way in which information is transferred to users. This could have a knock-on effect regarding the appreciation of water quality management by politicians and the man in the street.

Estimated cost: R488 960 (KSA 1)
Expected term: 2007 - 2009

Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater

University of the Free State

No. 1766

The programme outputs will establish an improved understanding of the origin of pollutants, the pathways of these pollutants into the environment and the ultimate fate of these pollutants (LNAPLs). This project will produce tested techniques and guidelines for application in the industry. Available approaches are usually based on international case studies dealing mostly with porous aquifers. South African-specific case studies will enable a better understanding of the behaviour of LNAPLs in the subsurface with a specific emphasis on the fractured-rock environments.

Estimated cost: R3 500 357 (KSA 1)
Expected term: 2007 - 2011

Investigation of the positive and negative consequences associated with the introduction of low-P detergents

University of KwaZulu-Natal (Pietermaritzburg)

No. 1768

Eutrophication is rated as one of the major water quality problems being experienced by South Africa. Eutrophication, specifically the accumulation of phosphorus (P), gives rise to serious problems with the water quality management of South African dams. It is estimated that up to 50% of P in South African sewage comes from detergents. This project will investigate the positive and negative consequences that the introduction of detergents with lower P contents would have on the eutrophication of dams, users of detergents, water and wastewater treatment works and the waste discharge charges system.

Estimated cost: R689 200 (KSA 1)
Expected term: 2007 - 2009

Development of the AWARE model for the Inkomati CMA

University of KwaZulu-Natal

No. 1935

RISKOMAN, a joint project with UNESCO-IHE, aims to develop a policy tool that: (a) can optimise water allocation in multi-purpose multi-reservoir systems in water scarce environments, based on economic values and socio-political preferences; that (b) can continuously adjust these allocation policies based on seasonal flow forecasts and knowledge of their uncertainties; and that (c) can hedge against inflow risks using adaptive, risk dynamic, management and operation strategies. This project adds 2 extra components to the RISKOMAN research: i.e. (a) The development of an interactive multi-level information system in which information will be provided to different levels of basin water resources stakeholders, with an emphasis on providing the integrated information from RISKOMAN to the level of CMA

Board members; (b) improved understanding of the hydrological functioning of the Inkomati Basin through focused research on the spatial and temporal variability of hydrological drivers in the catchment with the use of remote-sensing methodologies and the application of these within the RISKOMAN project as a whole.

Estimated cost: R1 800 000 (KSA 1)
Expected term: 2007 - 2013

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development

Conningarth Economist

No. 1570

Water being a limited resource, it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000 (KSA 1)
Expected term: 2005 - 2009

A philosophy and strategy enabling learning for good ecosystem governance

CSIR

No. 1689

The project takes the creation of knowledge to the level of utilisation of knowledge by end users and to the progressive creation of learning organisations. Therefore the aim is to articulate the philosophy and establish the principles within which WRM institutions will be able to create appropriate learning environments for good ecosystem governance. In addition, the aim is also to develop a strategy and implement it using the above principles in pilot areas. As a new, emerging field such studies are needed to enhance the role of the WRC as a knowledge hub and to share the knowledge with decision makers for other policy applications.

Estimated cost: R639 200 (KSA 1)
Expected term: 2006 - 2009

Management effectiveness in implementing cross-sector policy objectives for conserving freshwater biodiversity

CSIR (Natural Resources and the Environment)

No. 1710

The National Spatial Biodiversity Assessment (2005) indicates that South African freshwater systems are in a much poorer state than terrestrial ecosystems. Responsibility for managing biodiversity vests in several government departments as well as society. There is a need for a process which will effectively integrate the varying mandates of the institutions involved in decision-making in a

situation of varying levels of certainty and of potential conflict. Research undertaken during this follow-up project will, with the international experience in this field, develop guidelines for the implementation of performance indicators and effectiveness scorecards for South Africa and facilitate a process of dialogue among mandated stakeholders that will promote collaborative learning and high-level support/endorsement for the effectiveness of measurement guidelines.

Estimated cost: R697 820 (KSA 2)
Expected term: 2007 - 2009

Guidelines for the utilisation and disposal of water treatment residues

Golder Associates Africa

No. 1723

WRC **Project No. 1148** found that the disposal of water treatment residues (WTR) to land could have positive effects. No local guidelines for land disposal exist at present. In order to determine what information is still required to develop such guidelines, a follow-on project (**No. 1601**) produced a scoping report on the development of guidelines for the land disposal of WTR. Although a number of knowledge gaps remain, this new study will develop guidelines based on the best current local and international information. The objective is to revisit these guidelines after 5 to 10 years of application and include actual field data and experience gained during this period. A national survey will determine the variation in the characteristics of different WTRs. The previous research and survey data will be used to develop guidelines that describe the requirements for the land disposal and agricultural use of WTR. A stakeholder consultation and scientific peer review process is planned to gain broad acceptance for the guidelines.

Estimated cost: R746 820 (KSA 3)
Expected term: 2007 - 2009

Development of guidelines for urban metros to facilitate legal compliance with respect to industrial waste management

Nancy Oosthuizen Consulting

No. 1733

eThekweni Metro has recognised that better waste management practices should be achieved as ineffective waste management practices are impacting negatively on cities' water resources. This case study aims to develop a set of easy-to-interpret, laymen's guidelines aimed at industry, ports, and intermediate waste contractors to achieve legal compliance related to responsibly managing wastes to achieve legal compliance. The products will not only benefit eThekweni, but all large metros and coastal cities as well.

Estimated cost: R350 000 (KSA 3)
Expected term: 2007 - 2009

Protocol for quantitative assessment of industrial effluents for discharge permitting

University of KwaZulu-Natal

No. 1734

Local authorities manage industrial wastewater by:

- Using their wastewater treatment plants for remediation
- Issuing discharge permits with limits on discharge

- Charging a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system

An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of the WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000 (KSA 3)
Expected term: 2007 - 2011

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water

CSIR

No. 1749

DWAF is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles were used in the *1996 South African Water Quality Guidelines (Vol 6: Aquatic Environment)* the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in characterizing the biotic effect of various endocrinal active substances at various levels of biological organisation, critical interpretational gaps remain. In its commonly used paradigm, health-risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water. The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500 (KSA 1)
Expected term: 2007 - 2009

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

Geochemical sampling and analyses for environmental risk assessments using the Wits Basin as a case study

Pulles, Howard & de Lange

No. 1624

Each environmental risk assessment (ERA) study is faced with questions regarding the location, number, size and type of samples that need to be collected for a proper assessment.

Answers to these questions are partially dependent on the predictions that need to be made, the available material and costs. This project will establish a methodology to guide users of an ERA process to quantify the uncertainty associated with predicted mine drainage quality as a function of sample representivity. Existing mineralogical and geochemical data for the Wits Basin, that are available from previous studies, will be used to demonstrate the application of the methodology that will be developed.

Estimated cost: R562 000 (KSA1)
Expected term: 2005 - 2009

Determine the applicability of ecological informatics modelling approaches for South African conditions with preliminary testing on algal blooms

North-West University (Potchefstroom, School for Environmental Sciences)

No. 1675

Ecological informatics was formalised as a discipline in 2004 and is defined as an interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing, at and between all levels of complexity of ecosystems, for use as a decision-making tool. Cyanobacterial blooms pose an ongoing problem in the water treatment industry, and there is currently no way of forecasting events, with planning being based on past experience. The ecological informatics approach is being developed, with some early success, for the forecasting of cyanobacterial blooms in Australia. The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use, based on the technologies used in Australia, for use by water resource managers and water treatment works.

Estimated cost: R225 000 (KSA 2)
Expected term: 2006 - 2009

Periphyton flow dynamics

University of Cape Town (Zoology Department)

No. 1676

Periphyton (benthic algae) in rivers is highly sensitive to changes in both water quality and flow. Periphyton forms the base of the riverine food chain and any change at this level will be reflected throughout the ecosystem. In addition, the growth of undesirable periphyton can have negative economic consequences in several ways. Filamentous algae can clog irrigation and water purification equipment as well as render the habitat unfit for sensitive organisms, blue-green algae can cause toxin, taste or odour problems and any excessive algal growth will reduce the recreational value of the water body. Knowledge of the dynamics of the relationship between water quality and flow on the one hand, and the response of the periphyton on the other, will enable more accurate prediction of this response; this capability is required in the determination of the ecological Reserve. During this project understanding of the interrelationship between periphyton growth and water quality/flow will be developed to a point where preliminary predictions can be made, and this knowledge will be transferred to managers involved in determination and implementation of the Reserve

Estimated cost: R1 000 000 (KSA 2)
Expected term: 2006 - 2009

Sedimentation and sediment yield maps for South Africa
University of Stellenbosch
No. 1765

Loss of storage capacity in dams due to sedimentation is a major strategic threat to our country's available water resources. Soil erosion, and therefore sediment yield and reservoir sedimentation, is accelerated by human activities such as clearing of vegetation and poor farming practices. In order to regulate and manage these negative actions, it is important to have accurate national maps of eroded areas and sediment yield. The sediment yield maps to be developed in this project are expected to assist DWAF in mitigating sedimentation impacts and making adequate provisions for sedimentation in dam developments. The better understanding of localised sedimentation processes from this research will feed into the land and soils conservation and management practices which are major concerns in farming communities and the National Department of Agriculture.

Estimated cost: R1 400 000 (KSA 1)
Expected term: 2007 - 2010

South African Handbook on Environmental Hydraulics
Ninham Shand
No. 1767

A great deal of river hydraulics knowledge has been gained through WRC projects. In the past, research projects have addressed a number of subjects which have included flow hydraulics, sediment transport and deposition, which are cornerstones of environmental studies. The knowledge gained from WRC research has been accumulated into a number of research reports, some of which are no longer available for distribution. This project will seek to collate available knowledge and experiences and integrate these into a user-friendly handbook of river hydraulics. The project will engage several experts to contribute on their specific research areas.

Estimated cost: R920 000 (KSA 1)
Expected term: 2007 - 2009

THRUST 4: ENVIRONMENTAL DEGRADATION AND MITIGATION

Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments
Pulles, Howard & de Lange
No. 1659

Defunct gold mines on the East and West Rand are rapidly filling up with contaminated water that will decant into the Vaal River system. Previous studies focused on either reducing inflow to the underground or on diverting decant water to preferred locations for treatment. This project will identify locations within the flooded basin where water quality is relatively good and which are also major recharge points (and therefore decant drivers). It is proposed to dewater the basins from these points. If found feasible, the extraction of water from such points, would serve as a source of water for Gauteng and at the same time reduce the magnitude of decant.

Estimated cost: R501 300 (KSA 3)
Expected term: 2006 - 2009

The development and testing of a coherent, integrated and practicable set of indicators for the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation
Association for Water and Rural Development (AWARD)
No. 1709

Indicators provide a method for presenting information in a standard way that can be monitored and used to measure change. The wetlands in the communal areas are important resources which provide livelihoods for many of the poor people in the area. While the land tenure system is not conducive to the exercise of close control of practices, these wetlands do form part of the national water resource and South Africa's IWRM policies require the integration of the many components of the water resource. Research done in this project will develop and test a coherent and practicable set of indicators for an integrated approach to the sustainable use and management of communal wetlands and their catchments, with a strong focus on rehabilitation. Specifically, generic indicators for successful and sustainable wetland management with a particular focus on communal wetlands will be developed. In addition, international indicators (e.g. poverty) that do not fit the South African situation will be refined for use within the existing governance situation.

Estimated cost: R236 100 (KSA 2)
Expected term: 2007 - 2009

Refinement of the decision support system for metalliferous tailing disposal facilities
Golder Associates Africa
No. 1735

WRC **Project No. 1551** developed a first-order decision support system (DSS) for the sustainable design, operation and closure of metalliferous tailings disposal facilities as part of a long-term programme to deal with these facilities on a sustainable basis. This follow-on project will refine the first-order DSS by developing guidance and support to demonstrate that the environmental impacts on the surface stability and water aspects are acceptable and to identify new and promising technologies and approaches.

Estimated cost: R2 200 000 (KSA 3)
Expected term: 2007 - 2009

Consideration of the impact of classification and landfilling of hazardous waste
CSIR
No. 1736

The minimum requirements for general and hazardous waste have been in place for over a decade. A systematic assessment is needed to determine whether the desired groundwater protection has been achieved, particularly at sites that have received delisted wastes. The assumptions made in the delisting process (i.e. whether they are conservative or not) are tested against field data from operational landfills. Further, the impact of the disposal of hazardous waste on leachate quality and landfill processes is required. This study aims to begin the process by considering the impact of selected delisted hazardous or industrial waste on a selection of landfill sites. The study includes an assessment of leachate quality from a selection of general waste landfill sites that receive hazardous wastes compared

to those that do not, to validate the assumptions made in the delisting process and to determine to what extent a selected hazardous waste type impacts on leachate quality.

Estimated cost: R800 000 (KSA 3)
Expected term: 2007 - 2009

New Projects

THRUST 1: ENVIRONMENTAL FUNCTIONING WITHIN THE HYDROLOGICAL CYCLE

Testing a prototype methodology for environmental water assessments in non-perennial rivers

University of the Free State (Centre for Environmental Management); University of Cape Town; Rhodes University; Limpopo Province (Department of Economic Development, Environment and Tourism)

No. 1798

This proposal will extend an existing 3-year contract (K5/1587) on environmental water requirements for non-perennial rivers scheduled to end March 2008. The environmental Reserve must be determined for each significant water body before water-use licences may be issued, but methods are needed to determine environmental water requirements for non-perennial systems as non-perennial systems predominate in the arid west of the country. Standard hydrological models cannot predict along the whole hydrological spectrum from perennial to episodic systems, so water licensing will have to be based on a new understanding of the non-perennial hydrology. This study will test the prototype methodologies which have been developed on one system on a different system.

Estimated cost: R3 000 000 (KSA 2)
Expected term: 2008 - 2012

Investigating private on-site water use and its impacts

University of Stellenbosch

No. 1819

Water resource managers, water demand managers and water infrastructure planners alike, are faced with an acute lack of knowledge regarding private on-site water resources (conveniently termed 'POSWAR' in this application). The most common water resources of this nature include:

- On-site groundwater abstraction by means of private boreholes
- Rainwater harvesting from rooftops
- Grey-water reuse

The nature and extent of POSWAR application by individual water users, particularly in residential areas, impact on all infrastructure elements of the water supply and waste cycle. POSWAR-application creates an apparent load reduction on all piped reticulation systems, treatment works and on the water supply resources. Unfortunately these 'insignificant' resources are entirely neglected during urban and resource-planning exercises. This study will determine and confirm the extent to which and in which way water demand and wastewater flow are influenced by the application of POSWAR.

Estimated cost: R300 000 (KSA 1)
Expected term: 2008 - 2009

THRUST 2: ENVIRONMENTAL GOVERNANCE SYSTEMS

The Shared Rivers Initiative Phase 1: Part A - Contextual profiles of the shared rivers of the Kruger National Park

Association for Water and Rural Development (AWARD); SANParks (Kruger National Park); University of the Witwatersrand; CSIR; Tlou & Mallory (Pty.) Ltd.

No. 1711

Research undertaken during this project will address a recently-identified gap in the governance process of water resources, in that a formal route of response to the red flag raised when a Threshold of Probable Concern is exceeded during the Strategic Adaptive Management process needs to be defined.

There is growing concern among scientists, managers and the general public in South Africa about the continuing decline in the integrity of the river systems of South Africa's north-east Lowveld in spite of an excellent knowledge base on the biophysical aspects of the rivers and an enabling legislative and institutional framework to support river management. The Lowveld river basins are all shared between neighbouring sovereign states (Zimbabwe, Mozambique, South Africa, Botswana and Swaziland). Each has to achieve their own important resource management and water supply priorities within their portions of these basins. Each neighbour faces a similar set of needs and challenges in its attempts to balance social development imperatives with management for resource sustainability. There is a clear need to harmonize management and decision-making within relevant institutions and between neighbours to ensure fair and effective policy implementation and water service delivery.

This project aims to explore water policy implementation as a complex social-ecological process and initiate an action research programme that combines research, learning and implementation to secure institutional and operational competency in river management. During this process, an understanding will be developed towards managing the Lowveld rivers following a cooperative, international and basin-wide approach.

Estimated cost: R1 500 000 (KSA 2)
Expected term: 2007 - 2009

Nitrate removal for groundwater supply to rural communities

CSIR; University of Stellenbosch; Biostream

No. 1848

This is a follow-up project whose main contribution will be the design criteria for a range of *in situ* and *ex situ* treatment of nitrates in groundwater. This provides alternatives for the specific needs of rural communities. The project investigates applicable identification systems in specific circumstances (i.e. rural communities, town water supply and stock watering, etc.).

Estimated cost: R600 000 (KSA 1)
Expected term: 2008 - 2010

Deriving conservation targets for freshwater systems

Ezemvelo KZN Wildlife; Albany Museum; ARC (Range and Forage Institute)

No. 1796

Systematic conservation planning provides a structured approach for identifying biologically significant areas which

require conservation action. Conservation planners aim to protect biodiversity by planning for persistence and representivity. Rivers are complex, longitudinal systems showing continuous gradients, and conceptually, the application of the process to rivers (freshwaters) is at least a decade behind the application to terrestrial systems. Systematic conservation planning for terrestrial systems makes use of island biogeography theory and species-area curves to set defensible conservation targets. Rivers are characterised by length not area, and species persistence at one site is a function of upstream and downstream ecological processes. Therefore, the species-area method is not suitable in these situations. An approach with a theoretical grounding similar to the species-area curve is necessary for setting meaningful targets in freshwater conservation planning. The research seeks to develop such an approach.

Estimated cost: R404 015 (KSA 2)
Expected term: 2008 - 2011

Application and testing of a strategic adaptive management system for freshwater protection, associated with implementation of South Africa's national water policy
SANParks Scientific Services; University of the Witwatersrand; Fluvius Environmental Consultants; Alexander & Llewellyn (Environmental Division); SAEON (Ndlovu Node)
No. 1797

River-based goods and services, with the explicit benefits to society, rely on healthy sustainable ecosystems. South Africa's water policy requires CMAs to manage the resource to achieve equity and social justice within ecological limits. These management practices are usually in conflict, but there is a growing body of research, geographically centred on South Africa's north-east Lowveld, on gaining coherence between these goals to achieve sustainable development. Strategic Adaptive Management (SAM) provides a proven vehicle for learning-by-doing by providing effective knowledge management. This project seeks to consolidate the SAM process developed within the Kruger National Park for wider and long-term implementation in water management areas (WMA) and to ensure that it is appropriately underpinned by the necessary knowledge, integration with the WMAs in the area and to support a wider enabling environment to ensure successful resource management

Estimated cost: R1 335 725 (KSA 2)
Expected term: 2008 - 2012

THRUST 3: INTEGRATIVE KNOWLEDGE FOR ECOSYSTEM-BASED WATER RESOURCE MANAGEMENT

An investigation of the potential use of ocean colour remote sensing to assess the influence of variations in freshwater inputs to coastal ecosystems: Phytoplankton and sediment dynamics of the Natal Bight
CSIR; University of Cape Town
No. 1852

The freshwater flows into the estuarine systems and beyond, as well as the flow drivers, are of importance in cost-effective routine assessment of the productivity of riverine-influenced coastal ecosystems. Ocean colour remote sensing has been identified as a unique means of assessing the influence of variations in freshwater inputs to coastal ecosystems. The study will improve

understanding of the relationship between freshwater-derived fluxes into the marine environment and ecosystem response; in particular this study will distinguish between inflow (drivers) and the associated response of marine systems.

Estimated cost: R315 000 (KSA 1)
Expected term: 2008 - 2010

Development of a revised desktop Reserve estimation model: application of abiotic components of the Reserve within SPATSIM and other tools
Water for Africa; Rhodes University (Institute for Water Research)
No. 1856

The existing desktop Reserve model is dependent upon the characteristics of the reference hydrology used and largely ignores the advances in understanding of habitat-flow-ecology relationships that have emerged in the last 5 years or so. It also ignores regional differences in these relationships. While a comprehensive ecological Reserve study is expensive and typically addresses the main stem of major rivers and key tributaries and also takes a long time to complete, it is frequently inappropriate for many smaller water resource development assessments where the Reserve is required. The Desktop Reserve model has been demonstrated to be an appropriate analysis tool, whether used with default parameters or after adjustment through a Rapid Reserve assessment. However, the uncertainty associated with the outputs from the Desktop Reserve model remains a major concern, especially if these outputs are ever likely to be challenged in a court of law. Recent research has made a great deal of progress towards improving our understanding of the relationships between physical drivers and biotic response and how these relationships vary in different parts of the country. The existing project is expected to develop initial databases related to the habitat requirements of fish and invertebrates that could contribute to quantifying the parameters of an improved Desktop Reserve model. The research will further enhance our understanding of the relationships between flow and ecological functioning, as well as enhancing our ability to use that understanding to make improved Reserve estimates. Research carried out within this project seeks to review the current understanding of the links between habitat availability and ecological functioning for different ecoregions, develop a hydraulic habitat generator model, and to incorporate the hydraulic habitat generator model and the ecological functioning rule base into an updated version of the Desktop model.

Estimated cost: R850 100 (KSA 2)
Expected term: 2008 - 2010

Optimised monitoring of groundwater – surface water – atmospheric parameters for enhanced decision making at a local scale
CSIR; University of the Western Cape; University of Stellenbosch; GEOSS; University of KwaZulu-Natal
No. 1846

The primary objective of this research will be to develop a framework for optimised monitoring of the most important variables required to manage groundwater resources and understand the fluxes between atmosphere – soil – groundwater – surface water systems at a local level. The secondary objectives of the project are to understanding the institutional and legal interactions of different agencies responsible for various monitoring

programmes, develop guidelines for monitoring best practices applicable to South(ern) African conditions and further develop a framework for the monitoring of the different fluxes so that they are closely measured in time and space, where applicable.

Estimated cost: R1 300 000 (KSA 1)

Expected term: 2008 - 2011

THRUST 4: ENVIRONMENTAL DEGRADATION AND MITIGATION

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact

University of Stellenbosch (Division of Aquaculture)

No. 1802

This project will investigate the feasibility and practical implications of using on-farm irrigation water storage dams for aquacultural fish production. A recently-completed WRC **Project (No. 1461)** found that although this dual use of water is mostly beneficial, it can also impact on water quality. This is a follow-on project that will continue with monitoring the effects of aquaculture at a number of sites, follow-up on the environmental concerns (especially enrichment or eutrophication of dam water) and investigate management and other measures aimed at reducing the enriching effects associated with intensive cage aquaculture.

Estimated cost: R1 680 000 (KSA 4)

Expected term: 2008 - 2012

The impacts of unpaved access roads on runoff, sediment fluxes and soil water movement within timber plantations

Aquagreen Consulting; University of KwaZulu-Natal

No. 1807

Despite wide acceptance that access roads in timber plantations are important hydrological pathways that affect the volume and distribution of overland flow and corresponding sediment fluxes, there is little quantitative information to account for this process in South African catchments. Water flowing unrestricted on unpaved road surfaces directly to the stream network is effectively lost to forestry compartments and potential uptake by tree roots, which in turn has a bearing on timber production. The main aim of the project is to evaluate the direct contribution of unpaved forestry access roads as a potentially ready source of runoff and sediment through physical on-site measurements and modelling at the plot and road segment scale. Based on field assessments done in close co-operation with the forestry industry, two catchments will be targeted for further monitoring and detailed modelling. Each of the catchments will represent a different bioclimatic zone, have varying ages of timber stands and have different soil types. Once the target catchments have been identified a detailed geographic information (GIS) coverage of the soils, topography, age, species and size of forestry compartments, extent of the riparian zone and the stream and road networks will be sourced or developed. Based on the findings of the modelling, verified by actual measurements, a research report will be produced on the feasibility of redirecting runoff from access roads to down-slope forestry compartments and practical strategies that could be used by the industry to accomplish this.

Estimated cost: R1 700 000 (KSA 4)

Expected term: 2008 - 2011

A comparison of the costs associated with pollution-prevention measures to that required to treat polluted water resources

CSIR; University of Cape Town

No. 1845

It is widely assumed that prevention is better than cure. This project will determine whether or not this assumption holds when applied to cleaner production technology costs (prevention) compared to the cost of treatment of pollution and the external costs borne by downstream users (cure). Four of the most important water quality contaminants will be covered: namely, salinity, eutrophication, microbial pollution and sediments. Because of the differences in the sources of the contaminants to be investigated and in the levels of information available for each, a differential approach will be followed in conducting this project. Specific catchments where the specified pollutants are of concern will be identified and the study will be undertaken in the identified catchment, e.g. salinisation in the Vaal catchment and eutrophication in the Crocodile catchment.

Estimated cost: R2 000 000 (KSA 1)

Expected term: 2008 - 2011

Management of human-induced salinisation in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity

University of Pretoria; University of the Western Cape; Western Cape Department of Agriculture

No. 1849

Salinisation is a major problem affecting Western Cape waters. The situation is exacerbated by an increasing demand for water. The recognition that dry-land agricultural practices (rather than only irrigation return flow) make a major contribution in this regard is of relatively recent origin (the current WRC **Project No. 1503** made a significant contribution in this regard). This follow-on project intends to continue with its small-scale process studies, expand their breadth by incorporating long-term studies of the Department of Agriculture and integrating the cumulative knowledge into predictive models to simulate the salt load and the contributions made by different land-use practices. The insights gained in this way will be used to develop guidelines for regulating land use in terms of salt-generating capacity.

Estimated cost: R2 964 000 (KSA 1)

Expected term: 2008 - 2012

Development of a risk indicator methodology to estimate the relative risk of pesticide contamination in South African water resources

CSIR; DWAF; University of Johannesburg; Università Cattolica del Sacro Cuore

No. 1854

Pesticides are among the most crucial non-point-source pollutants, because of their extremely high toxicity to many non-target aquatic organisms (fish and macroinvertebrates). The Department of Water Affairs and Forestry (DWAF) has recently designed and implemented the National Toxicity Monitoring Programme (NTMP), which monitors toxicity and a number of priority toxic chemicals, the majority of which are

pesticides. The National Water Act (Act 36 of 1998) requires rivers to be classified according to a specific class and the establishment of resource quality objectives (RQOs) to protect the desired class of a specific river. Risk indicators can be regarded as lower-tier risk assessment tools that provide a relative assessment of the environmental impact of pesticides through integration of ecotoxicological, environmental fate and pesticide use data. This study proposes to examine the application of pesticide risk indicators as a meaningful tool to predict the relative impacts of pesticides on the aquatic environment.

Estimated cost: R900 000 (KSA 1)
Expected term: 2008 - 2011

Technical guidelines for the implementation of cleaner production initiatives (for point sources of pollution) in support of determining an incentive charge for municipal effluent charges

Process Optimisation and Resource Management (PRO&RM)
No. 1832

This project surmises that the only realistic way to calculate an incentive charge to promote the implementation of cleaner production technologies by industries disposing of their effluent into municipal sewers is to determine the equivalent implementation cost of cleaner production initiatives. The imminent implementation of the Waste Discharge Charges System adds impetus to the need for such a study. The objective is to develop Technical Guidelines through which the insights gained in the study can be transferred to other applications.

Estimated cost: R570 619 (KSA 3)
Expected term: 2008 - 2010

Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine drainage

Rhodes University
No. 1834

The treatment of acid mine drainage typically consists of a series of unit processes which include the pre-treatment (neutralisation and metal removal) followed by the removal of salinity and residual pollutants. Several passive and semi-passive unit processes have been developed locally for the neutralisation of acid mine drainage water as well as the subsequent sulphate reduction. Biological sulphate reduction is now well understood and several innovative technologies have been developed and are currently still being developed including the IMP and the Rhodes BioSURE™ Process. The subsequent sulphide oxidation step is also well researched and applied in active treatment systems. However, limited passive biological sulphide oxidation and subsequent sulphur removal solutions exist. This solicited project aims to further develop the tubular fixed biofilm reactor developed by Rhodes University to remove sulphur in a passive system. This study will focus on the design, development and operational configurations for the tubular sulphur biofilm reactor. The technology will be demonstrated on laboratory and pilot scale.

Estimated cost: R1 500 000 (KSA 3)
Expected term: 2008 - 2011

A systematic approach to sulphidic waste rock and tailings management to minimise AMD formation

University of Cape Town
No. 1831

Acid mine drainage (AMD) is almost certainly the biggest environmental issue facing the South African mining industry. Changes in legislation have put the burden of responsibility for perpetuity on mining companies. This has led to a change in process thinking in order to reduce potentially harmful emissions from deposits and thus reduce long-term costs of tailings management and AMD remediation. This project will address aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides, specifically with the focus of reducing capacity to form AMD through removal of the sulphidic component of the waste. It will use the understanding of the factors governing AMD generation from dump rock and tailings (similar to those governing mineral bioleaching) with the view to the improved categorisation, separation and planned disposal of its components to mitigate AMD generation.

Estimated cost: R598 320 (KSA 3)
Expected term: 2008 - 2010

Guidelines for the determination and management of wetlands buffer zones

University of KwaZulu-Natal
No. 1789

Watercourses are able to adapt to changing circumstances, but the current state of watercourses in the country is a clear indication that a threshold is easily reached and impacts of surrounding land uses and human activities can be detrimental. The Reserve, resource class and resource quality objectives are, however, legislative tools developed to reverse or prevent such detrimental impacts/consequences for the resource. The main importance of a buffer zone is to act as a safeguard or a defence against surrounding impacts when resources are stressed or negatively impacted on. The research conducted within this project seeks to identify ways of delineating the riparian buffer zone in order to protect the resource and the riparian fringe in order to provide ongoing protection for the resource. It is envisaged that the results of this buffer zone study, in addition to the appropriate delineation, would be used by all relevant Departments for activities associated with watercourses.

Estimated cost: R2 500 000 (KSA 2)
Expected term: 2008 - 2011

Contact Person

Dr Heidi Snyman
E-mail: heidis@wrc.org.za
Tel: +27 12 330 9027



Ms Annatjie Moolman: Head

Water and Health

Scope

Water-related health forms a crucial and integral component of our daily quality of life. Health-related water research is undertaken with the aim of improving water quality and hygiene practices in order to improve quality of life, save lives and reduce the cost and effort of treating diseases and their symptoms. Awareness building and the development of educational materials are inherent to this domain in order to promote a better understanding of water quality and health-related aspects.

This impact area continues to play an essential role in providing an integrating framework for all the WRC's health-related research and development initiatives, identifying gaps and negotiating the initiation of research to fill these gaps in crucial areas. In fulfilling this role, the impact area assumes the responsibility for the structuring of a needs-driven, dynamic health-related water research portfolio on behalf of the WRC, with contributing projects being funded and managed in the appropriate KSAs.

The focus is on water-linked health impacts associated with microbial or chemical contamination or transferred via water-associated vectors. The impact area aims to improve knowledge regarding the origin, survival and persistence of microbial, biological and chemical agents that may pollute water and may affect human health. The impact area supports the development and utilisation of methodologies to identify and quantify the occurrence of pathogens and contaminants in water, as well as risk assessment and epidemiological studies.

A holistic, multidisciplinary approach is followed in order to develop a comprehensive understanding of the origin/sources and spatial extent of pollution; water usage patterns; the effects of degraded water quality on human and animal health and the need for, and efficiency of, various water treatment options. The development of guidelines, protocols, manuals and pamphlets as tools to disseminate research findings is supported. The emphasis is on a pro-active approach to identify and address causes, rather than on a passive response to addressing symptoms. This approach should ensure research products that are relevant, user-friendly, practical and scientifically valid.

Objectives

The primary objective of this impact area is to contribute to the protection of human health by investigating the sources, occurrence, persistence and control of causes leading to water-related diseases and other water-related health problems.

Secondary objectives are to:

- Develop appropriate techniques, technologies and systems for monitoring of potentially harmful pollutants in water
- Obtain adequate understanding of the origin, survival and persistence of, and inter-relationships between, microbial, chemical and other biological and toxic pollutants in water
- Assess the impacts (actual and potential) of pollutants on human and animal health and on the environment by performing epidemiological investigations and developing health-risk assessment tools
- Investigate the effects of environmental change on health (e.g. the impact of global warming on the spread of malaria; the link between climate variability and epidemics caused by water-borne diseases)
- Develop scientifically-sound educational material on health, hygiene, the effects of pollution and the prevention of pollution, and the relationships between these
- Provide guidance for appropriate communication, awareness-building and management strategies

Thrusts and Programmes

THRUST 1: RESOURCE PROTECTION

Scope: The focus of research under this thrust is on the safeguarding of human health through the protection of both surface water and groundwater resources from impacts that compromise the quality of water and add to the economic burden of treating water to the national water quality norms and standards. Point and diffuse sources of pollution are addressed through pollution-prevention interventions and remediation where water quality has already deteriorated. The focus is on the detection, prevention and management of all contaminants that pose a threat to human health. Development of health risk assessment and management tools for protecting human health from water-related health hazards is addressed under this thrust.

Research under this thrust is addressed under the following programmes:

- Programme 1: Detection, prevention and management of water-related microbial agents*
- Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources*
- Programme 3: Management of eutrophication and algal toxins*

Programme 4: Management of impacts of land-use activities on surface water and groundwater at a catchment level

THRUST 2: DRINKING WATER

Scope: This thrust focuses on research addressing all health impacts of drinking water quality, risk assessment and risk management approaches such as water safety plans and development of water quality monitoring systems. Research contributes to ensuring that drinking water is safe, i.e. it does not cause any harm to human health, and is free from pathogens and chemical contaminants that can potentially induce pathological and physiological damage to humans. This is achieved through the development of rapid and sensitive technologies for detecting contaminants in drinking water and innovative treatment technologies for removing contaminants from water. Research also contributes to the development of effective governance systems which are necessary to facilitate the regulation of drinking water quality.

Research is addressed under the following programmes:

- Programme 1: Drinking water quality management*
Programme 2: Water treatment technologies and reticulation systems

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Scope: This thrust focuses on proximal factors, such as water quantity, health and hygiene education, that have a direct link to disease transmission. It also addresses the distal causal factors such as socio-economic factors that have an impact on both the health of a society and the individual through the linkages to the proximal factors. Public health protection has the following components:

- Surveillance to measure risk associated with specific water uses
- Comparisons of measured risk and predefined acceptable risk thus leading to the development of control strategies
- Public awareness campaigns and promotion of sanitation, health and hygiene education

The main focus of this research thrust is on the development of tools for the identification of conditions that are conducive to water-borne disease outbreaks and the development of appropriate precautionary and preventive measures that

can be taken to protect public health. Examples of tools include water quality monitoring systems, early warning systems, disease surveillance systems and health and hygiene awareness and education materials. The impact of sanitation, water quality and quantity on the health of HIV/AIDS patients is also addressed with a view to developing strategies for reducing their exposure to microbial agents associated with contaminated water. Capacity building and training of sector professionals is further receiving attention under this thrust because the availability of skilled personnel is critical to public health protection.

Research is addressed under the following programmes:

- Programme 1: Public health and hygiene awareness and educational materials*
Programme 2: Capacity building and training programmes for public health professionals and practitioners
Programme 3: HIV/AIDS linkage with water quality and quantity and access to adequate sanitation services
Programme 4: Impact of water quantity and service levels on human health

THRUST 4: SANITATION AND WASTE MANAGEMENT

Scope: This thrust focuses on health aspects of the different sanitation technologies and waste management practices, with special reference to health implications of using waste as a resource. Promotion of ecological sanitation technology is leading to a growing interest in the use of human excrement and grey-water in crop production. There is a need to find a balance between increasing food security for poor households and the protection of public and environmental health. Research provides scientific information and health risk management strategies for guiding decision-makers in setting minimum quality standards for use of wastewater in crop production in order to protect human health. Research addresses safe treatment and disposal of sludge from on-site sanitation systems, for example, pit latrines, septic tanks and urine diversion systems. Health implications of malfunctioning waterborne sewerage and poor stormwater drainage systems are also addressed under this thrust.

Research is funded under the following programmes:

- Programme 1: On-site sanitation treatment technologies*
Programme 2: Use of waste as a resource
Programme 3: Management of waterborne sewerage and stormwater systems

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Scope: Research under this thrust focuses on the health implications of other water uses such as health risks associated with the irrigation of crops with water of poor quality; polluted recreational waters and occupational exposure to water of poor quality. Irrigation of crops with water of poor quality can have both direct and indirect effects on human health. Health risk assessment studies for the different use categories should be undertaken and appropriate management strategies should be developed to mitigate negative health impacts of exposure to water of poor quality.

Research is addressed under the following programmes:

- Programme 1: Impacts of quality of irrigation water on human health*
Programme 2: Ensuring safe water for recreation
Programme 3: Management of health impacts associated with occupational exposure to water of poor quality

THRUST 6: GOVERNANCE SYSTEMS FOR SAFEGUARDING HUMAN HEALTH

Scope: This thrust focuses on research that supports the implementation of the basic principles of effective governance (stakeholder participation, transparency, equity, accountability, coherence, responsiveness and integration) within the context of water and human health. The research contributes to the development of a regulatory framework for the protection of public health from all water-related health impacts. It also develops tools and guidelines for the implementation of comprehensive risk management strategies for managing drinking water quality from the catchment to the end-users. Research necessary to evaluate and guide the policy formulation process is addressed under this thrust. Models for appropriate governance systems necessary to support effective regulation of water quality are addressed. These models should be flexible enough to accommodate the challenges faced by small water service authorities with regards to water quality aspects.

Research is undertaken under the following programmes:

- Programme 1: Governance system for the protection of public health from water-related impacts on human health*
Programme 2: Regulatory framework for an integrated water quality management approach

(This programme addresses governance issues pertaining to the protection of the resource, focusing on the development of appropriate instruments and tools for regulating integrated water quality management and enforcing compliance.)

Research Portfolio for 2008/09

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2008 and 31 March 2009.

Completed Projects

THRUST 1: RESOURCE PROTECTION

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

WRC research programme on endocrine-disrupting compounds (EDCs) Volume 2: Implementation of a research programme for investigating endocrine-disrupting contaminants in South African water systems

AEC Burger (Independent consultant); University of Pretoria; University of Stellenbosch; CSIR; ARC; AMPATH; MEDUNSA; SABS; University of the Western Cape

No. 1402 (incorporating **Nos. 1469, 1470, 1471, 1472, 1473, 1555, 1557**)

Endocrine-disrupting compounds (EDCs) are defined as chemicals that interfere with the structure or function of hormone-receptor complexes. They can cause endocrine-disruptive effects at exposure levels up to a million times lower than carcinogen exposure levels of concern. Internationally, the negative impact of EDCs on health is evident and no longer an issue of dispute. Before 1999 only limited research was done on possible contamination of EDCs in South Africa. A need has been identified for a coordinated research program involving all researchers and stakeholders such as government departments and water suppliers. EDC research requires a multidisciplinary approach involving research in disciplines such as zoology, physiology, toxicology and analytical chemistry to be able to assess the risk to the human and wildlife populations and the state of contamination of the water resources. The main objective of the research programme is to develop the tools to be able to determine the risk to the population. In order to conduct risk assessments reliable data are needed on occurrence, magnitude and frequency of pollution.

In the strategic research report (**Volume 1, KV 143/1/05**) a survey was conducted on the state of the science in South Africa and existing data was evaluated. A list of priority compounds to be investigated was compiled, and analytical methods for determining EDC activity and levels of individual EDC components were evaluated and selected. A survey of laboratory capability and capacity was conducted. Recommendations on a protocol for a research programme were suggested. The 1st phase of the implementation of the programme (**Volume 2**) consisted of building capacity in research facilities for activity testing as well as chemical analysis. A workshop was held to select appropriate activity tests to be used in the study, because no single test could be used to determine the EDC activity. A limited surveillance study was conducted at 4 selected sites during 4 sampling events. The samples (water and sediment) were sent to the different laboratories for activity testing and chemical analysis. The results of the different laboratories participating in the study are summarized and presented in this report. Water and sediment samples were analysed for pesticides, minerals and industrial chemicals. Hormone analysis was only conducted on water samples. Analysis of minerals was done on both water and sediment samples. Although only few minerals have EDC properties it is known that some of them have a synergistic effect with some pesticides. EDC activity was detected at all the sites and the presence of EDCs was confirmed by chemical analysis. Hormones (estrone, ethinylestradiol and estriol) were found in water. Pesticides

(endosulfan, terbutylazine, DDT and dieldrin) were found in low concentrations. Industrial compounds (p-nonyl phenol, phthalates and PCBs) were detected at some sites. No human health risk assessment was undertaken because there is not yet a model available for risk assessment of EDC pollution. The available risk-assessment models use the onset of cancer as an endpoint which could not be used for EDCs. Recommendations for future research needs and updating of the strategic research programme were also made.

Cost: R260 000 (KSA 2)
Term: 2003 - 2007

Programme 3: Management of eutrophication and algal toxins

Methods manual for monitoring phytoplankton and cyanobacteria

Rand Water (Scientific Services)

No. 1533

Reservoirs provide the bulk of South Africa's raw potable, irrigation and livestock water. These reservoirs are variously impacted by eutrophication arising from their catchments. Certain dams, especially those located in the interior of the country, are eutrophic to hypertrophic. Associated with these conditions is the excessive development of phytoplankton, especially cyanobacteria. As is globally common, cyanobacteria are associated with many aesthetically-displeasing (algal blooms, scums, odours) and health-related problems (toxins) which can adversely affect humans and animals.

Of greatest importance to the potable water industry is the production of cyanotoxins and taste and odour compounds such as geosmin and 2-methyl-isoborneol (2-MIB). The monitoring of phytoplankton, cyanobacteria and their related organic compounds, therefore, is essential to the production of water which is safe for human and animal consumption.

The objectives of the project were to develop a laboratory methods manual to be used for the analysis of phytoplankton, geosmin and 2-MIB and cyanobacterial toxins in South African freshwaters including validations for reference purposes. The manual has been written in the format prescribed by SANAS (South African National Accreditation System) and inclusive of the validation data. The following methods were evaluated and validated:

- Spectrophotometric methods for the determination of chlorophyll-a (usually performed on raw water samples) and chlorophyll-665 (total pigment – usually performed on drinking water)
- Filtration (one method) and two sedimentation methods used for phytoplankton and cyanobacterial identification and enumeration
- A reference for the determination of biovolumes for all phytoplankton and cyanobacteria found in South Africa
- A 'purge and trap' procedure, coupled to a GC/MS method, for the determination of geosmin and 2-methylisoborneol (2-MIB)
- ELISA method for the determination of microcystin concentrations
- HPLC method for the determination of microcystin and nodularin concentrations
- HPLC method for the determination of anatoxin-a and cylindrospermopsin concentrations

The condensed methods manual (**Condensed Laboratory Methods for the Analyses of Phytoplankton, including**

Cyanobacteria, in South African Freshwaters) mainly includes the step-by-step execution of all the methods, and is aimed to be used in the lab. This condensed methods manual is supplemented by a comprehensive methods manual (**Comprehensive Laboratory Methods for Monitoring Phytoplankton, including Cyanobacteria, in South African Freshwaters**) that includes all aspects of the methods as well as their validations, to serve as reference when methods are being developed or additional information regarding the methods are required. It is envisaged that these 2 manuals will support and facilitate capacity building in South African water laboratories.

Cost: R403 600 (KSA 3)
Term: 2004 - 2007

THRUST 2: DRINKING WATER

Programme 2: Water treatment technologies and reticulation systems

Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof

Emanti Management (Pty.) Ltd.

No. 1597

This project identified the minimum requirements for effective and sustainable drinking-water service delivery within non-metropolitan water distribution networks to ensure acceptable drinking-water quality. Interviews with municipalities followed by site visits provided insight into current treatment plant and distribution network operation and maintenance procedures and the key factors that result in water quality failures in non-metropolitan networks. A web-enabled risk assessment tool was developed, as were practical guidelines aimed at different levels and/or users of the water service team, supported by two web-enabled tools available via the electronic Water Quality Management System (eWQMS). The management guides provide assistance in understanding planning, legislation, drinking water quality issues, staff training and reporting. The process controller's guide has been developed to assist operations and maintenance personnel in the operation and maintenance of drinking-water treatment plants and identifies issues that need urgent attention. The distribution system personnel guide assists operations and maintenance personnel in understanding and rectifying typical failures experienced in drinking-water distribution systems.

Cost: R452 300 (KSA 3)
Term: 2005 - 2008

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Programme 2: Capacity building and training programmes for public health professionals and practitioners

A guideline document for the implementation of sanitation, health and hygiene education (HHE) programmes in informal settlements

Nemai Consulting

No. 1656

The need for this research study was largely informed by the outcomes of the Naidoo et al. (2007) research study, 'The Effectiveness of Sanitation Education and Awareness Programmes in Informal Areas'. Rapid urbanisation in South Africa has resulted in the mushrooming of numerous informal settlements; however, the provision of services, especially sanitation services, has not kept pace. According to the National Sanitation Task Team most water and sanitation projects carried out by local authorities have lacked significantly in the aspect of health and hygiene awareness. National and international experience has shown that the most successful sanitation initiatives have been those in which emphasis was placed on generating a high level of health and hygiene awareness rather than producing a large number of latrines. In addition, hygiene education programmes lay the foundation for an integrated approach to the provision of a wider set of environmental services. The benefits of effective and sustainable hygiene education programmes in informal settlements are numerous and include reduced infant mortality from diarrhoea, reduced environmental pollution, reduced health care costs, improved conditions of living, reduced operations and maintenance, etc. Hygiene education programmes are among the most cost-effective ways of lowering health costs, especially in high density settlements where residents are at greater risk to diseases related to poor sanitation. The study has determined that hygiene education programmes should be seen as an integral component of the functions provided by the Water Service Authority (WSA). As such, hygiene education can no longer be linked to only new sanitation infrastructure programmes. Instead, hygiene education should be a continuous function, like operations and maintenance, which is an ongoing function of local government. This approach will ensure that the message of good hygiene practice is continuously reinforced and the approach is supported by existing policy and legislation.

Cost: R570 000 (KSA 3)
Term: 2006 - 2008

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Programme 1: Impacts of quality of irrigation water on human health

Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams

University of Stellenbosch (Division of Aquaculture)

No. 1461

This project investigated the suitability of on-farm irrigation dams for aquaculture fish production and the effect this would have on the quality of the water for irrigation purposes. A study of irrigation dams in the Western Cape and the Makhathini Flats canal system in KwaZulu-Natal indicated that water exchange rate and inflow water quality are main factors in determining the suitability of water bodies for fish production. While the water chemistry did not show effects of aquaculture or differences between production and control sites, the phytoplankton composition and biomass did. Especially during the winter dam turnover, overall biomass of phytoplankton was higher at all production sites. The additional clogging of filters as a result of changes in

phytoplankton biomass was the most significant impact of aquaculture on the quality of water for irrigation. It was further found that a significant portion of the fertiliser requirements of the crops irrigated from the dams would become available because of aquaculture activities.

Cost: R1 000 000 (KSA 4)
Term: 2003 - 2008

Scoping study to determine the potential impact of agricultural chemicals (pesticides) with endocrine disruptor properties on the water resources of South Africa

AEC Burger (Private Consultant)

No. 1774

Endocrine-disrupting chemicals (EDCs) are defined as chemicals that interfere with the structure or function of hormone-receptor complexes that can cause endocrine disruptive effects at exposure levels up to a million times lower than carcinogen exposure levels of concern. Concern has been expressed that some of the pesticides used in agricultural practice may pollute rivers and dams and cause endocrine disruptor (ED) effects in animals and humans. It is, however, not clear what the impact of these chemicals is on the resources. The main objective of this study was to gather information in order to determine whether a larger study is justified. In this project, the focus is on chemicals (pesticides and drugs for domestic animal production) with ED properties used in crop production and animal husbandry activities to gather information in order to determine whether a larger study is justified. Other spraying programmes using pesticides are included in the report. The results indicated that a more comprehensive study is needed to determine the impact of agricultural pesticides with ED properties on South African water resources. However, it must be realized that ED activity in water resources is not only due to the presence of agricultural pesticides; therefore to determine the impact of only agricultural pesticides will be a difficult and complex exercise.

Cost: R250 000 (KSA 4)
Term: 2007 - 2008

Current Projects

THRUST 1: RESOURCE PROTECTION

Programme 1: Detection, prevention and management of water-related microbial agents

The effects of streamflow manipulation on the intermediate hosts and vector populations of disease and the transmission of associated parasites

Institute of Natural Resources

No. 1589

Altering the flow of a water body will alter the environment. One of the effects of an altered environment is a change of the organisms that inhabit the environment. When making decisions on environmental flows, the status of disease vectors or intermediate hosts is not considered, and yet diseases such as malaria, bilharzia (in people) and fascioliasis (in livestock) have a substantial impact on the economy of areas where they prevail. The overall objective of this study is to assess the impact on the

economy and to investigate ways in which it can be ameliorated, either through management actions or through altering the behaviour of the population groups at risk.

Estimated cost: R400 000 (KSA 2)
Expected term: 2006 - 2009

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

The environmental exposure and health risk assessment in an area where ongoing DDT spraying occurs

University of Pretoria

No. 1674

The presence of DDT and metabolites in single pilot water, sediment and fish samples from the Vhembe district, Thohoyandou, Limpopo Province, is of concern. The concordant high prevalence of urogenital birth defects and the DDE concentrations in cord blood in babies born in a DDT-sprayed area should be regarded as a matter of extreme concern. The research question is whether environmental levels of DDT and DDE may contribute to adverse health effects in catfish and may pose a health risk for humans. The project will review the effects of EDCs on aquatic invertebrates and develop a comprehensive research programme to investigate the use of aquatic invertebrates as monitors of ecological health effects of endocrine disruptors. A further objective is to link possible health effects in biota from a DDT-sprayed area to adverse health effects in humans living in the Vhembe area. A scenario-based health risk analysis will be performed, EDC assessment techniques evaluated, and a toolkit of tests for wider application in other spraying areas will be developed.

Estimated cost: R1 985 000 (KSA 2)
Expected term: 2006 - 2009

Thyroid-disrupting activity in South African waters: Amphibian metamorphosis as biological model to study effects of endocrine contaminants on thyroid function

University of Stellenbosch (Department of Zoology)

No. 1680

Endocrine disruption of the control and functioning of the reproductive system is of global concern but there is also evidence that EDCs may interfere with the normal functioning of the thyroid system. Changes in thyroid function could adversely affect several physiological systems in humans and wildlife but the specific effects and toxicants involved are not well-known. This project aims to set up, validate and review protocols of the *Xenopus* metamorphosis assay (XEMA) for testing effects of water-borne chemicals on the thyroid endocrine system. A chemical and water serial diluter system and a flow-through water exposure system for EDC screening will be designed and tested.

Estimated cost: R400 000 (KSA 2)
Expected term: 2006 - 2009

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface- and groundwater

University of Pretoria

No. 1686

The adverse effects of endocrine disrupting chemicals (EDCs) in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In South Africa no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal. In this study the presence/absence of veterinary drugs in the environment will be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources screened for oestrogenic and anti-androgenic activity, using a battery of bio-assays

Estimated cost: R1 900 000 (KSA 1)
Expected term: 2006 - 2009

Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources

New detection methods for EDCs

University of Stellenbosch

No. 1534

The project will aim to produce and test an endocrine-disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand-binding domain (LBDER) into a suitable yeast (*Pichia pastoris*) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotinylation of LBDER and preparation of biotinylated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialised polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection.

Estimated cost: R647 500 (KSA 2)
Expected term: 2004 - 2009

Persistent organic pollutants (POPs) in the environment

North-West University

No. 1561

South Africa is a signatory to the Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research now needs to be taken further in order to:

- Assess with higher confidence the scale and significance of the occurrence of POPs in the water environment in South Africa, the potential short-term and long-term impacts on water resources and water-linked ecosystems and the

associated threats to sustainability of water resources and water use

- Better identify and quantify the fate and effect of selected POPs in the water environment
- Guide and inform the development of appropriate policy and regulatory measures that will:
 - Support implementation of the requirements of the Stockholm Convention
 - Substantially contribute to the protection of water resources and water-linked ecosystems with regard to POPs.

Estimated cost: R1 500 000 (KSA 1)
Expected term: 2005 - 2009

Programme 3: Management of eutrophication and algal toxins

Determine the applicability of ecological informatics modelling approaches for South African conditions with preliminary testing on algal blooms

North-West University (Potchefstroom, School for Environmental Sciences)

No. 1675

Ecological informatics was formalised as a discipline in 2004 and is defined as an interdisciplinary framework promoting the use of advanced computational technology for the elucidation of principles of information processing, at and between all levels of complexity of ecosystems, for use as a decision-making tool. Cyanobacterial blooms pose an ongoing problem in the water treatment industry, and there is currently no way of forecasting events, with planning being based on past experience. The ecological informatics approach is being developed, with some early success, for the forecasting of cyanobacterial blooms in Australia. The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use, based on the technologies used in Australia, for use by water resource managers and water treatment works.

Estimated cost: R225 000 (KSA 2)
Expected term: 2006 - 2009

Investigation of the distribution and diversity of South African toxic freshwater cyanobacteria with special reference to analysis of the neurotoxin BMAA and molecular genetic methods for microcystin screening

Nelson Mandela Metropolitan University

No. 1719

There is a lack of standardised methods and facilities for analysis of toxic cyanobacteria and quantification of cyanobacterial toxins in South Africa. Commercial primer sets for such screening will soon be available, but their suitability or applicability to South African isolates is totally unknown. No comprehensive analysis of wild strains has been attempted using any molecular technique. The application of appropriate techniques will yield information on the relationship between South African and other strains and information on the distribution and spread of strains within South Africa. Screening studies by various laboratories have indicated that all known species of cyanobacteria can produce BMAA. This has obvious implications for the human/health-related chronic exposure to BMAA in water, where cyanobacterial aggressions occur. The aim of the study will

therefore be to investigate the distribution and diversity of South African freshwater toxic cyanobacteria from a phylogenetic/phylogeographic perspective with specific reference to toxicity for known toxins and including the establishment of analytical procedures for the novel toxin BMAA.

Estimated cost: R1 000 000 (KSA 3)
Expected term: 2007 - 2009

Programme 4: Management of impacts of land use activities on surface water and groundwater at a catchment level

Modelling non-point source (NPS) pollution in agriculture from field to catchment scale

Sigma Beta Consulting

No. 1516

It is increasingly recognised that non-point source (NPS), or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore increasingly accepted that it is unfeasible to properly manage water quality without addressing the contribution from non-point-sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. Since most of the land area is utilised for agricultural activities, agriculture has both locally and internationally been implicated as a major source of NPS pollution. It is therefore necessary to assess the contribution that the different agricultural activities make to the different manifestations of NPS pollution, to devise the means through which these can be controlled and to determine and predict the effect that control measures will have to reduce NPS pollution. Understanding the production, delivery, transport and use components of agriculture-derived NPS loadings of water resources and having a predictive ability about the fate of agriculture-related NPS constituents are discrete research themes that will enhance the usefulness of the existing guidelines in the agricultural domain. The contribution of irrigation activities towards the salinisation of water resources has been studied for quite some time and is currently still receiving attention. Other water quality issues of concern that are potentially aggravated by agricultural activities are eutrophication (through fertiliser leaching and wash-off from human settlements), sediments (as a result of erosion), pathogens (from intensive animal production units), pesticides (through the application of insecticides, fungicides and herbicides) and some heavy metals. Although agricultural activities that give rise to the latter water quality issues have been the subject of previous studies, the present level of knowledge concerning them is not as advanced as for irrigation-induced salinisation of water resources. The project will address those issues that require priority attention, with regard to NPS pollution.

Estimated cost: R5 000 000 (KSA 4)
Expected term: 2004 - 2009

Osmoregulation in freshwater invertebrates in response to salt pollution

Rhodes University (Institute for Water Research)

No. 1585

Salinisation is a major cause of water quality deterioration. Current methods for water quality assessment include boundary values for specific salts. Biological data is scarce for most of these salts, and what exists is based on acute toxicity data. This research aims to provide chronic toxicity test data, for selected indigenous stream organisms, which are biologically relevant for the country. This will be done through physiological experimental research (oxygen consumption and osmolarity), using samples generated during acute and chronic toxicity testing, and evaluating the salt boundary values in the setting of resource quality objectives.

Estimated cost: R201 160 (KSA 2)
Expected term: 2005 - 2009

THRUST 2: DRINKING WATER

Programme 1: Drinking water quality management

Situation and gap analysis of water quality testing in South Africa

Jeffares & Green

No. 1720

The irregularities and occasional health risks currently experienced in water quality throughout South Africa highlights the urgent need for the introduction of an accepted and practical water quality testing standard to be employed by all laboratories in South Africa and enforced at national regulatory level. In order to produce such a standard, it is imperative that a thorough investigation be carried out into existing conditions, problems and capacities of all water-testing laboratories in South Africa. The assessment of the current status of testing laboratories will therefore play an important role in establishing what action needs to be taken to ensure acceptable water quality throughout South Africa. The overall aim of the project will be to develop a strategy for a national programme that will address the needs of the water quality assessment in South Africa.

Expected cost: R800 000 (KSA 3)
Estimated term: 2007 - 2009

Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water

CSIR

No. 1749

DWAF is considering the use of risk as the basis for setting resource water quality guidelines. While certain risk principles were used in the *1996 South African Water Quality Guidelines (Vol 6: Aquatic Environment)* the currently proposed review will consider the application of risk as a tool in deriving water quality guidelines for a range of water use and contaminants. The National Toxicants Monitoring Plan (NTMP) has been developed with endocrine disruptors forming an integral part. Although significant advancements have been made in characterizing the biotic effect of various endocrinal active substances at various levels of biological organization, critical interpretational gaps remain. In its commonly used paradigm, health-risk assessment methodology is not able to address the specific chemicals suspected of being endocrine disruptors. An

alternative framework is therefore needed to assist in making recommendations for guideline values for these chemicals in water. Testing of this proposed framework will enable the selection of a battery of tests best suited to assess the endocrine activity of mixtures of chemicals in drinking water. The project aims to develop and test a protocol for endocrine disruptors in drinking water (treated and untreated) based on the human health risk assessment framework that was developed for handling this class of chemicals in South Africa.

Estimated cost: R650 500 (KSA 1)
Expected term: 2007 - 2009

Investigation into the effects of water quality (organic vs. inorganic) on the immune systems of humans

University of the Western Cape

No. 1756

This will be a comprehensive study of the effects of water quality on the immune system of humans. The quality of potable and raw water could vary considerably from place to place and this depends on the microbiological and chemical constituents of the water. Several of the physiological systems (e.g. immune, thyroid-hypothalamus, reproductive and the neuro-physiological system) can be impacted on by the quality of the water. The complexity of mixtures is that different constituents (depending on the concentration of each) could have synergistic or antagonistic or no effects in the particular mixture on the human body. Some man-made chemicals affect the function of one or more immune pathways and this can have adverse effects on the health of man and animals. The objective of the study will be to develop and validate analytical tools to evaluate the impact of aquatic pollutants on the immune system. Water extracts obtained from various areas will be evaluated for its immunotoxicity and analytical procedures will be verified to measure the different effects on the human immune system.

Estimated cost: R1 500 000 (KSA 1)
Expected term: 2007 - 2010

Compliance of non-metropolitan South African potable water providers with accepted drinking water quality and management guidelines and norms

University of Fort Hare

No. 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers that are preventing compliance to these guidelines and norms, and communicate these solutions to the municipal management authorities. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000 (KSA 3)
Expected term: 2006 - 2009

THRUST 3: PUBLIC HEALTH AND HYGIENE ISSUES

Programme 1: Public health and hygiene awareness and educational materials

Develop the guideline: *Management of Microbial Water-Borne Diseases Vol 5: What We and Our Children Ought to Know*

University of Venda

No. 1672

This volume will include home hygiene and a link to sanitation, different water sources and handling of water from the sources. Disinfection and its side effects, the boiling of water and when not to boil, danger of burn wounds, etc. The origin and transmission of diarrhoeal diseases, prevention and care, will be included, as well as emergency treatment of diarrhoeal cases and special care of the immuno-compromised. Handling of containers in households, storage, contamination, etc. will also be included. All of these need to be described in a simple, demonstrative way taking into account the posters, pamphlets and reports already available at the WRC, Department of Health and DWAF, as well as other such documents developed by water suppliers, NGOs, Department of Education (school curricula), etc., to get the most suitable and effective method of transferring the message to the community. Cultural differences and preferences have to be taken into consideration.

Estimated cost: R400 000 (KSA 3)

Expected term: 2006 - 2009

A guideline document for emergency disinfection of drinking water

Tshwane Institute of Technology

No. 1737

Untreated or inadequately treated water is still drawn directly from rivers, ponds, streams and boreholes in some South African rural communities for domestic use. Various water-related infectious diseases including diarrhoea are often contracted, in some cases causing the death of the immuno-compromised individuals. In some instances, following natural disasters, a local authority may urge consumers at risk of contracting water-borne diseases to follow emergency disinfection measures. Messages and recommendations regarding the 'emerging' disinfection of untreated water do not take into account the variation in the quality of the source water. General guidance and recommendations on the use of a disinfectant or boiling of the water is usually given. In some instances this could add to the detrimental health effects of the water. The aim of this study is to consolidate available literature and information and develop a user-friendly guideline for emergency disinfection of untreated water.

Estimated cost: R600 000 (KSA 3)

Expected term: 2007 - 2009

Programme 3: HIV/AIDS linkage with water quality and quantity and access to adequate sanitation services

Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS

University of Venda (Department of Microbiology)

No. 1653

The spread of the human immunodeficiency virus (HIV), which causes Acquired Immunodeficiency Syndrome (AIDS), is taking place at an alarming rate. The situation for HIV/AIDS-infected individuals is exacerbated by the fact that a large proportion has no access to safe water or adequate sanitation. The lack of safe water compounds health risks to HIV/AIDS individuals leading to increased vulnerability, decline in productivity and income and consequently a general decline in their socio-economic status. HIV/AIDS is not a water-borne disease therefore there appears to be little relation to each other but a poor microbiological quality of their drinking water could have detrimental impacts on the health of HIV/AIDS-infected individuals. This project aims to do a health impact assessment study based on the microbiological quality of drinking water used by rural households that have at least one HIV/AIDS-infected individual. The presence of selected pathogenic and opportunistic bacteria and viruses in drinking water with those present in stool samples of both people living with HIV/AIDS and healthy individuals will be correlated to identify the relationship between point-of use drinking water quality and health indicators (such as diarrhoeal morbidity and mortality)

Estimated cost: R800 360 (KSA 3)

Expected term: 2006 - 2009

Assessment of water, sanitation and hygiene services in relation to home/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas of South Africa

University of Venda

No. 1738

This project will be done in collaboration with the Department of Health (DoH) and will provide an extension of the project funded by DoH. The HIV/AIDS epidemic has a devastating effect on the health and well-being of the South African nation, but it also presents grave consequences for the socio-economic development of South Africa. Safe water and sanitation are basic needs and a human right, especially for people affected by HIV/AIDS, as it will help them to live longer in good health and with increased dignity. This project will highlight the issues underlying the broad context for water supply, sanitation, and hygiene behaviour, and the need for systematic attention to these. This will be done in collaboration with DoH and the Medical Research Council. The aim of this study is to provide insight into the extent to which water, sanitation and hygiene issues/practices are important and relevant for service providers and people living with HIV/AIDS, especially with regard to home/community-based care.

Estimated cost: R500 000 (KSA 3)

Expected term: 2007 - 2009

How does the HIV and AIDS epidemic in South Africa impact on the water, sanitation and hygiene sectors?

University of the Western Cape

No. 1813

In South Africa HIV/AIDS tends to be treated predominantly as a health issue with intervention efforts narrowly focused on prevention and treatment. Issues like accessibility to clean water for people living with HIV and AIDS (PLWHA) in both urban and rural areas, and related issues like sanitation and hygiene have not received a lot of policy debate, support and attention in South Africa. Safe water and sanitation constitute the most basic needs

and human right issues, especially for PLWHA as it will help them to live longer in good health and increase their dignity. Therefore, information on water, sanitation and hygiene is important for making the right decisions. Access to basic sanitation and effective solid waste management is essential in reducing morbidity and mortality, particularly for those with a reduced immune function such as PLWHA. Access to clean water is essential in promoting effective health and hygiene practices amongst PLWHA. Effective health and hygiene requires an enabling environment that includes not just safe water supply, but effective wastewater disposal and solid waste management. The raising of health and hygiene awareness amongst affected households will be of little value unless safe water supplies are available to these households, so that they can practise good hygiene. Hygienic behaviour in turn reduces opportunistic infections and lengthens the time period between HIV infection and full-blown AIDS, thereby extending the period in which HIV sufferers can be both domestically and economically active. A complicated web of relationships exists between water and HIV and AIDS and cannot be underestimated. An investigation of the linkages and perspectives between PLWHA, water, hygiene practices and sanitation will enhance the development of integrated approaches. The central objective of this research study is to provide insight into the extent to which water, sanitation and hygiene sectors must strategise for services provided to people living with HIV and AIDS. Further the study intends to look at 3 distinct cross-sections; urban, peri-urban and rural areas across 3/4 selected provinces. The rationale being that the impact of intervention measures ought to differ across the 3 segments and across provinces.

Estimated cost: R700 000 (KSA 3)
Expected term: 2008 - 2010

THRUST 4: SANITATION AND WASTE MANAGEMENT

Programme 1: On-site sanitation treatment technologies

Understanding the sludge accumulation in VIPs and other on-site sanitation systems and strategies to manage desludging in the future when pits are full

Partners in Development

No. 1745

Current emphasis in sanitation rollout and the millions invested therein have a bias towards putting in sanitation facilities in the form of dry VIP toilets. Though this is one of the essential components of sanitation delivery and the easier component, less emphasis is afforded to aspects such as ownership, participation, hygiene education and ongoing maintenance which are basically the more challenging and also essential elements for sustainability in sanitation. It can be estimated that more than 1 million VIP systems will be built to meet backlogs. This is a huge investment by the Government; however, very little foresight and strategies have been developed as to how to manage these systems into the future. The research aims to tackle these questions of sustainability and, through the knowledge which is generated, make the sector better prepared to deal with the challenges. This study will develop an understanding of the sludge accumulation in VIPs and strategies to manage desludging in the future when pits are full.

Estimated cost: R1 600 000 (KSA 3)
Expected term: 2007 - 2010

THRUST 5: HEALTH IMPLICATIONS OF WATER USES OTHER THAN DOMESTIC USE

Programme 1: Impacts of quality of irrigation water on human health

Guidelines for sustainable use of grey-water in small-scale agriculture and gardens in South Africa

University of KwaZulu-Natal (School of Biological and Conservation Sciences)

No. 1639

The *White Paper on Agriculture* emphasises food security. Since household and urban food gardens form part of the spectrum of production systems and processes that can contribute to food security, they are supported by government. However, a shortage of water to supplement rainfall often limits the application potential of these systems. The use of grey-water may overcome this limitation by providing a dependable water source that is under the control of the household gardener. Grey-water is the untreated household effluent that is produced from baths, showers, kitchen and hand-wash basins as well as washing machines. More than half of the indoor household water use is normally used for these purposes and can thus potentially be intercepted by the householder for additional uses. Initial indications from a scoping study to evaluate the fitness-for-use of grey-water in urban and peri-urban agriculture are that there is considerable potential to use this largely untapped source to augment household food security. However, there are also risks involved with the practice that need to be better assessed and quantified under controlled conditions. These risks are largely associated with factors that affect the sustained productivity of the irrigated soil and health considerations. A workshop is planned to prioritise these risks and finalise the appropriate experimental approach to address them before finalising the terms of reference and soliciting project proposals

Expected cost: R1 670 000 (KSA 4)
Estimated term: 2005 - 2009

A quantitative investigation into the link between irrigation water quality and food safety

University of Stellenbosch (Department of Food Science)

No. 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in, e.g., informal settlements, and failing water treatment in, e.g., non-operating sewage works. This water is often used for irrigation and there is a direct relationship between irrigation water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers, while there is also an increase in the susceptible individuals. A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and



internationally. The problem of contamination of irrigation water and food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets. Biomonitoring of irrigation water quality is currently fragmented and not regularly published. Little is therefore known on a national level regarding the contribution of irrigation water and the associated potentially-contaminated raw produce to the burden of disease. Consequently little action is taken to remedy the situation. A clearer understanding of the problem is urgently required to make inputs for policy formulation and regulation to reduce contamination of irrigation water. This project will investigate the links between irrigation water quality (microbial and nutrient chemistry) and food safety in commercial as well as subsistence agriculture and give guidance towards treatment options of irrigation water to ensure food safety. This research project will therefore evaluate the extent of the problem regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two and provide recommendations on the way forward in terms of treatment of irrigation water. To achieve this, the main tasks include a baseline study on the extent (types and quantities) of contamination found in irrigation water as well as contamination found on the irrigated raw produce (fruit and vegetables) before and after harvest at the selected sites. The final report will document the extent of contamination found in irrigation water and on the irrigated raw produce; the links between contamination on raw produce and irrigation water applied; and make recommendations for further research in respect of validation of results and treatment options.

Estimated cost: R3 300 000 (KSA 4)
Expected term: 2007 - 2012

THRUST 6: GOVERNANCE SYSTEMS FOR SAFEGUARDING HUMAN HEALTH

Programme 2: Regulatory framework for an integrated water quality management approach

Development of a conceptual framework for the regulation of water quality within the context of an integrated, preventative management approach

Golder Associates Africa (Pty.) Ltd.

No. 1769

The implementation of the integrated preventive management approach that guides the *DWAF Drinking Water Quality Management Framework for South Africa* (2005) and *WHO Water Quality Guidelines* (2004) requires a well co-ordinated regulatory system for the management of the entire water supply system from the catchment to the consumer and the quality of effluents discharged into the water resources. Currently, the linkages between water resource management and drinking water quality management are not strongly followed nor addressed within the regulatory framework. Therefore, this project aims to develop a conceptual framework for integrating the regulation of the quality of water resources with that of drinking water quality in order to support the implementation of the integrated, preventative management approach.

Estimated cost: R600 000 (KSA 1)
Expected term: 2007 - 2009

New Projects

THRUST 1: RESOURCE PROTECTION

Programme 3: Management of eutrophication and algal toxins

Assessment of the toxicity of cyanobacteria in the Kruger National Park

ARC; SANParks Veterinary Wildlife Services; University of Pretoria; State Veterinary Services

No. 1850

Cyanobacteria (blue-green algae) are found throughout the world in freshwater and marine habitats. Cyanobacteria produce a variety of toxins known as cyanotoxins which have an adverse effect on livestock, domestic animals and wildlife. There have been reports of deaths of wildlife suspected to have been caused by cyanobacteria in the Kruger National Park after exposure to water containing cyanobacteria. It is suspected that a large percentage of wildlife succumb to cyanobacterial poisoning every year as no normal data on mortality are recorded. The only time there is assessment of the surface water is when there are deaths of wildlife, and sometimes the cyanobacterial toxin content of the nearby rivers/dams, which the animals were exposed to, would have changed completely by the time of assessment of the water, thus not reflecting the toxin levels that caused mortality. The study aims to generate information (database) on the extent to which cyanobacteria and their toxins affect wildlife.

Estimated cost: R395 000 (KSA 1)
Expected term: 2008 - 2010

Programme 4: Management of impacts of land use activities on surface water and groundwater at a catchment level

Nitrate removal for groundwater supply to rural communities

CSIR; University of Stellenbosch; Biostream

No. 1848

This is a follow-up project whose main contribution will be the design criteria for a range of *in situ* and *ex situ* treatment of nitrates in groundwater. This provides alternatives for the specific needs of rural communities. The project investigates applicable identification systems in specific circumstances (i.e. rural communities, town water supply and stock watering, etc.).

Estimated cost: R600 000 (KSA 1)
Expected term: 2008 - 2010

Development of a risk indicator methodology to estimate the relative risk of pesticide contamination in South African water resources

CSIR; DWAF; University of Johannesburg; Università Cattolica del Sacro Cuore

No. 1854

Pesticides are among the most crucial non-point-source pollutants, because of their extremely high toxicity to many non-target aquatic organisms (fish and macroinvertebrates). The Department of Water Affairs and Forestry (DWAF) has recently

designed and implemented the National Toxicity Monitoring Programme (NTMP), which monitors toxicity and a number of priority toxic chemicals, the majority of which are pesticides. The National Water Act (Act 36 of 1998) requires rivers to be classified according to a specific class and the establishment of resource quality objectives (RQOs) to protect the desired class of a specific river. Risk indicators can be regarded as lower-tier risk assessment tools that provide a relative assessment of the environmental impact of pesticides through integration of ecotoxicological, environmental fate and pesticide use data. This study proposes to examine the application of pesticide risk indicators as a meaningful tool to predict the relative impacts of pesticides on the aquatic environment.

Estimated cost: R900 000 (KSA 1)
Expected term: 2008 - 2011

THRUST 2: DRINKING WATER

Programme 1: Drinking water quality management

Quality control and assurance guideline for South African toxicity testing laboratories

CSIR; Golder & Associates Africa; Renaissance Environmental Hub; Umgeni Water; Rand Water; DWAF; SASOL; South African National Accreditation System (SANAS)

No. 1853

The South African National Water Act (Act 36 of 1998) (NWA) mandates the establishment of policies and approaches to reduce and prevent degradation; and to assess the quality of water resources. To comply with the above requirements the National Toxicity Monitoring Programme for Surface Waters (NTMP) (DWAF, 2005) and the Direct Estimation of Ecological Effect Potential (DEEEP) approach for waste discharge (DWAF, 2003) were introduced. Standard methods were documented for both of these approaches. The toxicity methods are presented in terms of the test environment; materials; equipment and reagents; test organism (breeding and maintenance); test procedure; data analysis and expression of results; test precision of results; test report format; as well as related issues such as sample collection; transport; and storage and waste disposal. Quality requirements pertaining to the above-mentioned sub-sections and training of new staff to comply with minimum requirements for accreditation purposes, will also be addressed.

Estimated cost: R600 000 (KSA 1)
Expected term: 2008 - 2010

EDC bio-assay toolbox

University of Pretoria; A Burger (independent consultant); North-West University; CSIR (Natural Resources and the Environment)

No. 1816

The WRC has been funding a structured and well planned endocrine-disruptor chemical (EDC) and toxicant research programme from 2001. Education (training) and awareness building and management of EDCs form an integral part of the programme and several manuals will be developed. The sampling, biological and analytical procedures used in this programme and in collaboration with the Global Water Research Coalition (GWRC), now need to be taken a step

further to the development of training and user-friendly manuals. It is also of utmost importance to the success of the programme and benefits to the country that the training manuals will be ready during the 3rd phase of the EDC programme, and the implementation of the National Toxicant Monitoring Programme (NTMP) of DWAF in 2008. This volume (III) will focus on the identification, selection and standardisation of biological assays for EDCs, with special reference to oestrogenic compounds.

Estimated cost: R870 000 (KSA 3)
Expected term: 2008 - 2010

Programme 2: Water treatment technologies and reticulation systems

Application and performance of slow sand filtration

Cape Peninsula University of Technology

No. 1836

Slow sand filtration is generally highly recommended in small and rural community water treatment because of its simplicity in design, operation and maintenance. However, little awareness of the application of slow sand filters exists in South Africa. Very little is further known about the slow sand filters in operation in South Africa and how they are performing. The project, therefore, aims to investigate the extent of slow sand filtration applications in the country and practical performance of these filters, covering both successful and failed examples. It will also investigate and document the types, application and performance of the various pre-treatment processes prior to slow sand filtration. A database of all sand filtration plants in the country will further be compiled.

Estimated cost: R760 000 (KSA 3)
Expected term: 2008 - 2011

Contact Person

Ms APM Moolman

E-mail: annatjiem@wrc.org.za

Tel: + 27 12 330 9021

Addendum

Catalogue of available TT Reports

KSA 1:

Protocol for the Assessment of the Status of Sustainable Utilization and Management of Groundwater Resources with special reference to Southern Africa.

E Braune, B Hollingworth, Y Xu, M Nel, G Mahed & H Solomon

The development role for groundwater in Africa and Southern Africa is still poorly understood, resulting in under utilisation and poor management of the important resource. The international experience is that turning around this situation will require strategic action across sector and international boundaries. The study confirmed that SADC has made excellent progress to address groundwater in its comprehensive regional water resources policies and strategies. Groundwater is explicitly referred to in the SADC Protocol on Shared Watercourses. It is also featuring in the SADC Regional Strategic Action Plan for Integrated Water Resource Management and the Regional Water Policy and it has its own Groundwater Management Programme for the roll-out of this plan. When it comes to implementation in individual countries, the performance in groundwater resources management in SADC must still be generally rated as "below expectation", compared to relevant international best practice. The importance of groundwater in this region, the cooperative regional IWRM structures and institutions that already exist and the understanding there is already for groundwater at the highest decision-making levels, offers a major opportunity to initiate a systematic, region-wide, and ultimately continent-wide, programme and approach, as foreseen by AMCOW, for building the capacity required to ensure that groundwater resources are utilized and managed sustainably in the SADC region. It is felt that the South African capacity for IWRM and, in particular for groundwater resources management, can make a much greater

contribution than at present to developments in southern Africa and that the Water Research Commission should strategically position itself for such a role.

Report No: TT318/08
ISBN: 978 1 77005 712 8
Overseas price : \$20-00 excl postage

An introduction to dense NON-AQUEOUS phase liquids (DNAPLs) in South Africa: A community guide

Usher BH, Pretorius JA, Gebrekristos RA

This document is aimed specifically at the lay person, to make them aware of DNAPLs and its occurrences, sources and behaviour. This document forms part of a series of documents, produced by Water Research Commission project K5/1501 "Field investigations to study the fate and transport of dense non-aqueous phase liquids (DNAPLs) in groundwater". The documents in this series include:

- Executive Summary of the Project (only available on CD accompanying all reports listed below)
- Manual for Site Assessment at DNAPL Contaminated Sites in South Africa (WRC Report 1501/2/08)
- Groundwater monitoring guidelines for DNAPLs in South African Aquifers (WRC Report 1501/3/08)
- Guidelines for the acceptance of Monitored Natural Attenuation processes in South Africa (WRC Report 1501/4/08)
- Handbook for DNAPL Contaminated Sites in South Africa (TT 326/08)
- An Introduction to DNAPLs in South Africa: A Community Guide (WRC Report TT 326/08)
- Field and laboratory investigations to study the fate and transport of DNAPLs in groundwater (1501/5/08)

Report No: TT 325/08
ISBN: 978 1 77005 658 9
Overseas price : \$25-00 excl postage

Handbook for DNAPL contaminated sites in South Africa

Usher BH, Pretorius JA, Gebrekristos RA

Report No: TT 326/08
ISBN: 978 1 77005 659 6
Overseas price : \$30-00 excl postage

A guide to catchment-scale eutrophication assessments for rivers, reservoirs and lacustrine wetlands.

J N Rossouw, W R Harding, O S Fatoki

A study commissioned in 2000 by the WRC found that South Africa's policy and approach to eutrophication control has been inadequate over the previous 20 years. A strong need was identified to remobilise and redevelop our capacity to manage eutrophication. A workshop followed in 2001 to discuss research and capacity building within the field of eutrophication where assessment of the eutrophication problem was identified as the highest priority research area. This project produced a Guide to assess eutrophication related water quality using the same protocol as the DWAF Guide to catchment scale water quality assessment studies. The Guide is structured around six management questions that are designed to establish the eutrophication status and management options at catchment scale. The best eutrophication assessment practice was,

furthermore, captured in a Web-based nutrient enrichment assessment protocol (NEAP). Course material making use of these two products was developed to fast track capacity building concerning eutrophication assessment. The primary target audience of the short course material is water resource practitioners, water resource managers and freshwater scientists

Report No: TT 352/08
ISBN: 978 1 77005 715 9
Overseas price : \$30-00 excl postage

Technical instruments to support water quality use allocation

Rossouw JN, Kamish W & Gorgens AHM

The National Water Act prescribes the minimum components of a catchment management strategy. Prime amongst these are the formulation of water allocation principles and a Water Allocation Plan for each Water Management Area. This project focused on a very particular part of the allocation challenge, namely the allocation of "Water Quality Use". It aimed to develop a conceptual framework for water quality use allocation procedures, and to develop and disseminate Technical Guidelines for water quality use allocation procedures. The project employed a process of "learning-by-doing" by applying the framework in a stressed catchment with water quality concerns. The ACRU Salinity model was applied to the Berg River catchment because it also offered a ready-made water quality information system (WQIS) previously developed under WRC Project No 951.

Report No: TT 363/08
ISBN: 978 1 77005 653 4
Overseas price : \$20-00 excl postage

Towards a socio-ecological systems view of the Sand River catchment, South Africa: An exploratory resilience analysis.

Pollard SR, Biggs HC, Robert D

South Africa is in the process of implementing IWRM, which by definition is a process based on managing the behaviour of people and their response to a finite resource. In addition, wetland systems are under increasing pressure to support subsistence livelihoods, and their sustainability is being compromised. New thinking and understanding on the functioning of complex socio-ecological systems (SES) and how these contribute to the resilience of these systems could give managers a tool for improved management of these systems. This consultancy investigated how this new thinking may be employed in this situation.

Report No: TT 364/08
ISBN: 978 1 77005 747 0
Overseas price : \$20-00 excl postage

Fire management in the Cape Peninsula: lessons for catchment management agencies from the Ukuvuka Campaign

Fowkes SM

The Ukuvuka initiative was a short term collaborative campaign designed to inject finance, skills, innovation and passion to address a core issue of common concern to the partners – changing fire-related behaviour. Ukuvuka ran from 2000 to

2004 and was supported by the three spheres of government, business (a short-term insurance company, a bank, an oil company and a daily newspaper) and NGOs. The trigger for the initiative was the immediate crisis of fires in the mountains of Cape Town's Cape Peninsula.

The purpose of this report is to make a contribution to the policy implementation challenge by sharing some practical insights and experiences from that crisis initiative. The report focuses particularly on applying the lessons to the water sector, specifically the formation of Catchment Management Agencies (CMAs).

Report No: TT324/07

ISBN: 978 1 77005 656 5

Overseas price : \$10-00 excl postage

High-yielding groundwater areas around the Nelson Mandela Bay Municipality.

Murray R, Goedhart M, Baron J

Prime groundwater development areas were identified and grouped into five hydrogeological domains. Within each of the domains specific groundwater exploration target areas were identified and prioritised. No ground-truthing was done to verify the target areas. It is likely that some of the areas may be unsuitable for groundwater development for a variety of reasons, and it is equally likely that there are a number of other areas that could be developed for large-scale groundwater supply.

The total groundwater potential for each domain was estimated using the GRA II data sets and by assuming the number of high-yielding boreholes that could be obtained in each domain. This latter approach is based largely on estimates of the number of prime drilling targets that can be located. It was not based on a remote sensing analysis and the identification and weighting of individual drilling targets. Thus in some areas there may be fewer prime drilling targets, and in other areas, more. The purpose of this exercise was to provide a first-order estimate of the groundwater potential, and thus it will not be correct, but it should serve as a good starting point. A summary of the groundwater potential of all five domains is presented:

- Groundwater Exploitation Potential (normal years) = 48 Mm³/a
- Groundwater Exploitation Potential (dry years) = 32 Mm³/a
- Borehole yield without artificial recharge and continuous abstraction = 28 Mm³/a
- Borehole yield with artificial recharge and 6-month/a abstraction = 41 Mm³/a
- Existing use = 9 Mm³/a

Report No: TT 327/08

ISBN: 978 1 77005 671 8

Overseas price : \$20-00 excl postage

National Microbial Monitoring Programme for Groundwater: Implementation Manual

Murray K, du Preez M, Meyer R, van Wyk E, Parsons R, Flanagan L, Taylor M

The general purpose of this manual is to describe how the national microbial monitoring programme (NMMP) for groundwater should be implemented on a national scale. This national monitoring programme for groundwater supplements the National Microbial Monitoring Programme for surface waters. However, it should not be regarded as an extension

of it. Monitoring groundwater is fundamentally different from monitoring surface water and accordingly has a completely different design.

This manual gives guidelines, procedures and methods for microbial monitoring of groundwater as well as how and when such data can be reported.

Accordingly, this manual is aimed at a variety of people and organisations. It is initially aimed primarily at DWAF officials who will have the primary responsibility to implement national water-related monitoring programmes. However, it is also aimed at Catchment Management Agencies (CMAs) and water management institutions to which monitoring responsibilities may be delegated.

Report No: TT 312/07

ISBN: 978 1 77005 594 0

Overseas price : \$20-00 excl postage

Integrated water resource management plan guidelines for local authorities: (IWRMP)

Burke J

The principle of integrated water resource management is endorsed by the National Water Act, Act 36 of 1998 and the National Water Resource Strategy (2004). Simply put, integrated water resource management in Local Authorities is about striking the right balance between a Local Authority's developmental role and the need to maintain environmental integrity in fulfilling the Constitutional obligations of sustainable development, socioeconomic development and a safe and healthy environment. Striking this balance is a challenge and requires cooperation between all tiers of government as well as between government and the private sector, but there are no hard and fast rules as the environment is a dynamic system, continually adapting itself to a new balance, following the effects of both human and natural influences on it. Implementation of the Local Authority Integrated Water Resource Management Plan will be a positive step forward in ensuring that Local Authorities achieve sustainable integrated water resource management in line with the catchment vision set by the Catchment Management Agency

Report No: TT 304/07

ISBN: 978 1 77005 548 3

Overseas price : \$30-00 excl postage

A task oriented approach to participation (PLEASE DOWNLOAD FROM <http://www.wrc.org.za/>)

Burt J, du Toit DR, Neves DT

The NWA puts emphasis on the decentralization of water resource management to the catchment level. This necessitates an adoption of participatory management approaches that can support a multi-stakeholder dialogue of diverse interest groups such as water user associations (WUAs), community based organisations, NGOs, water resource managers, policy-makers and planners.

Therefore, there is a need for appropriate tools that can be used to support meaningful participation of the public at different levels of decision-making. This project answers the following questions:

- What is the appropriate CMA level of organisation that will be effective in ensuring that voices of marginalized groups are also taken into consideration in the governance of CMAs?

- How can civil society be best organized to play a meaningful role in the management of water resources at a catchment and sub catchment level?

Report No: TT 289/06
ISBN: 1 77005 502 9
Overseas price : \$15-00 excl postage

Water as a human right, made easy! Workbook 1
(PLEASE DOWNLOAD FROM <http://www.wrc.org.za/>)

Derick du Toit, Teresa Squazzin

Report No: TT 269/07
ISBN: 978 1 77005 435 6
Overseas price : \$15-00 excl postage

Human Rights project WORKBOOK 2
(PLEASE DOWNLOAD FROM <http://www.wrc.org.za/>)

Derick du Toit, Teresa Squazzin

A key concept evident in the South African Constitution is that National Government is committed to providing adequate food and water '... to meet basic human needs'. Arguably the most crucial resource, in terms of human need, is water. This commitment in providing water for basic human needs is captured by the National Water Act (1998) in the concept of the 'Basic Human Needs Reserve' (BHNR). The notion of the BHNR essentially elevates the status of water for basic human needs to that of a human right. Although an orientation that accepts access to water as a human right is enshrined in South African law, it represents a very new concept in water management in South Africa (and the world). One of the major obstacles hampering implementation is a lack of familiarity and understanding of the notion of the BHNR by the very people tasked with the responsibility for ensuring that it is honoured, i.e. local government. An informal, preliminary survey conducted by AWARD indicates that most members of local government have not heard about the BHNR.

Report No: TT 296/07
ISBN: 978 1 77005 513 1
Overseas price : \$15-00 excl postage

Guide for local government cooperation with catchment management agencies.

Mazibuko G, Pegram GC

The recent demarcation process and the on-going specification of the powers and functions between the district, local and metro councils have further clarified the roles and functions of local government. Local government is constitutionally responsible for the implementation and control of a range of activities that affect water resources. This research will amongst others provide recommendations on the requirements for co-operative governance and the most appropriate approaches and mechanisms to foster co-operative governance between CMAs and local government, to achieve a range of objectives under differing circumstances.

Report No: TT 270/06
ISBN: 1 77005 460 X
Overseas price : \$15-00 excl postage

Artificial Groundwater Recharge: Wise water management for towns and cities

Rickey Murray

Report No: TT 219/03
ISBN: 1 77005 092 2
Overseas price : \$15-00 excl postage

Surface water: Groundwater interaction in a South African context: A Geohydrological Perspective.

Parsons Roger

In response to a greater awareness of the role of groundwater in sustaining the environment and recognition of a unitary and interdependent hydrological system, surface-groundwater interaction has emerged as an issue requiring greater attention. This publication aims to establish the correct and consistent use of hydrological terms which is key for developing a better understanding of surface water-groundwater interaction

Report No: TT 218/03
ISBN: 1 77005 084
Overseas price : \$25-00 excl postage

An explanation of a set of national groundwater, plus 2 Hydrogeological maps (SA Price: R114.00)

Vegter JR

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

Report No: TT 74/95
ISBN: 1 86845 183 6
Overseas price : \$70-00 excl postage

Explanation of the 1:500 000 hydrogeological map 2326 Pietersburg (SA Price: R50.00)

Water Systems Management & DWAF

This is a high-quality hydrogeological map of the Pietersburg map sheet at a scale of 1:500 000 and a set of explanatory notes which provide guidelines as to the need for detailed groundwater investigations and what hydrogeological conditions are expected to occur.

Report No: TT 75/95
ISBN: 1 86845 188 7
Overseas price : \$35-00 excl postage

Dealing with reservoir sedimentation (SA Price: R171.00)

Basson GR & Rooseboom A

Dam siltation has always been and still is a serious problem in South Africa. This report presents different techniques for controlling and managing dam siltation in South Africa.

Report No: TT 91/97
ISBN: 1 86845 255 7D
Overseas price : \$70-00 excl postage

Sluicing flumes: A new structure for discharge measurement in sediment-laden rivers

Rossouw J, Loubser C, Rooseboom A & Bester A

This report confirms the flumes' good characteristics with respect to handling heavy sediment loads.

Report No: TT 103/98

ISBN: 1 86845 368 5

Overseas price : \$35-00 excl postage

Dealing with reservoir sedimentation -Dredging (SA Price R200.00)

Basson GR & Rooseboom A

In this report the reservoir sedimentation theory and dam dredging techniques from around the world are evaluated. A criterion for selecting dredging techniques which emphasise on cost cutting measures is presented.

Report No: TT 110/99

ISBN: 1 86845 493 2

Overseas price : \$60-00 excl postage

A Global Overview of Inter- Basin Water Transfer Schemes, Socio- Economic and Socio - Political Implications, and Recommendations for their Management

Snaddon CD, Davies BR & Wishart MJ

This report combines two source documents. The first is the report on the research done during the project and the second is a worldwide synthesis of information on inter-basin transfer (IBTs) with contributions from scientists in the USA and Australia.

Report No: TT 120/00

ISBN: 1 8645 583 1

Overseas price : \$20-00 excl postage

Groundwater Development in South Africa and an introduction to the Hydrogeology of Groundwater Regions

Vegter JR

This report presents a historical overview from the introduction of the first drill in 1880 – a manually powered diamond rig – up to the present. The following topics are covered:

- Groundwater exploration and exploitation
- Investigation and research; and
- the evaluation of groundwater legislation

Report No: TT134/00

ISBN: 1 86845 642 0

Overseas price: \$25-00 excl postage

Hydrogeology of Groundwater: Region 1 – Makoppa Dome

Vegter JR

Report No: TT135/00

ISBN: 1 86845 643 9

Overseas price: \$ 20-00 excl postage

Hydrogeology of Groundwater: Region 3 – Limpopo Granulite-Gneiss belt

Vegter JR

Report No: TT136/00

ISBN: 1 86845 644 7

Overseas price: \$20-00 excl postage

Hydrological information and techniques to support the determination of the water quality component of the ecological reserve for rivers

Hughes DA & Munster F

Report No: TT 137/00

ISBN: 1 86845 646 3

Overseas price: \$20-00 excl postage

Hydrogeology of Groundwater: Region 7 – Polokwane/Pietersburg Plateau

Vegter JR

Report No: TT 209/03

ISBN: 1 86845 027 2

Overseas price: \$20-00 excl postage

Hydrogeology of Groundwater: Region 19 – Lowveld

Vegter JR

Report No: TT 208/03

ISBN: 1 86845 026 4

Overseas price: \$20-00 excl postage

Hydrogeology of the main Karoo basin: Current knowledge and future research needs

Woodford AC & Chevallier L

This document is aimed primarily at the *groundwater practitioners* working in Karoo fractured-rock aquifers, especially those involved on rural water supply projects and WRC-funded research projects. The level of information presented is also useful to other professionals with only limited groundwater knowledge

Report No: TT 179/02

ISBN: 1 86845 851 2

Overseas price: \$40-00 excl postage

Evaluation of the role of water user associations in water management in South

Pegram G & Mazibuko G

The new institutional reforms in water resource management prescribed in the National Water Act of 1998, delegate many water resource management functions (particularly resource protection and allocation) to organisations within Water Management Areas (WMA), namely Catchment Management Agencies (CMAs) and Water User Associations (WUAs). WUAs are statutory bodies intended to operate at a restricted localised level aimed at facilitating co-operative associations of individual water users, who wish to undertake water-related activities for their mutual benefit. This study is aimed at clarifying the roles of WUAs, evaluating the functioning of a number of established WUAs against this framework and the particular needs of the local conditions, and formulating guidelines for the institutional and management arrangements.

Report No: TT 204/03

ISBN: 1 8645 982 9

Overseas price : \$25-00 excl postage

Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning.

Dickens C, Kotze D, Mashigo S, MacKay H, Graham M

The South African legal environment provides for the sustainable use of the country's water resources. Yet, all is not well with the wetland resources of this country. Already suffering from years of abuse and over-utilisation, wetlands remain under threat as part of the water resource. These guidelines provide management agencies with much needed information for the management of wetlands. The impact of these guidelines is expected to be significant, especially for professional staff and interested members of society working at ground level

Report No: TT 220/03

ISBN: 1 77005 096 5

Overseas price : \$30-00 excl postage

An assessment of the water policy process in South Africa (1994 to 2003):

de Coning C, Sherwill T

The political changes which have taken place in South Africa during the last decade have had profound impacts on the development of new water policy, and have opened the way for significant shifts in policy and legislation generally, in relation to sustainable management of natural resources. The implementation context will strongly influence the future development and strategic direction of water policy in South Africa, but there is still limited understanding of the inter-relationships between policy development and implementation, with the added shaping forces of politics, economics and social factors.

This project aims to provide, through critical review and analysis, an understanding of where we have come from and where we are going to in terms of water policy, in order to support ongoing development and implementation throughout this and future policy cycles.

Report No: TT 232/04

ISBN: 1 77005 180 5

Overseas price : \$15-00 excl postage

Sediment control at river abstraction works in South Africa: Vol 1

Brink CJ, Basson GR, Denys F

This report presents a review of the international and South African state of the technologies available for controlling sediments at river abstraction works. Optimum abstraction locations, flushing channel designs and suitable pumping designs. Guidance for planning and design of river abstraction works is one of the main highlights of this report.

Report No: TT 259/06

ISBN: 1 77005 410 3

Overseas price : \$85-00 excl postage

Considerations for the design of river abstraction works in South Africa: Vol 11

Basson GR

Report No: TT 260/06

ISBN: 1 77005 411 1

Overseas price : \$40-00 excl postage

Guide for local government cooperation with catchment management agencies.

Mazibuko G, Pegram GC

The recent demarcation process and the on-going specification of the powers and functions between the district, local and metro councils have further clarified the roles and functions of local government. Local government is constitutionally responsible for the implementation and control of a range of activities that affect water resources.

This report provides recommendations on the requirements for co-operative governance and the most appropriate approaches and mechanisms to foster co-operative governance between CMAs and local government, to achieve a range of objectives under differing circumstances. The guide is a user friendly document for all levels of local government.

Report No: TT 270/06

ISBN: 1 77005 460 8

Overseas price : \$15-00 excl postage

Guide for catchment management agency cooperation with local government.

This is a working guide for Catchment Management Agencies to cooperate with local governments in their areas of operation to achieve common objectives in the management of water resources and hence the development of their respective areas.

Report No: TT 271/06

ISBN: 1 77005 439 1

Overseas price : \$15-00 excl postage

A synthesis of the hydrogeology of the Table Mountain Group – Formation of a research strategy

Pietersen K, Parsons R

A project was initiated during 2000 to synthesize the current knowledge about the Table Mountain Group (TMG) aquifer systems. This resulted in a document on the "Synthesis of the Hydrogeology of TMG – Formation of a Research Strategy." The document is subdivided into technical papers and appropriate case studies. This exercise resulted in the understanding that to realize the potential, of this groundwater supply, many uncertainties and barriers need to be overcome, including: deficient understanding of the occurrence, attributes and dynamics of TMG aquifer systems; lack of understanding of environmental impacts of exploitation; and uncertainties about how best to manage the resource within a multi-objective environment. Research of a multi-disciplinary nature is thus needed to find appropriate answers to questions concerning the water resource potential and optimal management of TMG aquifers, in the interest of furthering integrated water resource management in the region.

Report No: TT 158/01

ISBN: 1 86845 804 0

Overseas price : \$40-00 excl postage

Learning about participation in IWRM: A SA review: Book 1 and 2

(also available in Venda, Sotho and Zulu)
Burt J, du Toit D, Pollard S

Report No: TT 293/06
ISBN: 1 77005 506 1
Overseas price : \$20-00 excl postage

Research on Berg river water management: Summary of water quality information system and soil quality studies: (Integrated Catchment Management: ICM).

Gorgens AHM, de Clercq WP

This report describes the development of an integrated information system specifically for water quality (WQIS) for the Berg River that is both integrated and interactive. The WQIS has been developed in close cooperation with its intended technical users to provide water resource operational and planning decision support. The WQIS has a user-friendly GIS-based Graphical User Interface and incorporates interfaces with DUFLOW and CE-QUAL-W2. It was applied to the proposed Skuifraam Dam in the Upper-Berg to illustrate its utilisation to support decision-making for various in-dam water quality management scenarios.

Also reported are field-scale process studies and large-scale soils data interpretation, with a strong focus on salinisation processes. The main products are a soils map and a salinity hazard map that were compiled for the Berg River catchment.

Report No: TT 252/07
ISBN: 1 77005 367 0
Overseas price : \$30-00 excl postage

Developing and trailing guidelines for participatory water resources management

Rowntree K, Motteux N

South Africa's National Water Act of 1998 makes the management of any water resource a partnership between local water users, regional catchment managers, and DWAF. The Act encourages communities to become actively involved in developing and managing their water resources. The three sets of guidelines - Participatory Guidelines, Environmental Guidelines, Planning and Economic Guidelines - are aimed at IWRM practitioners who work with stakeholder communities. The guidelines help practitioners make participatory water resource management a reality.

Report No: TT 258/07
ISBN: 1 77005 064 7
Overseas price : \$20-00 excl postage

A study of Roman water law, with specific reference to water allocations and prior appropriation.

Burger A

In view of the common law of South Africa being Roman-Dutch and Roman law, the question was asked: Can the Roman law provide some guidance for water law and water allocations in South Africa in as much as the Roman law represents principles developed and successfully applied for almost a thousand years. The principles of Roman law were developed over a very long period in the vast Roman Empire, which covered a number

of different countries with widely different climates. The final version of the Roman law is contained in the *Corpus Juris Civilis* compiled under the direction of the Emperor Justinian around 534 AD. The law of all European, and many other countries grew out of Roman law. It is, with Roman-Dutch, the common law of South Africa. That part of the Roman law constituting the principles of the water law is set out in this article. Before a law has withstood the test of years of practice, one cannot say whether it is a successful law or not. The Roman interdicts offer practical, tested guidance for resolving conflicts arising in water-stressed situations typical of arid and semi-arid areas. This makes the body of Roman water law worthy of attention and further study for application in South Africa, particularly as we approach full-scale implementation of the National Water Act.

Report No: TT 279/06
ISBN: 1 77005 469 3
Overseas price : \$20-00 excl postage

Hydrogeology of groundwater region 26 Bushmanland

Vegeter JR

This report forms part of a series on the hydrogeology of the various groundwater regions in South Africa. Region 26 (Bushmanland) is the fifth region that will be published; there are 64 Groundwater Regions. The Regions previously published are: 1 (Makoppa dome), 3 (Limpopo Granulite-Gneiss belt), 7 (Polokwane/Pietersburg Plateau) and 19 (Lowveld). The hydrogeology of the Bushmanland Region is described using available data and gives a good overview of the groundwater conditions in this region.

The main findings indicate that with decreasing rainfall and an increase in thickness of the superficial deposits there is a corresponding though not uniform deterioration in groundwater conditions from east to west. The report lists the conditions at which potential water strikes can be encountered. The data revealed that weathering enhances secondary porosity only where the water levels are less than about 30-metres deep. Water is generally struck in fractured fresh rock below the weathered zone and not in the transition between weathered and fresh rock as is the case in the higher rainfall areas. Seventy-four percent of groundwater samples, out of 968 samples, tested were unsuitable for domestic use. The constituents of concern in the groundwater are, in order of frequency of occurrence: fluoride, nitrate, chloride, sodium and sulphate. In most instances if a borehole produces significant water then the poor quality of the water becomes a limiting factor for development.

Report No: TT 285/06
ISBN: 1 77005 495 2
Overseas price : \$40-00 excl postage

Groundwater Research needs in the Eastern Karoo Basin of South Africa

Murray EC, Cobbing JE

The main aim of the report is to outline the current groundwater research needs in the densely populated, impoverished eastern regions of the Eastern Cape Province. Groundwater is the main source for community water supply in the rural areas. Little groundwater research has been done to date in the eastern regions of the Eastern Cape Province - an area that comprises the Eastern Karoo Basin (the geological term for this region).

The focus area of this document is Water Management Area 12, incorporating most of the former Transkei and Ciskei 'homelands'. This document describes how new research will coincide with national and provincial development priorities. It takes into account past research, proposes broad research areas, and finally, it lists what are considered to be the most important geohydrological research projects completed to date. It was developed after widespread consultation that included officials from the Department of Water Affairs and Forestry (DWAF) in the Eastern Cape Province, and a number of locally-based groundwater and engineering consultants.

Report No: TT 286/06
ISBN: 1 77005 497 0
Overseas price : \$25-00 excl postage

Integrated water resource management plan guidelines for local authorities (IWRMP)

Burke J

From a groundwater perspective, Groundwater Resource Directed Measures (GRDM) is more important than the Reserve on its own. While the Reserve only addresses the role groundwater plays in meeting basic human needs and sustaining aquatic ecosystems such as rivers and wetlands, GRDM allows the use and protection of the entire groundwater resource to be addressed holistically. Four levels of GRDM assessments are recognised – desktop, rapid, intermediate and comprehensive – each providing an increased level of confidence.

The objectives of this project were:

- To review and implement methods developed to set RDM for groundwater through an appropriate case study;
- To refine and adapt methods as a result of lessons learnt during the pilot study; and
- Align methods with other components of RDM (e.g. estuaries, rivers and wetlands).

The E10 catchment containing the Olifants River was selected as the pilot study area. A Groundwater Resource Directed Measures assessment was undertaken. Additional data and information was collected, through a hydro census, for the study area where data was lacking. The research resulted in the development of the GRDM manual that can be used as a guide by both experienced and inexperienced geohydrologists to undertake and review GRDM assessments. Accompanying software was developed to assist with the assessments

Report No: TT 299/07
ISBN: 978 1 77005 510 0
Overseas price : \$30-00 excl postage

Groundwater Sampling: a comprehensive guide for sampling methods: Second edition

Weaver JMC, Cave L, Talma AS

This revised edition incorporates a number of additional sections, such as sampling for isotopes, down-hole logging, etc. Some chapters have been substantially revised to include advances in field instrumentation, such as pH meter technology and increased attention to organic compounds. A short chapter on the sampling of wetlands, springs and groundwater seeps has also been included. Other chapters have undergone only minor

changes, since what was relevant in 1992 is today still relevant. Groundwater quality data collected according to these described techniques can then reliably be used to evaluate hydro geochemical conditions

Report No: TT 303/07
ISBN: 978 1 77005 545 2
Overseas price : \$20-00 excl postage

KSA 2:

River Ecoclassification Manual For Ecstatus Determination (Version 2)

MODULE A: Ecoclassification And Ecstatus Determination
Kleynhans CJ, Louw MD

Report No: TT 329/08
ISBN: 978 1 77005 677 0
Overseas price : \$20-00 excl postage

River Ecoclassification Manual For Ecstatus Determination (Version 2)

MODULE D: Volume 1: Fish Response Assessment Index (FRAI)
Kleynhans CJ

Report No: TT 330/08
ISBN: 978-1-77005-678-7
Overseas price : \$30-00 excl postage

River Ecoclassification Manual For Ecstatus Determination (Version 2)

MODULE D: Volume 2: Reference frequency of occurrence of fish species in SA
Kleynhans CJ, Louw MD, Moolman J

Report No: TT 331/08
ISBN: 978-1-77005-681 7
Overseas price : \$25-00 excl postage

River Ecoclassification Manual For Ecstatus Determination (Version 2)

MODULE E: Volume 1: Macroinvertebrate Response Assessment Index (MIRAI)
Thirion C

Report No: TT 332/08
ISBN: 978-1-77005-679-4
Overseas price : \$25-00 excl postage

River Ecoclassification Manual For Ecstatus Determination (Version 2)

MODULE F: Riparian Vegetation Response Assessment Index (VEGRAI)
Kleynhans CJ, MacKenzie JA, Louw MD

Report No: TT 333/08
ISBN: 978-1-77005-680 0
Overseas price : \$30-00 excl postage

MODULE G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual)

Kleynhans CJ

Report No: TT 377/09
ISBN: 978-1-77005-800-2
Overseas price : \$25-00 excl postage

MODULE G: EcoClassification and EcoStatus Determination in River EcoClassification: Manual for Index of Habitat Integrity (Section 2, Model Photo Guide).

Graham M, Louw MD

Report No: TT 378/09
ISBN: 978-1-77005-801-9
Overseas price : \$20-00 excl postage

Environmental flow assessments for rivers: Manual for the building block methodology – Updated version

King JM, Tharme RE, De Villiers MS

Environmental (or instream) flows are flows that are left in, or released into, a river system with the specific purpose of managing some aspect of its condition. As the condition of river systems deteriorates globally, environmental flows are increasingly appearing in legislation. The science of advising on environmental flows is relatively young (about 50 years), but more than 100 methodologies in existence.

South Africa formally addressed the topic in the 1980s, and during the 1990s made considerable progress at a national level. Recognising that international approaches to environmental flow assessments did not meet South Africa's needs entirely, development of a local approach was initiated. Through a decade of extraordinary cooperation and willingness to contribute, the national body of aquatic scientists, water managers and engineers developed the BBM to the point where it is now one of only a few advanced environmental flow methodologies in the world with a formal manual. In addition, the BBM (Building Block Methodology) has advanced the field of environmental flow assessment in an entirely new direction, being a holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem. The BBM is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. This manual describes its basic nature and main activities, and provides guidelines for its application.

Report No: TT 354/08
ISBN: 978-1-77005-721-0
Overseas price : \$40-00 excl postage

Assessing the Impact of Research Funded by the Water Research Commission in Support of the River Health Programme

Roux DJ, Hill L, Strydom W

The River Health Programme is a multi-institutional national programme which has 3 custodians, the DWAF, the DEAT and the WRC. The WRC, with its mandate for research, was very closely involved during the developmental stages, and published the first few State of the Rivers reports (SoR). Once the programme was running the WRC withdrew support from the publication of the SoR, but has remained involved at the levels of national coordination and research as required.

The report covers the history and development of the River Health Programme (RHP) from the concept of using biological systems for monitoring environmental quality, which was new when the

programme was first conceived, through the early growth phase to its becoming established as a national programme.

Report No: TT 360/08
ISBN: 978-1-77005-742 5
Overseas price : \$20-00 excl postage

Local institutions for water governance: the development of a water users association and catchment forum in the Kat River Valley, Eastern Cape

Burt J, McMaster A, K Rowntree K, Berold R

This report describes the development of water resource management organisations (institutions) in the Kat River Valley from 1997 to 2006. The two organisations described here – the Kat River Valley Water User Association and the Kat River Catchment Forum – are given separate narratives for the sake of clarity, although they developed in close association. The developments described here were taking place at a time of great change in South Africa's political and institutional structures, both locally and nationally. The Kat River Valley was one of the first catchments in the country to set up water management structures. At the time there was no clear direction from the Department of Water Affairs and Forestry about requirements for the water users association process, nor was there a clear policy in relation to catchment forums. Researchers, practitioners and the members of the various institutions had to learn as they went along.

This report offers a reflection on what worked and what did not. The authors hope that the story will be useful to others who are grappling with how to implement the National Water Act in a way that honours the Act's principles of equity, sustainability and efficiency.

Report No: TT 295/07
ISBN: 978 1 7005 586 5
Overseas price : \$20-00 excl postage

Estuaries and Integrated Development Planning: A Managers' Guide

Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07
ISBN: 978 1 77005 541 4
Overseas price : \$15-00 excl postage

An introduction to Aquifer dependent Ecosystem in South Africa

Colvin C, Le Maitre D, Saayman, Hughes S

Aquifer Dependent Ecosystems (ADE) occurs throughout the South African landscape, but their identification is often difficult although this is relevant for water management and allocation. ADEs have been categorised by 8 principal aquifer types (based on lithology) and 7 habitat types. At a coarse national scale it is possible to identify areas with a high probability of supporting terrestrial and aquatic ADEs and to assess their vulnerability to disturbance. High areas of risk are linked to shallow discharge zones where over abstraction is taking place and mining and irrigated agriculture dominate land-use. South Africa is moving towards IWRM and ADEs need to be considered in this context. The successful protection of ADEs requires cooperative governance of land, water and the environment.

Report No TT 301/07
ISBN: 978-1-77005-532-2
Overseas price : \$ 25-00 excl postage

**Learning and teaching about water in our classrooms:
A series of lesson plans for grades
8-12**

Peddie C, Hibbert D, Conway-Physick C

In support of learning and teaching about water-related issues, the Water Research Commission of South Africa and Share-Net (a project of the Wildlife and Environment Society of South Africa) have developed a series of lesson plans on water. These lesson plan packs, from Grade 8 to 10, are linked to the South African National Curriculum.

All the lesson plan packs (Grade R-8) are available on www.envirolearn.org.za

Other useful websites are the Water Research Commission: www.wrc.org.za and the Wildlife and Environment Society of SA www.wessa.org.za

Report No: TT 346/08
ISBN: 978 1 77005 693 0
Overseas price : \$30-00 excl postage

**2. Learning and teaching about water in our classrooms:
A series of lesson plans for grades R-7**

Clare P, Hibbert D, Conway-Physick C

Report No: TT 345/08
ISBN: 978 1 77005 650 3
Overseas price : \$30-00 excl postage

WET-Roadmap: A guide to the wetland management series

Dada R, Kotze D, Ellery W, Uys M

This programme, co-funded by Working for Wetlands, aims to establish national wetland rehabilitation procedures by establishing a framework within which wetlands requiring rehabilitation may be prioritised and continually assessed. It will develop a diagnostic framework for assessing the underlying causes of degradation and develop national guidelines for rehabilitation including a review of the methods available. It will also develop synergy with other research being done on wetlands, examine the institutional arrangements around wetland management, and develop a long-term monitoring system that will allow strategic adaptive management of wetlands.

Report No: TT 321/07
ISBN: 978 1 77005 632 9
Overseas price : \$10-00 excl postage

Guidelines for the planning, design and operation of fishways in South Africa

Ralph Heath, Anton Bok, Pieter Kotze, Paul Fouche, Hylton Lewis, Jan Rossouw, Mathew Ross

The need to manage water has led to the construction of barriers in rivers, effectively fragmenting the habitat and curtailing the passage of migratory biota. This project will develop protocols for assessing the extent of blockage to free passage, and so prioritizing river systems for remedial measures, for the assessment of sites for use in the EIA and the RDM process. Understanding of the biological / hydraulic requirements of the relevant biota will be developed and this, together with data from existing fish-ways, will be used to develop cost-effective designs for local biota.

Report No: TT 287/07
ISBN: 978 1 77005 577 3
Overseas price : \$30-00 excl postage

Hydrology and water quality of the Mgeni catchment

Kienzle SW, Lorentz SA, Schulze RE

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 87/97
ISBN: 1 86845 297 2
Overseas price : \$30-00 excl postage

The biological and chemical database. User manual (SA Price: R28.50)

Dallas H, Janssens P

A Biological/Chemical Database was developed as part of this project, incorporating virtually all the ecological studies done on South African rivers which include both taxonomic and chemical data. Using SASS4 (South African Scoring System, version 4), several of the water-quality variables in the DWAF guidelines for environmental water quality were tested for each of the four regions (mountain, foothills, transitional and low land rivers).

Report No: TT 100/98
ISBN: 1 86845 421 5
Overseas price: \$50-00 excl postage

GUIDES TO THE FRESHWATER INVERTEBRATES OF SOUTHERN AFRICA

The principle aim of the series of ten books is to synthesize much of the existing knowledge on the identification of freshwater invertebrates into a standard format that is accessible to users who wish to identify taxa beyond their field of expertise. This series will include an introductory volume containing general information and a key to the families of invertebrates.

Volume 1: In preparation**Volume 2: Guides to the freshwater Invertebrates of Southern Africa: Crustacea I (SA price: R50.00)**

Day JA, Stewart BA, De Moor IJ & Louw AE

Report No: TT 121/00

ISBN: 1 86845 581 5

Overseas price : \$25-00 Postage inclusive

Volume 3: Guides to the freshwater Invertebrates of Southern Africa: Crustacea II (SA price: R50-00)

Day JA, Stewart BA, De Moor IJ, Louw AE

Report No: TT 148/01

ISBN: 1 86845 703 6

Overseas price : \$25-00 Postage inclusive

Volume 4: Guides to the freshwater Invertebrates of Southern Africa: Crustacea III (SA price: R50-00)

Day JA, Stewart BA, De Moor IJ, Louw AE

Report No: TT 141/01

ISBN: 1 86845 676 5

Overseas price: \$25-00 Postage inclusive

Volume 5: Guides to the freshwater invertebrates of Southern Africa: Non-Arthropods (SA Price: R114-00)

Day JA, De Moor IJ

Report No: TT 167/02

ISBN: 1 86845 827 X

Overseas price: \$50-00 Postage inclusive

Volume 6: Guides to the freshwater invertebrates of Southern Africa: Arachnida & Mollusca: Araneae, Water Mites & Mollusca (SA Price: R50-00)

Day JA, De Moor IJ

Report No: TT 182/02

ISBN: 1 86845 875 X

Overseas price: \$50-00 Postage inclusive

Volume 7: Guides to the freshwater invertebrates of Southern Africa: Insecta; Ephemeroptera, Odonata & Plecoptera (SA Price: R114-00)

De Moor IJ, Day JA, De Moor FC

Report No: TT 207/03

ISBN: 1 86845 875 X

Overseas price: \$50-00 Postage inclusive

Volume 8: Guides to the freshwater invertebrates of Southern Africa: (SA Price: R100-00)

De Moor IJ, Day JA, De Moor FC

Report No: TT 214/03

ISBN: 1 77005 055 8

Overseas price: \$50-00 Postage inclusive

Volume 9: Guides to the freshwater invertebrates of Southern Africa: Diptera (SA Price: R100-00)

De Moor JA, AD Harrison AD, De Moor IJ

Report No: TT 201/02

ISBN: 1 86845 900 4

Overseas price: \$50-00 Postage inclusive

Volume 10: Guides to the freshwater invertebrates of Southern Africa" (SA Price: R100-00)

Stals R, De Moor IJ

Report No: TT 320/07

ISBN: 978 1 77005 629 9

Overseas price: \$50-00 Postage inclusive

The Kruger National Park Rivers research programme

C Breen, M Dent, J Jaganyi, B Madikizela, J Maganbehari, A Ndlovu, J O'Keeffe, K Rogers, M Uys, F Venter

The Kruger National Rivers research programme is a co-operative undertaking by resource-use managers, funding agencies and researchers. It addresses the water quality and water quantity requirements of the natural environments of rivers, particularly those flowing through the Kruger National Park.

Report No: TT 130/00

ISBN: 1 86845 622 6

Overseas price: \$35-00 excl postage

State of the Rivers Report

DWAf, WRC, CSIR, Mpumalanga Parks Board & Dept of Environmental Affairs

Between 1996 and 1999, the River Health Programme (RHP) conducted surveys on the three major river systems of Mpumalanga, the Crocodile, Sabie Sand and Olifants Rivers, including some of their tributaries.

The RHP collected and assessed a substantial body of data on the ecological health of these rivers during the surveys.

The following reports are available:

1. State of the Rivers Report: Letaba and Luvuvhu River Systems 2001 (TT 165/01)
2. State of the Rivers Report (TT 147/00)
3. State of the rivers report: Umngeni River and neighbouring rivers and streams. (TT 200 /02)

Report No: TT 147/00

ISBN: 1 86845 689 7

Overseas price : \$20-00 excl postage

Ecological risk assessment guidelines (South African price: R50-00)

Claassen M, Strydom W F, Murray K & Jooste

Ecological risk assessment is a structured approach that describes, explains and organizes scientific facts, laws and relationships and provides a sound basis to determine sufficient protection measures and to develop utilization strategies. The risk assessment process has the potential to improve communication between scientists, managers and the public, thereby promoting mutual understanding and collaboration. Appropriate use of this guideline document will thus promote cooperative governance and sustainable development.

Report No: TT 151/01
ISBN: 1 86845 721 4
Overseas price : \$25-00 excl postage

The Botanical importance rating of the Estuaries in former Ciskei/Transkei

Colloty BM, Adams JB & Bate GC

Botanical importance refers to the contribution of the plants to the conservation status of an estuary. In this study botanical importance is the sum of functional importance, species richness, community richness and community type rarity.

Report No: TT 160/01
ISBN: 1 86845 790 7
Overseas price : \$20-00 excl postage

Guidelines for *Legionella* levels in water: A code of practice

Pauline Coubrough

The guidelines are intended for use in South Africa, taking in account South African environmental conditions. International guideline documentation, results from outbreaks that have occurred throughout the world, and the National *Legionella* Action Group's research findings were used in the formulation of the guidelines.

Report No: TT 174/02
ISBN: 1 86845 846 6
Overseas price : \$15-00 excl postage

Predicting water quality and biotic response in ecological reserve determinations

Malan H; Day JA

The management of water quality in the environmental Reserve is more complex than that of water quantity. The principal aim of this project is to examine the relationship between water quality and water quantity with particular reference to instream flow requirement assessments, and to produce a framework for the assessment of water quality in IFR studies. Secondary aims are to investigate how the Biobase database may be used in the assessment of water quality guidelines.

Report No: TT 202/02
ISBN: 1 86845 923 3
Overseas price : \$30-00 excl postage

Prioritisation of South African estuaries based on their potential importance to estuarine-associated fish species

Maree RC; Whitfield AK; Quinn NW

This report presents a ranking of South African estuarine systems based on their importance to estuarine-associated fish species, and aims to facilitate the identification of South African estuaries with a high conservation priority, by placing all South African systems in a regional and national context.

Report No: TT 203/03
ISBN: 1 86845 979 9
Overseas price: \$10-00 excl postage

Freshwater fish and human health: Overview guide

Heath R; du Preez H; Genthe B; Avenant-Oldewage A

This programme focuses on the development of a series of guidelines and protocols to promote and advocate the safe use of water with the aim to build awareness and to transfer technology to the public to minimise water-related health risks. This programme is intended to meet the needs of practitioners and will consider aspects of water use and health, hygiene, hazards and risks as well as epidemiological studies, communication protocols and education guidelines. These projects are concerned with translating scientific data into accessible formats.

Report No: TT 212/04
ISBN: 1 77005 046 9
Overseas price: \$20-00 excl postage

Freshwater fish and human health: Reference guide.

Heath R; du Preez H; Genthe B; Avenant-Oldewage A

Report No: TT 213/04
ISBN: 1 77005 047 7
Overseas price: \$25-00 excl postage

Environmental water quality in water resources management

Palmer T; Berold R; Muller N

The release of harmful and potentially harmful substances into the environment has caused water quality problems worldwide. Toxicology offers a cost-effective way of measuring the likely impact of an effluent on the environment, in that it will identify whether the effluent is toxic, including any synergistic and antagonistic effects. This will allow for both the determination of the suitability of the effluent for discharge to be determined for licensing purposes, and for specific industries to monitor their compliance with license conditions.

Most toxicity tests measure acute effects and the chronic values are calculated empirically. The measurement of sub-lethal methods will, thus, provide accurate values on which to base decisions, so enhancing the capacity of managers to protect the water resource.

During this project new methods will be developed for quantifying the chronic effects of toxic effluents at sub-lethal concentrations.

Report No: TT 217/04
ISBN: 1 77005 083 3
Overseas price: \$10-00 excl postage

The effect of water quality variables on aquatic ecosystems review

Dallas HF; Day JA

Water is a scarce resource in South Africa, and increasing population pressure has meant that the resource is heavily exploited and carries an increasing pollution load. Aquatic ecosystems are able to remediate a certain amount of pollution, but once this level has been exceeded then the ecosystem, together with its ability to remediate pollution declines.

Chapters 2 and 3 of the review provide a general introduction to the issue of water quality in relation to aquatic ecosystems. Chapters 4 to 12 synthesise what is known about the effects on aquatic ecosystems of specific physical attributes and chemical constituents. Specifically, these include temperature, turbidity, pH, total dissolved solids and dissolved oxygen. Organic enrichment,

including bacterial contamination, as well as the effects of enrichment by specific nutrients are covered, as are biocides and trace metals. The last eight chapters examine the effect of different types of whole effluents or other specific disruptions resulting from human activities, including agriculture, aquaculture, engineering and construction with specific reference to river regulation, forestry, industrial effluents, mining and urban runoff.

Report No: TT 224/04
ISBN: 1 77005 131 7
Overseas price: \$30-00 excl postage

Towards the conservation and sustainable use of Eastern Cape estuaries.

Breen C; et al.

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 237/04
ISBN: 1 77005 235 6
Overseas price: \$20-00 excl postage

Spatsim, an integrated framework for ecological reserve determination and implementation.

Hughes DA; Palmer CG

Water quality is currently trailing water quantity in the ecological Reserve methodology. Further development of the methods used is necessary to enable the water quality component to be considered adequately. The aims of this project are to develop acceptable time-series data for selected water quality variables, encapsulate the expert water quality knowledge in an organised way and encode these for inclusion into the DSS currently being developed as part of a parallel project, and co-ordinate this with other water quality projects working on the Reserve. This will ensure that decisions taken on water quality in the Reserve determination process are done in a standard way and in parallel with those on water quantity.

Report No: TT 245/04
ISBN: 1 77005 296 8
Overseas price: \$25-00 excl postage

Managing sedimentary processes in SA Estuaries: A guide

Hay D; Huizinga P; Mitchell S

Ingress of marine sediments into estuaries was the single most important issue in estuary management identified in the western part of the Eastern Cape during the early stages of the EC Management Programme. The local authority for the Port Alfred / Boesmans River area has committed funds to develop the predictions of the effect of interventions on the problem. If the predictions indicate that an intervention may be successful, then the EIA around the planned intervention will be undertaken within this project. Thereafter, the implementation of any technology will be for the expense of the local authority.

Report No: TT 241/05
ISBN: 1 77005 272 0
Overseas price: \$20-00 excl postage

THE SA DIATOM COLLECTION:

1. An appraisal and overview of needs and opportunities

Harding WR; Archibald CGM; Taylor JC; Mundree S

The South African Diatom Collection (which extends beyond South Africa's borders) was established over the period 1950 to 1995 by a number of collectors and is amongst the larger collections worldwide. A number of case studies were carried out which showed the relevance of the OMNIDIA software package (use of diatom-based water quality indices) for South African conditions. The general conclusion is that the data and information contained in this collection will add value to, and have a place in, the current suite of assessment tools currently being used for the management of the surface water resource in South and Southern Africa.

Report No: TT 242/04
ISBN: 1 77005 275 5
Overseas price: \$25-00 excl postage

2. Benthic diatoms in the rivers and estuaries of South Africa

Bate GC; Smailes PA; Adams JB

This follow-on project (from the project entitled Identification of diatoms and their use in the assessment of water quality) will address 3 aspects of the use of diatoms in monitoring for water quality. The determination of the relationship between dominant diatom assemblages and freshwater quality will continue. The same will be done for estuarine diatoms, where the relationship between water quality and dominant assemblages will be defined. Thirdly, a manual of South African diatoms will be produced. The product of this project will enable the use of diatoms, long recognised as being sensitive indicators, in water quality management at the technician level, not achieved elsewhere before.

Report No: TT 234/04
ISBN: 1 77005 182
Overseas price: \$35-00 excl postage

3. A methods manual for the collection, preparation and analysis of diatom samples.

Taylor JC; Harding WR; Archibald CGM

Report No: TT 281/07
ISBN: 1 77005 483 9
Overseas price: \$20-00 excl postage

4. An illustrated guide to some common diatom species from South Africa.

Taylor JC; Harding WR; Archibald CGM

Report No: TT 282/07
ISBN: 1 77005 484 7
Overseas price: \$30-00 excl postage

The state of Yellowfish report in South Africa: (SA price R50-00)

Wolhuter LE; Impson ND

Report No: TT 302/07
ISBN: 978 1 77005 543 8
Overseas price: \$30-00 excl postage

Cross-sector policy objectives for conserving South Africa's inland water biodiversity.

Roux D; Nel JL; MacKay HM; Ashton PJ

Report No: TT 276/06
ISBN: 1 77005 459 6
Overseas price: \$25-00 excl postage

Conservation planning for river and estuarine biodiversity in the Fish to Tsitsikamma water management area.

Lindsay NJ, Smith-Adao L, Roux DJ, Adams J, Cambray JA, de Moor FC, Kleyhans CJ, Kotze I, Maree G, Moolman J, Schonegevel LY, Smith RJ, Thirion

This study piloted the development of a planning framework for systematic conservation of inland water biodiversity in South Africa. The tool for river prioritization and selection was tested, refined and demonstrated in the Fish to Tsitsikamma Water Management Area, and provides a process for implementing biodiversity conservation in practice.

Report No: TT 280/06
ISBN: 1 77005 473 1
Overseas price: \$30-00 excl postage

Estuaries and Integrated Development Planning: A Managers' Guide

Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07
ISBN: 978 1 77005 541 4
Overseas price: \$15-00 excl postage

KSA 3:

Integrated algal ponding systems and the treatment of domestic and industrial wastewaters: part 4: Report 7

Rose PD; Hart OO; Dekker LG; Clark SJ

Inadequate sanitation is a leading cause of water pollution and consequently illness in many underdeveloped countries, including South Africa, for example the Eastern Cape Province, where cholera has reportedly become endemic. As modern wastewater treatment processes are often energy-intensive and expensive,

they are not suitable for use in these areas. There is thus a need to develop more sustainable wastewater treatment technologies for application in smaller communities. The integrated algal ponding system (IAPS) was identified as a possible solution to this wastewater management problem and was investigated for adaptation to local conditions at the Rhodes University Environmental Experimental Field Station in Grahamstown.

The system was monitored over a period of nine years, with various configuration adjustments of the high rate algal pond (HRAP) unit operation investigated. Under standard operating conditions, the system was able to achieve levels of nutrient and organic removal comparable with conventional wastewater treatment works.

The mean nitrate level achieved in the effluent was below the 15mg.l⁻¹ South African discharge standard, but nitrate removal in the IAPS was found to be inconsistent. Although the system was unable to sustain chemical oxygen demand (COD) removal to below the 75mg.l⁻¹ South African discharge standard, an average COD removal rate of 87% was recorded, with the residual COD remaining largely in the form of suspended algal biomass.

Previous studies in the Eastern Cape Province have shown that few small wastewater treatment works produce effluent that meets the microbial count specification. Therefore, in addition to the collation of IAPS data from the entire nine year monitoring period, this study also investigated the use of the HRAP as an independent unit operation for disinfection of effluent from small sewage plants. It was demonstrated that the independent high rate algal pond (IHRAP) as a free standing unit operation could consistently produce water with *Escherichia coli* counts of 0cfu.100ml⁻¹. The observed effect was related to a number of possible conditions prevailing in the system, including elevated pH, sunlight and dissolved oxygen.

It was also found that the IHRAP greatly enhanced the nutrient removal capabilities of the conventional IAPS, making it possible to reliably and consistently maintain phosphate and ammonium levels in the final effluent to below 5mg.l⁻¹ and 2mg.l⁻¹ respectively (corresponding South African discharge standards are respectively 10mg.l⁻¹ and 3mg.l⁻¹).

The quality of the final effluent produced by the optimisation of the IAPS would allow it to be used for irrigation, thereby providing an alternative water source in water-stressed areas. The system also proved to be exceptionally robust and data collected during periods of both high-intensity and low-intensity management regimes were broadly comparable.

In summary, the results of the nine-year study have demonstrated reliable performance of the IAPS and its use as an appropriate, sustainable wastewater treatment option for small communities. For producing a treated water suitable for irrigation, some significant strengths of IAPS compared to other wastewater treatment technologies are the relatively low capital and operating (e.g. energy) costs, stable performance and low management demands. The system should find ready application in the RSA.

Report No: TT 193/07
ISBN: 978 1 77005 890 5
Overseas price: \$35-00 excl postage

Part 4: Process Scale-up in the Treatment of Mine Drainage Wastewaters and the Disposal of Sewage Sludge

Neba A; Whittington-Jones KJ; Rose PD

Acidic wastewaters from mining operations (acid mine drainage, AMD) and various industrial and metal-refining processes often

contain high levels of sulphates and heavy metals. WRC studies have shown that AMD volume flows may reach hundreds of megalitres per day for decades, with acute and long-term impacts on the public water resource system, the environment, and community health, and consequences thus for the economic and social development of the water-scarce Gauteng region.

The development of suitable biological treatment processes has to date been constrained by reactor design appropriate to the large volume flows and the availability of cost effective carbon sources. Recent WRC projects have researched algal ponding technologies and applied these low-cost processes to the treatment of mining and tannery wastewaters. This has led to the development of the biological sulphate-reducing (biodesalination) BioSURE™ Process using sewage solids as the carbon source for sulphate reduction and algal activity for precipitating heavy metals and neutralising of acidic drainage streams. In early 1998 a pilot plant was constructed and commissioned at Grootvlei Mine in a collaborative research venture involving the WRC (Project No. 869), ERWAT and Grootvlei Mine. Detailed study of the basic process mechanisms was undertaken in WRC Project No.972. In project 1078 the outstanding components of the pilot plant were constructed to enable evaluation of the complete integrated process over an appropriate time period. In this one-year project 1291, the specific aim was to provide managerial inputs into operationalization and optimisation of the BioSURE™ plant constructed at Ancor Sewage Works by ERWAT and Grootvlei Mine, and thus to assist in process decision-making relating to the full-scale engineering of the process and to provide specialist support to WRC research partners in their implementation of process scale-up for technology transfer,

The above aims were in general achieved and reported on during the course of the project. The operationalisation of the BioSURE™ Process in this project has contributed significantly to the development of the current situation, where a full-scale plant is being constructed at Ancor Sewage Works to treat AMD from Grootvlei Mine.

The final report on this project 1291, along with the final report on project 1169, is to be published as Report 12 in the series "Salinity, Sanitation and Sustainability" (ISBN series 1-86845-853-9, Volume 4, Part 4 "Treatment and Disposal of Sewage Sludges"). The report will include early results (to December 2004) from the full-scale plant currently being built and commissioned at ERWAT'S Ancor Sewage Works.

Report No: TT 198/07
ISBN: 978 1 77005 895 0
Overseas price: \$30-00 excl postage

Management of water-related microbial diseases: Volume 2: What causes the problem? – A what to do for water suppliers following diarrhoea incidents?

M Steynberg; B Genthe; A van Middelkoop

Internationally there is growing concern about the general failure of authorities to understand the public health impact of waterborne and related infectious diseases. The water supplier is responsible for protecting the health of the public by providing water that is considered to be safe. When cases of diarrhoea occur in the community, the public is also very quick to blame the water. Confidence in the quality of the water can then only be restored if the allegation has been investigated to the satisfaction of the public.

This handbook provides practical guidelines on how to conduct such an investigation. The methods and materials are not original, and can be found in many books and publications that abound in the fields of water management and epidemiology. No attempt is made in this handbook to discuss all the issues surrounding the recommended procedures-the relevant literature will provide far greater insight. What sets this book apart is the fact that it pulls together the relevant methodology from traditionally remote disciplines, the methodology that is required to find out whether cases of diarrhoea could be due to water consumption.

The water quality and water treatment data routinely collected by the water supplier form an important starting point in finding out whether the water could be responsible for cases of diarrhoea. This handbook shows how to record and interpreted such routine data appropriately so that they facilitate the investigation.

The target audience for this handbook includes both the water supplier and the district health services, for example the water quality officer and the environmental health practitioner. The successful implementation of the recommended procedures depends on the involvement of both sectors. All water suppliers, however large or small, should take note of the guidelines provided in this handbook.

Report No: TT 297/07
ISBN: 978 1 77005 520 9
Overseas price: \$30-00 excl postage

Management of water-related microbial diseases: Volume 4: How dangerous is the problem?-Communicating the risk
B Genthe; M Knoetze

Water-related microbial disease such as cholera causes untold misery in communities across South Africa every year. As part of the effort to promote awareness and understanding of the conditions promoting infectious disease transmission, water service providers are increasingly required to have a risk communication programme in place.

Health risk communication is the exchange of information and opinions concerning risk and risk-related factors among risk assessors, risk managers, consumers and other interested parties.

It is not merely the dissemination of information. If well managed, it will ensure that the message is constructively formulated, transmitted and received and will result in meaningful actions.

This guideline document presents the fourth in a five-volume series aimed at addressing the question of how best South Africans can protect themselves from water-related microbial disease. It provides a framework of principles and guidelines for the communication of health risks, specifically for water service providers.

Communicating with the public is an essential element of health risk communication. Ineffective communication often results in conflict, which in turn leads to the erosion of public confidence, and inefficient use of water service providers' resources. The recognition that people are entitled to make decisions about issues that affect their lives can assist water service providers in forming a better understanding of, and formulating more appropriate reactions to, a particular risk. Appropriate risk communication not only promotes consistency and transparency in arriving at and implementing risk management decisions, it also fosters public trust and confidence in the safety of the water supply.

The document will provide guidelines and examples that will assist water service providers in communicating with the public when a water quality issue arises that has a potential impact on health.

It is hoped that this document will assist water service providers, government departments, water boards, municipalities and district councils in communicating with the public when a water quality issue arises that could have a potential impact on health. In this way, the guide will hopefully make a significant contribution to protecting our most vulnerable communities against water-related microbial disease.

Report No: TT 298/07
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Overseas price: \$25-00 excl postage

Guidebook for the selection of small water treatment systems for potable water supply to small communities.

C D Swart, I Goldie; G Mwiing, LM Daries; BA Delcarme; JD Seconna, JC Geldenhuys

Small water treatment plants are defined as water treatment systems that have to be installed in areas which are not adequately serviced and do not normally fall within the confines of urban areas. They are therefore mostly used in rural and peri-urban areas and include chlorination plants for water supplies from boreholes and springs, small treatment systems for rural communities, treatment plants of small municipalities and treatment plants for establishments such as rural hospitals, schools, clinics, forestry stations, etc. Most of these applications require small plants of less than 2.5 ML/d (although plants of up to 25 ML/d may sometimes also fall into this category).

The decision-maker selecting one of these small water treatment plants has a great number of local and international system designs to choose from. Especially in the case of novel and emerging systems, very little may be known of these systems in terms of cost, efficiency and the applicability to the intended application. Supplier information may be sketchy, or promising new technologies have not yet been fully evaluated under South African conditions. Socio-economic factors are also very important and should be taken into account in the selection of small water treatment systems in order to ensure sustainability.

Although some evaluation of a selected number of small water treatment plants has taken place under previous WRC projects (WRC Report No 450/1/97: Package water treatment plant selection, and WRC Report No 828/1/01: Field evaluation of alternative disinfection technologies for small water supply), a number of other small water treatment plants, available on the international market, have not yet been assessed in any way for possible (beneficial) application in South Africa. This guidebook is therefore seen as complementing existing guidelines in providing assistance in the selection and operation of specific small water treatment systems being marketed for the treatment of potable water for small communities.

A number of local and international studies have shown that the selection of the correct water treatment system is but a first step in ensuring a sustainable supply of potable water to small communities. Following of the correct operational and maintenance procedures is of even greater importance for ensuring sustainability of water supply. Although most suppliers of small water treatment systems provide their clients with some operational and maintenance guidelines, these may not be exhaustive, or certain important generic aspects may not be

covered. Information on operation and maintenance aspects will be of significant value to the owners and operators of such small water treatment systems.

The guidebook aims to provide guidelines for the identification and optimal selection of available and emerging new water treatment systems, which are currently being marketed for the supply of potable water to small communities in South Africa.

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Overseas price: \$30-00 excl postage

Enabling water fluoridation on small drinking water treatment plants Part A: Guidelines for the implementation of fluoride dosing in small systems Part B

R Rajagopaul; PThompson; A Hariram

Regulations for the fluoridation of South African potable water supplies to an optimum concentration of (and not more than) 0.7 mg/l in order to limit the development of dental caries were published in the Government Gazette of 8 September, 2000. Water Services Providers (WSP's) had to register with the Department of Health (DOH) by 8 September 2001 for fluoridation of their water supplies to consumers – or apply for exemption. However, because of the larger safety risk foreseen for both plant operators and water users in smaller and rural water treatment plants, such plants supplying water to less than 60 000 people, currently receive, on application, temporary exemption from the Director-General: Health. This unfortunately excludes a large part of the population from receiving the benefits of fluoridation. By far the majority of water treatment plants fall within the category of supplying less than 60 000 people with potable water. In addition, most of the operators on these smaller plants are not at a skills level required by the regulations for the safe operation of a fluoride dosing facility. A need therefore existed to enable these smaller plants to administer fluoride safely through the correct choice and operation of instrumentation and equipment, as well as by innovative ways in which to make a plant fail-safe in terms of both technology and human shortcomings. The project aimed to enable fluoridation to be done safely on small water treatment plants by means of the evaluation, selection and implementation of safe handling and dosing equipment and monitoring instrumentation.

Potentially suitable handling and dosing equipment and monitoring instrumentation were evaluated at an Umgeni Water treatment plant and the following products emanated from the study and evaluation: i) A full report was produced on the various fluoridation handling, dosing and monitoring equipment evaluated, including cost implications to the water treatment plant. ii) A comprehensive guideline document was compiled, outlining suitable fluoridation techniques, equipment available, correct installation and use of the equipment and general safety measures that (especially) small plant personnel need to adhere to. In the light of the fact that fluoridation will go ahead in the near future, this guideline is a very timely document, which will assist especially the small water treatment facilities – but also larger plants – in ensuring that their fluoridation requirements are met in an efficient and safe way.

Report No: TT 347/08
ISBN: 978 1 77005 700 5
Overseas price: \$30-00 excl postage

On-site mobile training of water treatment operators in small rural water supplies.

MNB Momba, N Makala, M Dugeni

Many small rural water treatment plants in South Africa do not produce the quality or quantity of water that they were meant to. Both technical and human factors have been reported to be the major causes of the failure of small rural water treatment plants to provide potable water to their consumers. Inadequate water treatment systems are therefore placing rural communities at risk of diseases. It has been found that most of the operators who operate rural small water treatments lack the knowledge of plant operational processes. Even when an attempt has been made to offer training, the level of the material used is well beyond the educational level of the operators. Consequently there is a need for the training to be adapted to their capability as well as to be done on-site. This guide was meant to complement the cartoon guide "An illustrated Guide to Basic Water Purification Operations" by providing a practical, mobile course oriented training manual.

Report No: TT 348/08

ISBN: 978 1 77005 704 3

Overseas price: \$20-00 excl postage

Water Services Barometer Study

SM Martin

Community consultation in the provision of water services is both a legislative obligation and a critical success factor. Legislation and policy require government to engage with communities in the provision of Water Services. In order to inform/consult the public and obtain their participation and support, national departments such as DWAF and DPLG embarked on awareness campaigns and/or solicited public participation through meetings, leaflets and the mass media.

No single comprehensive study has been done which provides a barometer of the general public's knowledge and understanding of the water services messages as communicated, and their involvement in, and preferences for, consultative processes. To this end, this study into the level and status of community consultation on a range of water services issues was undertaken. The study gives a 'reading' of the current state of knowledge and awareness amongst the South African public regarding five key water services knowledge areas. The analysis of the data furthermore identifies areas of strength and weakness with the view to developing recommendations for improvement.

For the purpose of this study, the term 'community consultation' was broadly defined to include all types of communication aimed at the general public, ranging from information dissemination to community participation. The study limited itself to water services messages and it focuses on two major communication campaigns of the Department of Water Affairs and Forestry that have dealt specifically with Water Services, Free Basic Water and Water and Sanitation Hygiene (WASH).

In order to assess the results/ outcomes of these water services campaigns, a barometer instrument was constructed. The barometer quantifies, with a composite score out of a possible 10, the knowledge /awareness/ desired behaviour of adult South Africans regarding key messages of the campaigns.

Five key water services knowledge areas were identified from the literature review and the analysis of the e National Spatial Biodiversity Assessment (NSBA) established that 30% of grasslands in South Africa are irreversibly transformed and only 2.8% are formally conserved. The National Grasslands Biodiversity Programme (NGBP) aims to mainstream biodiversity in production landscapes involving the coal mining and agricultural sectors, and is investigating both regulatory and market based approaches to achieve this. Offsite mitigation and mitigation banking for wetlands have been identified as concepts with the potential to achieve the desired conservation of aquatic biodiversity within the priority areas of the grassland biome. The concept of wetland mitigation banking developed in the United States to meet the country's policy of 'no-net loss' of wetlands. It is, however, a controversial concept, with the overriding argument against adopting the mechanism being that "it encourages a commodity approach to conservation wherein wetlands are traded for cash".

Report No: TT 353/08

ISBN: 978 1 77005 743 2

Overseas price: \$20-00 excl postage

Guidelines for the improved disinfection of small water treatment plants.

MNB Momba, CL Obi and P Thompson

The efficacy of drinking water treatment by small water treatment plants – and particularly the disinfection aspects thereof, is fraught with several technical and management problems. This is corroborated by the extensive documentations on the supply of water of poor microbiological quality which is unsafe for human consumption in different provinces of South Africa. In order to unravel the intricacies around the operational and management parameters impinging upon the disinfection efficiency of small water treatment plants and to ensure sustainability of potable water supply to rural communities, this study was executed, involving 181 small water treatment plants across seven provinces of South Africa. The goal was to determine the nature and full extent of the disinfection problems experienced and to provide practical and user-friendly guidelines for intervention.

From extensive surveys at these plants and their disinfection systems, it was established that equipment, maintenance, operator education, operator training, operator working conditions and Management-operator interaction were normally inadequate. These aspects were quantified and graphically portrayed on the report. A detailed and user friendly guide document was further drawn up to assist in improving disinfection of final water at small water treatment plants and distribution systems. It includes practical steps and also installation and operating costs for the different disinfection systems and chemicals. This guide document is intended for use at operational and management levels by plant managers, supervisors, plant operators and plants owners, consultants and Municipal Water Local Authorities. The report and guide document will fulfill a long-standing need for more complete information on (both technical and social) aspects regarding improved final water quality produced from small water treatment systems in South Africa.

Report No: TT355/08

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Overseas price: \$20-00 excl postage

Research into UD/VIDP (Urine diversion ventilated improved double pit) toilets: Prevalence and die-off of ascaris ova in urine diversion waste.

CA Buckley, KM Foxon, DJ Hawksworth, C Archer, S Pillay, C Appleton

Urine Diversion (UD) systems have recently received a great deal of international attention in the context of "Ecological Sanitation" or "EcoSan". EcoSan refers to a cycle, or closed-loop system, which treats human excreta as a resource. In this system, excreta are processed on site until they are free of pathogenic (disease-causing) organisms. Thereafter the sanitized excreta are recycled by using them for agricultural purposes. Despite the obvious benefits of the design, there are a number of unresolved scientific, technological, social and health-related questions about how the design works from a biological and mass transfer perspective, and what the real health and environmental risks are to the householder, community and any outsiders involved in the pit emptying process. The processes of drying and biological degradation which take place in UD vaults were investigated, with a view to understanding the characteristics of the UD waste at the time that the vault is to be emptied. The process of degradation in a UD vault was thought to be anaerobic biodegradation, with some aerobic degradation occurring at the air interface at the top surface of the waste; however it was found that the conditions in the heaps are not conducive to anaerobic digestion. Because of the way in which the faeces and sand are added to the vault, the mixture is very non-homogeneous. Further the analysis has also highlighted the importance of the air circulation rate for achieving good drying. The fact that the Durban system is to close off the vault during the standing phase is therefore an unsatisfactory feature of the system, since it means that very little drying will occur during the standing phase. The risk assessment showed that there was a 31% reduced risk of diarrhoea in the areas where the on-site sanitation program had been implemented to areas where it had not been implemented

Report No: TT356/08
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Overseas price: \$20-00 excl postage

Scientific support for the design and operation of ventilated improved pit latrines (VIPS) and the efficacy of pit latrine additives.

Buckley CA; Foxon KM; Brouckaert CJ; Rodda N; Nwaneri C; Balboni E; Couderc A; Magagna D

This project proposed to undertake field and laboratory investigations of VIPs and their contents in and around the eThekweni Municipal area in order to understand the conditions found in the pits and to propose design and operating practice that will extend the life of pits. The standard VIP design was found to be effective for the accumulation and degradation of faecal sludge. However, it was observed that the ability of a VIP latrine to function as an improved sanitation system i.e. to provide hygienic separation of human waste from human contact, to limit the transport of pathogens from human waste by vectors such as rodents and insects, to reduce nuisance associated with flies and odour and to preserve the dignity of the user, was compromised in a number of respects due to poor construction, bad user habits, and during pit emptying operations. It was observed that poor construction or lack of maintenance often resulted in essential features of the VIP latrine design being missing or damaged, including vent-pipes, flyscreens, pedestal

lids, doors and back plates. Under these conditions, there were usually problems with odours and flies. Bad user habits resulted in rapid accumulation of pit contents, particularly when poorly degradable anal cleansing material such as magazines, plastic bags or stones were used. In many cases pit latrines appeared to double as waste disposal sites, resulting rapid filling of the latrines.

During pit emptying operations, significant risk of infection of workers and community members with human pathogens originating from the pit contents is expected due to difficulties in removing pit latrine contents and separating faecal sludge from solid waste. Examination of face masks worn by workers engaged in emptying pit latrines and screening the exhumed contents indicated that viable ova of a number of helminth species including *Ascaris*, *Trichuris* and *Taenia* spp (roundworm, whipworm and tape worm) may be present in pit latrine contents and that these constitute a significant health risk to workers involved in handling pit latrine contents, and community members who have access to the area around the pit latrine during and after pit emptying operations.

Finally, commercial pit latrine additives were found to contain large concentrations of active micro-organisms with the ability to utilise organic substrates. However, neither the field trials, nor the laboratory trials provided evidence that the use of these products could result in a significant reduction in either mass or volume of pit latrine contents.

Report No: TT357/08
ISBN: 978 1 77005 718 0
Overseas price: \$30-00 excl postage

The status and use of drinking water conservation and savings devices in the domestic and commercial environments in South Africa.

D Still, S Erskine, N Walker and D Hazelton

This study included four different surveys in order to gauge the status and use of water efficient devices in South Africa. Firstly, commercial and institutional settings such as hotels and hostels were investigated; secondly the suppliers of plumbing fittings were studied; thirdly the architectural profession was surveyed; and finally the knowledge and attitude of 1428 home owners in 10 towns and cities in South Africa were tested. The findings indicate that in commercial and institutional settings, there is clear evidence that water efficient devices are becoming more common. The plumbing industry demonstrates an increasing market share of water efficient devices and this is apparent on the showroom floors of the major plumbing suppliers. This is almost in spite of the suppliers, who as a rule do not push water efficiency (as one said, it is not their job to preach to their customers, who buy mainly on functionality, style and cost). Of the 1 428 homeowners surveyed, 29% indicated that they had at least one water efficient device in the home. Typically only about 20% of the respondents in the average town believed they might possibly use too much water, but significantly more, 40% to 50%, have considered reducing their water consumption.

Report No: TT358/08
ISBN: 978 1 77005 730 2
Overseas price: \$35-00 excl postage

The view from below: Citizen Voice and regulation in water services to the poor.

D Hemson, R Shirley & C Munthre

Regulation in a democratic society cannot work independently of participation by citizens. Public agencies acting as regulators have to have the views of citizens to hand as it is their interests which are being protected. As the regulatory strategy in South Africa acknowledges, without this knowledge, regulation will have a limited impact. Internationally there is increasing interest in engaging poor communities and capturing citizen voice in scorecards as a step towards improving accountability between citizen and provider. Such participation should assist developing the regulatory framework in South Africa as communities understand the operation and standards of water services, voice their needs, and, as necessary, seek redress. The expression of voice is an integral aspect of a developed reflexive delivery system in which community voice operates as an important prod to municipalities acting as Water Service Authorities to respond to expressed need. Although greater attention to citizen voice is advocated, the challenge remains as to what method can be adopted to involve poor communities on the widest basis actively in people's regulation of water services?

The project has succeeded in providing a set of tools for community appraisal and engagement with the evolving regulatory system. New tools appropriate to the situation have been developed and existing community tools reshaped. These tools and community materials on water services are supported by an established training programme and strategy for spreading their use and techniques. The methods and materials have been developed in deprived and remote communities with the greatest challenges in water services and the tools have been shown to add data and value to community advocacy for better services.

Report No: TT359/08

ISBN: 978 1 77005 733 3

Overseas price: \$25-00 excl postage

Guidelines for the implementation of sanitation and hygiene education programmes in informal settlements.

N. Naidoo and C. Chidley

The need for this research study was largely informed by the outcomes of the Naidoo et al (2007) research study, 'The Effectiveness of Sanitation Education and Awareness Programmes in Informal Areas'. Rapid urbanisation in South Africa has resulted in the mushrooming of numerous informal settlements, however the provision of services especially sanitation services has not kept pace. According to the National Sanitation Task Team most water and sanitation projects carried out by local authorities have lacked significantly in the aspect of health and hygiene awareness. National and international experience has shown that the most successful sanitation initiatives have been those in which emphasis was placed on generating a high level of health and hygiene awareness rather than producing a large number of latrines. In addition, hygiene education programmes lay the foundation for an integrated approach to the provision of a wider set of environmental services. The benefits of effective and sustainable hygiene education programmes in informal settlements are numerous and include reduced infant mortality from diarrhoea, reduced environmental pollution, reduced health care costs, improved conditions of living, reduced operations and maintenance etc. Hygiene education programmes are among the most cost effective ways of lowering health costs especially in high density settlements where residents are at greater risks to poor sanitation related diseases. The study has determined that

hygiene education programmes should be seen as an integral component of the functions provided by the Water Service Authority (WSA). As such, hygiene education can no longer be linked to only new sanitation infrastructure programmes. Instead, hygiene education should be a continuous function, like operations and maintenance, which is an ongoing function of local government. This approach will ensure that the message of good hygiene practice is continuously re-enforced and the approach is supported by existing policy and legislation.

Report No: TT365/08

ISBN: 978 1 77005 765 4

Overseas price: \$15-00 excl postage

Membrane-related Water Research Impact Assessment

Frost & Sullivan

This study was commissioned as one of the impact studies contemplated to showcase research funded by the WRC in specific water research areas. The WRC has been instrumental in building the membrane industry in South Africa. The WRC has already funded a few projects on membrane research since its inception in 1971. However, most projects were funded after the establishment of a dedicated membrane programme in the early 90's. 66 membrane projects were funded since 1993. Research on membranes have resulted in significant economic, social, environmental and health benefits. The projects in this category have further helped to develop guidelines for best practices and are expected to be important within the water industry in South Africa for some time to come. Projects in this category have often led to the commercialisation of new products. They have further resulted in guidelines that have significantly impacted membrane project operational improvement, helped to decrease fouling and created methods to extend the life of membranes. Therefore, membrane research funded by the WRC was selected as a theme to perform an impact assessment on as showcase of the research funded by WRC and its impact on the South African and international society.

Report No: TT366/08

ISBN: 978 1 77005 766 1

Overseas price: \$20-00 excl postage

Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 – 5: Impact Assessment

Cornelis van der Waal

The release of the 2006 Sludge Guideline series aims to rectify previous sludge guideline shortcomings and provide an easy to use management tool for the handling of wastewater sludge. The aim of this project was to quantify the potential impact of the 2006 Sludge Guidelines on South African society by analysing current examples of wastewater sludge best practice that are aligned with the 2006 Sludge Guidelines.

Numerous examples of wastewater sludge handling best practice were reviewed. A variety of organisations benefit economically from the re-use of wastewater sludge and distinct social impacts that stem from these economic benefits were also identified. Environmental impacts have resulted largely from unsustainable sludge handling and mismanagement practices.

The examples identified during the completion of this project clearly reflect that wastewater sludge management practices that are aligned with the 2006 Sludge Guidelines are having a significant impact across economic, social and environmental areas of South African society.

Report No: TT370/08
 ISBN: 978 1 77005 786 9
 Overseas price: \$20-00 excl postage

The impact of large consumer unit size on water and sanitation services in lower income urban areas in South Africa

Kim Lesley Walsh

The purpose of this research was to assess whether being a member of a large consumer unit, defined as more than eight people sharing a stand, results in inhibited access to water and sanitation services, and whether large consumer units find water and sanitation services to be unaffordable. This research suggests that large consumer units cannot be viewed simply as a homogenous group. Different types of consumer units, and different households making up those consumer units, face different challenges with respect to water and sanitation. Nuanced policy approaches will be necessary to help to alleviate these differing challenges. Such policy approaches might include considering programmes to upgrade backyard accommodation, and meter such accommodation separately; increases in the amount of Free Basic Water allocated to large consumer units; revisions to the rising block tariff structures, or consideration of alternative tariff approaches; and education programmes around the wise use of water. Indigent policies should also be reviewed to take large consumer unit size into consideration.

Report No: TT371/08
 ISBN: 978 1 77005 788 3
 Overseas price: \$20-00 excl postage

Development of a knowledge management system for operation of the algal integrated ponding system (AIPS)-A training and operations tool for small wastewater treatment plants.

KJ Whittington-Jones, PD Rose, W Leukes, G Lok, Si Naidoo and D Lok

TSI had been approached by the Environmental Biotechnology Research Unit (Rhodes University) in 2001, with respect to providing a solution to the loss of valuable tacit knowledge at Sewage Processing Plants around the country due to high staff turnover. A knowledge management technique, developed by Gerrit Lok, was proposed as a possible solution and a demonstration site was recommended by the Water Research Commission and Rhodes University to evaluate the applicability of this tool. The Integrated Algal Ponding System (IAPS) project, co-ordinated by the University at the Grahamstown Sewage Works was used for the demonstration of this tool. As part of its contribution towards the country's RDP, in terms of provision of low-cost sanitation for low-income consumers, the Water Research Commission (WRC) had embarked upon the IAPS project in Grahamstown. IAPS had been designed as both a demonstration plant and a research facility with the objective of promoting acceptance and advancing knowledge in the operation of low-cost photosynthetic water treatment systems.

The primary objective of this initiative was to capture the expertise, skills and knowledge developed by an individual or a team of individuals, who have performed demanding tasks at the IAPS. A secondary objective was to develop the decision support system to allow for the simulation of fault conditions with appropriate remedial actions and reference to background support material. One of the main requirements of the diagnostic

system was that it should not be another so-called "expert system" but would be a "non-robotic" system. In other words, when used for problem solving, it would actually enhance the learning of the user. A "hands-on" approach was used in this study to develop a totally comprehensive tool for the layman-operator.

A Decision Support System was developed on an MS Access database using web page support for the decision tree and reasoning path. The final product was presented in the form of a CD to the client with installation and operational instructions.

Report No: TT372/08
 ISBN: 978 1 77005 791 3
 Overseas price: \$20-00 excl postage

Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan water supply systems in South Africa, and guidelines for the practical management thereof.

G Mackintosh and U Jack

This project identified the minimum requirements for effective and sustainable drinking-water service delivery within non-metropolitan water distribution networks to ensure acceptable drinking-water quality. Interviews with municipalities followed by site visits provided insight into current treatment plant and distribution network operation and maintenance procedures and the key factors that result in water quality failures in non-metropolitan networks. A web-enabled risk assessment tool was developed, as were practical guidelines aimed at different levels and/or users of the water service team, supported by two web-enabled tools available via the electronic Water Quality Management System (eWQMS). The management guides provide assistance in understanding planning, legislation, drinking water quality issues, staff training and reporting. The process controller's guide has been developed to assist operations and maintenance personnel in the operation and maintenance of drinking-water treatment plants and identifies issues that need urgent attention. The distribution system personnel guide assists operations and maintenance personnel in understanding and rectifying typical failures experienced in drinking-water distribution systems.

Report No: TT373/08
 ISBN: 978 1 77005 736 4
 Overseas price: \$30-00 excl postage

Technical and social acceptance evaluation of microfiltration and ultrafiltration membrane systems for potable water supply to rural communities.

CD Swartz, MJ Philips, J Setlolela, B R Delcarme, JD Seconna

Conventional small rural plants have been shown to lack sustainability due to high technical abilities required to operate these plants successfully. As membranes are known to produce high quality water, require less operator attention and may be automated much easier, this project aimed at evaluating membrane technologies for treatment of surface waters, including the determination of social acceptance factors for transferring the new technologies to the community. Both bench and pilot plant trials were run and two communities studied regarding social acceptance of membrane technology. It was found that membrane technology will be eminently suitable in treating surface waters to potable standards with minimal

operator input. The social studies showed that community perceptions and preferences need to be taken into account before sighting of the plant. The project provided extensive insights into rural water supply with membrane based plants and the guideline will have a significant and positive impact on doing this correctly in order to ensure the sustainable supply of safe drinking water to rural communities.

Report No: TT374/08
ISBN: 978 1 77005 781 4
Overseas price: \$30-00 excl postage

Guideline for the inspection of wastewater treatment works.

Lee Ann Boyd and AM Mbelu

The Department of Water Affairs and Forestry (DWAF) monitors Waste Water Treatment Works (WWTW) as mandated through the National Water Act, 1998 (Act 36 of 1998). This is done through regular inspections of the WWTW. For an inspector to undertake inspections thoroughly and give proper guidance on any problems encountered, it is important that he/she fully understands the complex nature of the various unit processes involved in the treatment of wastewater. Equally, Process Controllers must have insight with regards to the aspects that are monitored during the inspection. This Field Guide provides Inspectors and Process Controllers with a tool to conduct inspections on a WWTW. It provides guidance on how to identify possible problem areas and makes recommendations on how to solve common problems. The guideline and electronic checklists will assist the Inspector undertaking the inspection providing guidance where a problem is identified as well as assist Process Controllers to prepare for an inspection at their WWTW and take corrective action where problems are identified.

Report No: TT375/08
ISBN: 978 1 77005 795 1
Overseas price: \$40-00 excl postage

Community-based governance of freshwater resources in Southern Africa.

S Pollard, T Cousins

One result of the process of democratisation is legal pluralism in areas of communal tenure, in that the traditional locally-derived rules and norms for natural resource management run in parallel to statutory systems. In addition, South Africa is about to implement reforms in the statutory systems aimed at brining about equity and sustainability. Within this complex social system, this project aimed to examine governance options for community based natural resource management in communal areas.

This project contributed to the growing discourse on legal pluralism in water management through examining local or customary, laws in practice, focusing on water resource management. The research reviewed the status of community governance of water resources in four SADC countries (South Africa, Mozambique, Zimbabwe and Zambia), and documented the complementarities and tensions between statutory and customary systems in these countries. One lesson from these countries is that where the implementation of national legislation is weak, people revert to the traditional governance structures.

The reality is that legal pluralism will be part of the South African Water governance landscape for some time to come, and

internationally based research has warned that the 'neglect of customary laws may cause IWRM implementation to fail, or will have negative consequences for individuals and groups who were better served by customary-based systems – especially the poor'. The report concludes that we should not be constrained by a few idealized models of centrally managed water. Preferably let us seek innovative ways to integrate, or embed, common-property regimes with the formal, statutory system.

Report No: TT328/08
ISBN: 978 1 77005 674 9
Overseas price: \$20-00 excl postage

Standard methods for the recovery and enumeration of Helminth Ova in wastewater, sludge, compost and urine-diversion waste in South Africa.

Priya Moodley, Colleen Archer, David Hawksworth and Lizette Leibach

These Guidelines detail a new classification system according to the microbiological class, stability class and pollutant class and total viable Helminth Ova have been added in the microbiology class. The Guidelines do not specify the analytical methods and as a result, different laboratories adopted different methods in South Africa. This project aims to validate a new EPA method for measuring Helminth Ova in wastewater and wastewater sludge. The method and related literature with sufficient visual material will be documented and used to build capacity in South African water and wastewater laboratories to measure all Helminth Ova in wastewater sludge and wastewater samples.

Report No: TT 322/08
ISBN: 978 1 77005 648 0
Overseas price: \$25-00 excl postage

Condensed laboratory methods for monitoring phytoplankton, including cyanobacteria, in South African freshwaters.

Swanepoel A; du Preez HH; Schoeman C; J van Vuuren S; Sundram A

The project will compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins, Geosmin and MIB for South African freshwaters. Current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis, as well as for Geosmin and MIB analysis will be synthesized and a summarized reference document compiled.

Report No: TT 323/07
ISBN: 978 1 77005 684 8
Overseas price: \$25-00 excl postage

Aqualite Water Balance Software – User Guide

Roland Scott McKenzie

The methodologies used in AquaLite draw strongly on recent recommendations of Task Forces of the International Water Association (IWA). It should be noted that the methodologies for quantifying water losses contained in the AquaLite model are not the only methods used worldwide. They are, however, well accepted and used extensively in many parts of the world and are rapidly being recognised as the most appropriate and pragmatic techniques for assessing the water balance components for potable water distribution systems. AquaLite

also includes the calculation of the Unavoidable Annual Real Losses (UARL) as well as the use of the Infrastructure Leakage Index (ILI) as a key performance indicator. These two parameters are currently the subject of considerable attention and debate throughout the world and are being used in many countries. When used properly they can provide very useful information on the performance of a water distribution system but must be used with care to ensure that the results are meaningful since there are situations where the estimates can be misleading.

Report No: TT 315/07
ISBN: 978 1 77005 599 5
Overseas price: \$10-00 excl postage

Water Services and HIV / AIDS; Integrating health and hygiene education in the water and sanitation sector in the context of HIV/AIDS

(PLEASE DOWNLOAD FROM WEB: www.wrc.org.za)
Clacherty A; Potter A

This Water Research Commission study (Project K5/1634) arose from a growing realisation that, in relation to water and sanitation infrastructure development projects, there is little consistency or coherence of approach to health and hygiene education (H&HE). As a result, many interventions are ineffectual. Further, the linkages between HIV/AIDS and the improvement of water and sanitation facilities and related H&HE are poorly addressed in this country. The response involved considerable research over a period of time. It has identified factors which constrain and enable effective implementation of project-based H&HE in the context of HIV/AIDS. Based on that research and understandings of the context, it has developed and tested various institutional and financial arrangements and developed implementation models based on this work. The study places considerable emphasis on the linkages between water and sanitation, health and hygiene education and HIV/AIDS. The impact of HIV/AIDS on the lives of many South Africans is severe; it is imperative that the water services sector formulates and implements an appropriate response as a matter of urgency. It is critical that issues around HIV/AIDS are mainstreamed, both in terms of prevention as well as in reducing the impact on people living with AIDS. Caregivers, in particular, require not only knowledge of water and sanitation and related health and hygiene issues, but also access to adequate quantities of water of good quality.

Report No: TT 316/07
ISBN: 978 1 77005 602 2
Overseas price: \$20-00 excl postage

Report No: TT 317/07
ISBN: 978 1 77005 603 9
Overseas price: \$20-00 excl postage

The assessment of training programmes and capacity needs for the water sector: Executive summary

Mjoli N; Schoeman G

The South African Government has committed itself to an ambitious target of eliminating the water and sanitation services backlog by 2008 and 2010, respectively. However, the current skills shortage at the local government level poses a threat to the achievement of the water and sanitation delivery targets. The slow rate of delivery is largely due to inadequate technical skills in most municipalities. The problem is particularly acute within

rural municipalities which have the lowest resource base and, at the same time, have the highest sanitation backlog figures.

The shortage of skills is not limited to the water services sector; the water resources management sector faces a similar problem. There is a growing concern among sector stakeholders that the current approaches to skills development are not producing the numbers of skilled people that are needed to improve the performance of municipalities. This situation calls for a review of the current practices in skills development and training provided by public and private providers in order to identify factors that are hampering accelerated skills development, despite the availability of large budgets from the skills development fund.

Report No: TT 306/07
ISBN: 978 1 77005 554 4
Overseas price: \$10-00 excl postage

Standardisation of the use of particle counting for potable water treatment in SA

Ceronio AD; Haarhoff J; Pryor M

Turbidity is a gross measure of the quality of potable water. Particle counting and size analysis is fundamental to a deeper understanding of flocculation, settling and filtration processes. The primary objective of water treatment is the removal of particles. This project investigated the use of particle size analysis as a control parameter for the optimisation of water quality, and compared this to the control using zeta potential and streaming current. It studied the effects of pretreatment processes such as ozonation and coagulation on the clarity of the filtered water by measuring particle size; and considered the use of particle size analysis together with CFD for the optimisation of water treatment equipment. The report stresses the importance of standardisation of this technology and also includes a substantial amount of fundamental principles and practices useful to potential users considering the implementation of this technology.

Report No: TT 166/01
ISBN: 1 86845 801 6
Overseas price: \$20-00 excl postage

An illustrated guide to basic water purification operations.

Bouwer JL; Haylett

Lack of skills because of lack of training was identified as one of the most important hindrances to the supply of good quality potable water, especially in rural areas. Suitable training material is not available and current training material is inadequately targeted for rural operator training. A cartoon based operator manual for sewage plant operator training had previously been completed and proved to be a big success. Therefore, it was seen as appropriate to complete a similar guide for operator training on, especially, small to medium sized water treatment plants

Report No: TT 247/05
ISBN: 1 77005 323 9
Overseas price: \$30-00 excl postage

Corporatisation of municipal services providers

Development group; University of Western Cape

The restructuring of municipal water departments into stand-alone companies has been a long-standing subject of debate within the industry. This study aimed to further explore the

concepts of corporatisation and its relevance to the South African water sector by, combining an international literature review with local case studies and policy reviews. The research concludes that corporatisation in itself does not guarantee performance. Whilst a shift in legal form from a municipal department to a stand-alone legal entity can make a difference, this is not the only or major determinant of performance. Various objective factors and broader governance factors are likely to have a greater impact than simply the legal form of the utility. Further corporatisation may be a suitable option for some municipalities. For capacity reasons corporatisation is only likely to be feasible within the large metro poles at this stage. As the experience base grows within South Africa, and transaction costs diminish, corporatisation may become feasible for smaller local authorities. This study highlights that before embarking on a corporatisation process municipalities should assess whether they have sufficient financial, managerial and political capacity to see the process through.

Report No: TT 199/02

ISBN: 1 86845 897 0

Overseas price: \$25-00 excl postage

Management of water-related microbial diseases.

DWAF; WRC

The purpose of this guideline series is to provide awareness building and management information on the nature and prevention of important water-related microbial diseases. The purpose of volume one in the series, "Disease characteristics", is to introduce and describe the basic facts of some important water-related diseases. This guide is primarily an awareness building guide to educate the upcoming generation in the need for: (1) disinfected drinking water, (2) safe waste disposal, (3) good personal and kitchen hygiene, and (4) protection of water resources from faecal pollution.

Report No: TT 175/03

ISBN: 1 86845 849 0

Overseas price: \$25-00 excl postage

1. Guidelines for the appropriate management of urban runoff in SA

Ashton PJ; Bhagwan JN

As the aim of this study was to establish general guidelines for the management of urban runoff water quality, especially focusing on dense settlements, urban runoff quality is a country-wide problem, the causes of which must be addressed. Past attempts to intercept urban storm water and channel it through a single storm water system to receiving water have failed. As storm water quality may be worse than treated sewage effluent and sometimes even raw sewage, treatment of storm water at some stage before discharge to the receiving waters has to be considered. Present engineering storm water management options do not cater for improving storm water quality. The impact of low-cost, high-density urban land use on the catchment warrants serious attention. Appropriate sanitation and waste disposal for peri-urban areas requires fundamentally new approaches. It is imperative therefore that applied research into these areas be conducted for the protection of South Africa's limited water resources.

Report No: TT 155/01

ISBN: 1 86845 764 8

Overseas price: \$15-00 excl postage

2. Expert system for design of storm water management systems for urban runoff quality

Coleman TJ

Report No: TT 156/01

ISBN: 1 86845 768 0

Overseas price: \$15-00 excl postage

PRESMAC: Development of a pragmatic approach to evaluate the potential savings from pressure management in potable water distribution systems in South Africa. (Presmac User Guide Version 1.1)

McKenzie R; Lambert A

This document incorporates the user guide to the South African Pressure Management and Control (PRESMAC) model which has been developed through the Water Research Commission (WRC) funded project titled "The Water Leakage: Pressure Management Model".

The PRESMAC model represents one of several models that are being developed through the WRC in order to assist water suppliers to manage and reduce their levels of unaccounted-for water. The models are supplied free-of-charge through the WRC for use within South Africa and further details can be obtained from the WRC web site on: <http://www.wrc.org.za>.

Report No: TT 152/01

ISBN: 1 86845 722 2

Overseas price: \$20-00 excl postage

Financial planning for infrastructure services at district level: A user guide to the district services model. Version 1.1

Palmer Development Group

This manual outlines the philosophy behind the model, its aims, limitations and key assumptions. The structure and operation of the model is described in detail, covering the required data inputs and the meaning and presentation of the various outputs.

The District Services Model (DSM) has been designed to assist district municipalities to undertake financial analysis of infrastructure investment plans. The model performs this analysis at two levels:

- Level 1: District-wide infrastructure planning, and
- Level 2: Medium-term Council budgeting.

Report No: TT 143/01

ISBN: 1 86845 680 3

Overseas price: \$15-00 excl postage

A guide to non-point source assessment to support water quality management quality of surface water resources in SA

Pegram GC; Gorgens AHM

The primary focus of this guide is to support water quality management of surface water resources, and particularly non-point sources management, through the provision of appropriate and cost-effective information for decision-making.

Report No: TT 142/01

ISBN: 1 86845 677 3

Overseas price: \$20-00 excl postage

The Development of Effective Community Water Supply Systems using deep and Shallow Well Hand pumps.

Hazelton DG

Deep- and shallow-well hand pumps are used extensively for rural community water supplies over large parts of South Africa. Very often, however, these installations fail to meet the requirements even though they are considered to be one of the simplest community water supply technologies.

It has, however, been demonstrated in other parts of the world that high failure rates are not inevitable and that these schemes can be transformed into reliable low-cost solutions through the adoption of the so-called village level operation and maintenance (VLOM)-concept, where appropriate design technologies and implementation policies are systematically included. The study indicated that 10% of the South African populations (2 million people) are dependent on the estimated 10 000 hand pumps which exist in this country. This can be equated to an investment of about R400 million, and the study estimates that between 40% and 50% of the hand pumps are not working at any one time.

Report No: TT 132/00
ISBN: 1 86845 629 3
Overseas price: \$25-00 excl postage

Applicability of waste minimisation clubs in South Africa: Results from pilot studies.

Barclay S; Buckley C

Industrial small-, medium- and micro-enterprises (ISMMs) are a strategic growth sector in the RSA but cumulatively are significant sources of pollutants which detrimentally affect sewage treatment. The overall objective of the project was the development of regional waste minimization clubs, in which cleaner production practices can be cost-effectively established as a contribution to the sustainability in South Africa of ISMMs that are both competitive and environmentally responsible.

Report No: TT 161/05
ISBN: 1 86845 831 8
Overseas price: \$30-00 excl postage

Guidelines for the utilisation and disposal of wastewater sludge: Volume 1 of 5: Selection of management options.

Snyman HG; Herselman JE; Kasselmann G; Steyn CE; Wilken JW

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 261/05
ISBN: 1 77005 422 7
Overseas price: \$20-00 excl postage

Guidelines for the utilisation and disposal of wastewater sludge: Volume 2 of 5: Requirements for the agricultural use of wastewater sludge

Snyman HG; Herselman JE; Kasselmann G; Steyn CE; Wilken JW

Report No: TT 262/05
ISBN: 1 77005 423 5
Overseas price: \$20-00 excl postage

Water purification works design: (SA Price R150-00)

Van Duuren FA

This project was aimed at facilitating the optimal, most economical water purification and treatment works by providing a design guide based on water quality considerations, processes and operations. This guide indicates water quality requirements, control and management of procedures, and water demands in all sectors. It also categorises water purification and treatment processes and operations

Report No: TT 92/97
ISBN: 1 86845 345 6
Overseas price: \$50-00 excl postage

Information transfer extraction management systems (ITEMS)

(SA Price R114-00)

Howard MR; Perkins M

This project developed a computerised Information Transfer, Extraction and Management System (ITEMS) which enables users to gain access to local and international information on mine-water quality, management, treatment and research. The six modules incorporated in ITEMS, viz. literature, water quality guidelines, contaminant properties, research results, an impact assessment manual and a mine-water management manual, and the options available in each of the modules, renders ITEMS an extremely versatile information tool. The total computer file size of the databases is 87 Mbytes. ITEMS is available on CD-ROM

Report No: TT 94/98
ISBN: 1 86845 378 2
Overseas price: \$70-00 excl postage

Solids-free sewer systems in South Africa: a community leader's guide

Du Pisani JE

This study evaluated the STED systems in South Africa. It showed that STED systems were used on over 16 000 erven in South Africa. The study showed that problems experienced with these systems were mainly due to poor operation and maintenance and some incidents of blockages were due to incorrect design and construction of the STED systems. The study concludes that with proper design, operation and maintenance, STED systems offer a cheaper alternative of meeting the sanitation needs of. The output of this research includes two guidelines, namely Operation and Maintenance of Solids-free Sewer Systems in South Africa: Guidelines for Engineers; and Solids-free Sewer Systems in South Africa: A Community Leader's Guide

Report No: TT 96/98
ISBN: 1 86845 401 0
Overseas price: \$20-00 excl postage

Handbook to guide communities in the choice of sanitation systems

Bernhardt Dunstan & Associates

The main aim of this study was to evaluate on-site sanitation systems from a socio-economic perspective with special reference to affordability, appropriateness and social acceptability. The study was undertaken in three case study areas, namely, Soshanguve TT, Ivory Park and Ga-Mmota. The study concluded that in all three case study areas, communities were dissatisfied with their on-site sanitation systems. Women

were unhappy about being excluded from decision-making on the selection of sanitation technologies, because as the main users, they are better qualified to select a sanitation system that could be operated and maintained by the users.

Report No: TT 104/98
ISBN: 1 86845 425 8
Overseas price : \$10-00 excl postage

Guidelines for the design and operation of sewage sludge drying beds

Ceronio AD; Van Vuuren LRJ; Warner APC

Current information and guidelines for the design and operation of sewage sludge drying beds in the RSA are very limited. The design data available are largely empirical and give almost no insight into the effect of climate, sludge concentration, loading rates, sludge volume index, filter media, etc. on the drying bed area required. Based on the research and support of experimental work done, as well as information obtained from literature, the study produced a guideline that is specific for South African conditions called Guidelines for the Design and Operation of Sewage Sludge Drying Beds (WRC Report No TT 107/99)

Report No: TT 107/99
ISBN: 1 86845 491 6
Overseas price : \$25-00 excl postage

Guidelines for the calibration of measuring flumes in sewers

Rooseboom A; Goodey GM

During 1992 a detailed investigation revealed that the majority of open channel flumes on South African sewer mains and at municipal wastewater treatment plants, do not comply with the generally accepted British Standards 3680. In this project tests were performed on different flumes in order to establish the impact of differences in shape and surface roughness on calibration coefficients. These guidelines are the product of a large number of practical tests, combined with existing standards for the measuring of fluids by flumes. The result is a set of methodologies and worked examples, which clarifies and simplifies measuring flume design to the point where plant personnel in the smaller plants will also be able to follow and utilise the guidelines to the full.

Report No: TT 111/99
ISBN: 1 86845 501 7
Overseas price: \$25-00 excl postage

Corrosion brochure for local authorities

Ramotlholo JS; Ringas C

The brochure highlights cost-effective ways in which external corrosion can be minimised. The brochure can also be useful to repair teams working in the field. The brochure contains colour photographs showing the different forms of corrosion in order to assist field teams to correctly identify the cause of the failure. Appropriate repairs can then be carried out. The brochure also describes how each local authority can build up its own database, thereby assisting in the long-term strategy of each local authority by ensuring that correct corrosion prevention strategies are used.

Report No: TT 112/99
ISBN: 1 86845 510 6
Overseas price: \$15-00 excl postage

DOMESTIC WATER SUPPLY: GUIDES

The provision of an adequate and safe water supply to all people is one of the goals of the South African Government. To ensure the safety of water supplies, a need for a user-friendly Guide to facilitate evaluation of the health-related quality of water supplies was identified as a priority by both the Departments of Health and Water Affairs and Forestry. This resulted in the production of a series of guides.

This Guide forms part of a series which is intended to provide water supply agencies, water resource managers, workers in health-related fields, as well as communities throughout South Africa, with the information they need to sample, analyse, assess and interpret the quality of domestic water supplies.

The following are documents from the series:

Quality of domestic water supplies – Volume I: Assessment Guide TT 101/98

Report No: TT 101/98
ISBN: 1 86845 416 9
Overseas price: \$25-00 excl postage

Quality of domestic water supplies – Volume II: Sampling Guide1 TT 117/99

Report No: TT 117/99
ISBN: 1 86845 543 2
Overseas price: \$15-00 excl postage

Quality of domestic water supplies – Volume III: Analysis Guide1 TT 129/00

Report No: TT 129/99
ISBN: 1 86845 620 X
Overseas price: \$20-00 excl postage

Quality of domestic water supplies- Volume 4: Treatment guide TT 181/02

Report No: TT 181/99
ISBN: 1 86845 873 3
Overseas price: \$30-00 excl postage

Quality of domestic water supplies – Volume 5: Management Guide TT 162/01

Report No: TT 162/99
ISBN: 1 86845 809 1
Overseas price: \$30-00 excl postage

The management of urban impoundments in South Africa Volume 2: Guideline manual

Freeman MJ; Howard MR; Wiechers HNS

This Urban Impoundment Management Guideline Manual is the product of a research project carried out for the Water Research Commission to investigate the water- quality problems most commonly experienced in South African urban impoundments, as well as the management techniques which can be used to address them.

The purpose of the Guideline Manual is to assist those responsible for, or with an interest in, the management of the water quality of urban impoundments. It is thus aimed predominantly at those persons in local authorities who must manage the water bodies in their areas.

Report No: TT 119/00
ISBN: 1 86845 553 X
Overseas price: \$25-00 excl postage

The economic cost effects of salinity – integrated report
Urban-Econ Development Economists

As the salt content of water increases, the water becomes less suitable for most users, and additional costs are incurred. The study was undertaken because of uncertainties about some of the methodology and assumptions that were used in the desk study and the need for a versatile economic model that can be used to quantify the effect of salinity in monetary terms and to compare the cost-benefit ratios of alternative options. A generic methodology to determine the financial, economic and social impacts associated with an increase in salt concentration were first developed, and then applied by conducting a survey to determine the impacts of increased salt concentrations in the middle Vaal River.

Report No: TT 123/00
ISBN: 1 86845 590 4
Overseas price: \$20-00 excl postage

Defluoridation, denitrification and desalination of water using ion – exchange and reverse osmosis
Schoeman JJ; Steyn A

This project concentrated on demonstrating the feasibility of using advanced adsorption, ion-exchange and membrane technologies to remove fluorides, nitrates and dissolved suspended solids from groundwater in order to produce potable water for rural communities which are remote from first-world infrastructure. Activated alumina, ion-exchange and reverse-osmosis systems were evaluated at a number of rural sites in terms of both technical and social acceptance factors. The results achieved in these demonstration studies show that activated alumina and ion-exchange processes and advanced water treatment processes such as membrane filtration can be employed successfully for the purification of adverse-quality groundwater to potable standards in the rural areas.

Report No: TT 124/00
ISBN: 1 86845 597 1
Overseas price: \$20-00 excl postage

Land-based effluent disposal and use: Development guidelines and expert systems-based decision support
Murphy K O'H

Effluents and soils were identified as factors which help in the process of making decisions on the applicability of a specific effluent on a specific land. The identification of the effluent takes into account health-related aspects, the risk of pollution to the water source and the effects of it on plants. The identification of the soil relates to the ability of soils to attenuate the contaminants in the effluents.

The user guide takes one through the process in order to be able to determine whether the combination is acceptable or not and whether it conforms to health guidelines. If this is acceptable, it is indicative of restrictions or protective measures. ELADS Effluents to land - application decision-support software is the expert systems-based decision-support software developed. It could be used not only for sewage effluents, but also for organic effluents, to some extent for nitrogenous effluents and effluents containing potentially toxic trace elements. It could be modified to accommodate any site, soil or effluent-related limits specified by new regulations. (WRC Report No TT 125/00).

Report No: TT 125/00
ISBN: 1 86845 551 3
Overseas price: \$20-00 excl postage

The level of communication between communities and engineers in the provision of engineering services
Pybus P; Schoeman G; Hart T

The purpose of this research was to test the hypothesis above and to establish how engineering information, for example, concerning the level of service, can best be given so that the community leaders can make a decision based on sound knowledge of the technicalities of the situation. In an analysis of the major factors that negatively affect communication between consultants (specifically engineering) and communities, it was found that the majority of factors stemmed from a lack of integrated and comprehensive project planning. The findings from this study are supported by an excellent set of guidelines, aimed at improving communication processes between practitioners and communities in water and sanitation development projects

Report No: TT 133/00
ISBN: 1 86845 630 7
Overseas price: \$20-00 excl postage

Waste minimisation guide for the textile industry: A step towards cleaner production: Vol I
Barclay S; Buckley C

The Waste Minimisation Guide for the Textile Industry has been found to be a useful tool for assisting the RSA textile industry to improve its environmental performance in the following areas of application:

- The textile industry can use the Guide to self-assess and improve its implementation of waste minimisation practices and, hence, its aquatic environmental performance
- Similarly, use of the Guide will assist factories in achieving compliance with environmental management standards e.g. ISO 14000, and, thereby, improving their international competitiveness
- Local regulatory authorities can use the Guide both as a training tool and as a management tool for monitoring and assessing the performance of textile manufacturers in their area of jurisdiction.

Report No: TT 139/00
ISBN: 1 86845 659 5
Overseas price: \$20-00 excl postage

Waste minimisation guide for the textile industry: A step towards cleaner production. Vol II

Report No: TT 140/00
ISBN: 1 86845 659 5
Overseas price: \$20-00 excl postage

Human resources planning and management system (HRPMS) user manual

Stewart Scott

The study has developed a management tool to help managers to implement integrated human-resource planning of water service institutions. The report focuses on the human resources that are required in order to support the infrastructure, as well as the organisational structure requirements of various sizes of water service institutions. The computerised human resources planning and management system (HRPMS), which was developed for water service institutions through this study, includes facets of both a management information system (MIS) as well as a decision support system (DSS). The management component of the HRPMS includes portions of the job analysis and employee profile modules. The reporting facilities provided by the HRPMS facilitate management, planning and decision-making.

Report No: TT 146/01
ISBN: 1 86845 686 2
Overseas price: \$15-00 excl postage

Assessment of the attended coupon-operated access-point cost recovery system for community water supply schemes

Lima Rural Development Foundation

The study highlights parameters in which attended coupon operated access point cost recovery system operates efficiently by analyzing seven existing schemes. The research to identify the operational constraints that community water supply schemes are currently facing by conducting sample surveys in the schemes.

Report No: TT 150/01
ISBN: 1 86845 716 8
Overseas Price: \$15-00 excl postage

Development of a simple and pragmatic approach to benchmark real losses in potable water distribution systems in South Africa: BENCHLEAK

Ronnie McKenzie & Allan Lambert

The BENCHLEAK software and this User Manual are part of the ongoing process of refining and improving the methodologies for calculating and presenting performance data associated with management of public water supply systems in South Africa.

Report No: TT 159/01
ISBN: 1 86845 773 7
Overseas Price: \$20-00 excl postage

The BENCHLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: <http://www.wrc.org.za>

Development of a Windows based package for assessing appropriate levels of active leakage control in potable water distribution systems: ECONOLEAK

Ronnie McKenzie

The ECONOLEAK model is aimed specifically at determining when a water supplier should invest in active leakage control for a specific zone metered area.

Report No: TT 169/02
ISBN: 1 86845 832 6
Overseas Price: \$20-00 excl postage

The ECONOLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: <http://www.wrc.org.za>

Guidelines for the implementation of benchmarking practices in the provision of water services in South Africa
Pybus P

The guidelines are intended to encourage the local authorities to benchmark their activities with their peers with a view to delivering water and sanitation services in a more effective and efficient manner.

Benchmarking offers a route to more effective and efficient service delivery.

Report No: TT 168/02
ISBN: 1 86845 842 3
Overseas price: \$20-00 excl postage

Environmentally responsible mining: Water management guidelines for small-scale mining

Clacherty A; Moodie P

This report identifies and characterises the critical water-related impacts of small-scale mining and is developing appropriate tools to assist their environmental management. The study focused primarily on the water-related issues of peat extraction, clay-mining for brick making, alluvial diamond-mining and other small-scale mining activities associated with gravels, alluvial sands and sediments.

Report No: TT 170/04
ISBN: 1 86845 833 4
Overseas price: \$20-00 excl postage

Guidelines for the application of natural stone trickling filters with some reference to synthetic media trickling filters

Wates, Meiring & Barnard (Pty) Ltd

Trickling filters are applied in many domestic and industrial wastewater treatment plants in Southern Africa. Trickling filtration technology is still evolving and this document provides current information on the design, operation and maintenance of filters.

Report No: TT 178/02
ISBN: 1 86845 852 0
Overseas price: \$15-00 excl postage

Water and wastewater management in the oil refining and re-refining industry: NATSURV 15

CSIR

In this study the water intake, water use and pollutant loads of the crude oil refinery, synthetic fuel refinery and refining sectors of the

industry were surveyed and characterised. Crude oil refineries in the RSA were found to have a relatively narrow range of specific water intake (SWI 0.51 to 0.67 m³/t) and re-refining SWIs were found to vary widely (0.06 to 7.2 m³/t), depending on the type of process used. The results obtained present a snapshot of the water and wastewater characteristics of the industry in which crude oil refining (at four refineries) is around 20 million t/a, syn-fuel refining (at two refineries) is around 9 million t/a and oil re-refining is around 120 000 t/a. In addition to the water and effluent survey data, the Guide produced contains a number of specific recommendations for reducing water use and effluent generation in the industry.

Report No: TT 180/05
ISBN: 1 86845 508 4
Overseas Price: \$15-00 excl postage

Elementary handbook of water disinfection Carlsson FHH

The salient features of the handbook covers:

- Description of water disinfection processes, principally chlorination and chloramination but including ozonation, peroxone, chlorine dioxide and ultraviolet treatments
- Written such that it is understandable by non-specialists in water treatment plants and informed lay-persons
- To be used as an aid in effective education and training of plant personnel while avoiding detailed chemistry
- To be used as a ready reference for daily use on water purification plants where disinfection is implemented.

Report No: TT 205/03
ISBN: 1 86845 983 7
Overseas price: \$20-00 excl postage

Watrex expert system for water treatment plant design: (South African price: R500-00) FR Sutherland

This is a Windows-based software package that applies expert system technologies to water treatment plant design. The software allows data acquisition, unit process design and modeling, process selection, and dynamically responding plant design, modeling and sensitivity analyses.

Report No: TT 206/03
ISBN: 1 77005 016 7
Overseas price: \$200-00
Postage inclusive

An assessment of the trickle feed system as a tool for implementing the free basic water policy Lenehan AM; Abelitis L

This study investigated the cost-recovery efficiency of the trickle feed system. In this system a known quantity of water is delivered each day to a storage tank at each customer's house. This allows the implementation of a monthly prepaid cost-recovery system with relatively low administration. There are potential benefits of implementing the trickle feed system in rural areas and it is currently implemented in pilot projects in Northern KwaZulu-Natal.

Report No: TT 210/03
ISBN: 1 77005 031 0
Overseas price: \$10-00 excl postage

The measurement and reduction of urban litter entering storm water drainage systems Marais M Armitage N

This project addresses the following aims:

- The improvement in the knowledge of the source type and amount of urban litter coming from different types of urban catchments; and
- Provision of scientific data on the efficacy of various management techniques in reducing the amount of urban litter reaching drainage systems. This information, together with the knowledge, would enable the development of Litter Management Plans (LMPs) resulting in reduced litter loadings and realizing considerable cost savings.

Report No: TT 211/03
ISBN: 1 77005 041 8
Overseas price: \$30-00 excl postage

A guidebook on household water supply for rural areas with saline groundwater Goldie I; Sanderson RD

This report captures and presents options of small-scale water purification technologies for potable water supply to farms, schools, clinics and small communities from brackish surface water sources. The report produced in the form of a guide will assist decision makers in the selection of these technologies. Both membrane-and distillation-based technologies have been assessed, mostly in terms of a desk study. Recently developed local innovations are also included into this guide.

Report No: TT 221/04
ISBN: 1 77005 107 4
Overseas price: \$30-00 excl postage

Feasibility of water fluoridation for South Africa Genthe B; Herold CE; Haarhoff J; Hosking S; Syke G

A team, consisting of five experts in their fields, was requested to perform a desk study to identify both the positive and negative consequences which could be expected to arise following the fluoridation of potable water supplies in South Africa.. Results from the study for the first time summarize and bring together a whole spectrum of aspects to take into consideration when potable water supplies are fluoridated. The results show that further actions, including further research, are required before fluoridation can be effected with full safety and confidence in a developing country such as South Africa.

Report No: TT 222/04
ISBN: 1 77005 108 2
Overseas price: \$25-00 excl postage

A summary of lessons and experiences from the Ethekwini pilot shallow sewer study Patti Eslick; John Harrison

Sanitation, because of the major impact it has on health and quality of life, is a service with a high priority. Findings from a previous WRC study indicated that shallow sewer systems provide a viable intermediate sanitation alternative, with a total cost between Ventilated Improved Pit latrines (VIPs) and conventional sewerage. With this as a stimulus, the Durban Metro Water

was the first local authority to indicate interest in taking the recommendations further. This study captures the lessons and experiences from the pilot implementation of the shallow sewers.

Report No: TT 225/04
ISBN: 1 77005 135 X
Overseas price: \$20-00 excl postage

An introduction to the concepts of customer relations management for water services institutions

Naidoo J; Mosdell T

The fact that the concept of customer service has received little attention in South Africa is perhaps related to the historic situation where water supply and sanitation services were provided on a monopolistic take it or leave it basis, particularly in the case of poorer customers. It is now recognized increasingly that successful water services provision is strongly associated with the application of good business principles. This implies a service orientation, with a primary focus on the customer. This report provides an overview of customer management, principles and methodology.

Report No: TT 227/04
ISBN: 1 77005 147 3
Overseas price: \$20-00 excl postage

Community identified performance indicators for measuring water services

Schoeman G; Magongoa

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 228/04
ISBN: 1 77005 158 9
Overseas Price: \$15-00 excl postage

Guidelines for economic regulation of water services in South Africa

Palmer Development Group

For the regulation of water services to become effective in South Africa, considerable work needs to be undertaken. In particular the methodology to be used in undertaking economic regulation is one of the key components. This report has investigated the subject of economic regulation and its relevance to South Africa and has defined the manner in which water services authorities should regulate water services providers, within the current legislative framework. It highlights the importance of the methodology for economic regulation and in particular regulating tariffs and associated financial parameters. This report is aimed to stimulate discussion on the subject matter, towards effective economic regulation.

Report No: TT 229/04
ISBN: 1 77005 164 3
Overseas price: \$20-00 excl postage

Guidelines on reduction of the impact of water infiltration into sewers.

Stephenson D; Barta B

The effects of urban developments on storm water quality and quantity as well as groundwater infiltration into the sewer facilities cannot be left anymore to ad hoc solutions and there is an urgency for a strategic approach to these problems. This report based on identifying and quantifying the problem of ingress, provides the necessary strategy and answers to these problems.

Report No: TT 239/05
ISBN: 1 77005 264 X
Overseas Price: \$20-00 excl postage

Benchmarking of leakage from water reticulation systems in South Africa

McKenzie RS; Seago C

In the attempt to get a better handle on the level of leakage at a municipal and national level, this study was undertaken in order to assess the levels of leakage in various water utilities throughout South Africa. The standard water auditing model BENCHLEAK, previously developed through a WRC study was used for the analyses since it is relatively simple to use and follows the standard IWA and BABE leakage benchmarking methodology. Benchleak introduces the concept of Infrastructure Leakage Index (ILI) as a standard method for the purpose of leakage evaluation, as it has been found to be the most reliable and meaningful indicator.

Report No: TT 244/05
ISBN: 1 77005 282 8
Overseas Price: \$25-00 excl postage

Water and waste-water management in the power generating industry (NATSURV 16)

Van Zyl HD; Premhlall K

The power-generating industry in the RSA is a substantial water user and effluent producer and impacts nationally both on water use allocations and the maintenance of resource water quality. The report provides the volumes and breakdown of water taken in and discharged by major and minor power generating plants, to determine pollutant loads and identify suitable wastewater management processes and strategies, and to a guideline document assisting both the industry and regulators in effective water and wastewater management of this sector.

Report No: TT 240/05
ISBN: 1 77005 270 4
Overseas Price: \$15-00 excl postage

Ecological sanitation – Literature review

Austin LM; Duncker LC; Marsebe; Phasha MC; Cloete TE

Urine-diversion sanitation systems have been successfully implemented in many countries; including South Africa where about 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. This report captures the state of knowledge on urine diversion toilets.

Report No: TT 246/05
ISBN: 1 77005 322 0
Overseas price: \$25-00 excl postage

Guidelines for ensuring sustainable effective disinfection in small water supply systems.

Momba MNB; Brouckaert BM

This is a follow-up to a previous project that evaluated a combined chlorine-monochloramine disinfection process for the inhibition of bacterial and bio film re growth in a laboratory-scale system. The emphasis is based on the maintenance of an effective residual disinfectant throughout the water system. This report provides strategies which will ensure sustainable effective disinfection in small municipal water distribution systems.

Report No: TT 249/05
ISBN: 1 77005 321 2
Overseas price: \$30-00 excl postage

Water poverty mapping: Development and introduction using a case study at the local municipal scale for the Eastern Cape.

Cullis J

This report demonstrates the feasibility of using water poverty mapping to define and study the nature of water poverty in South Africa as well as the basis for a clear decision tool for the allocation of scarce resources to development initiatives that will be most effective and as a way of measuring the impact of these initiatives.

Report No: TT 250/05
ISBN: 1 77005 337 9
Overseas price: \$20-00 excl postage

Handbook for Waterworks Operation

Christiaan Frederick Schutte (Editor)

There are a number of different books and instruction guides (mostly sourced from abroad and excessively priced in South African terms) available to assist with training of water treatment works operators, but a survey of these showed that none of the existing books is suitable to be used as a basis book for reference and for training. This report is an excellent reference book for training of water plant operators, as well as for the operation of water treatment works.

Report No: TT 265/06
ISBN: 1 77005 428 6
Overseas price: \$25-00 excl postage

The development of a successful unaccounted-for water management programme in the rural water supply context.

Ross-Jordan J

The challenge to develop simple and effective systems that are easily understood by water committees has resulted in this report which can be used by the community as well as their local authority to manage water losses in distribution systems.

Report No: TT 256/06
ISBN: 1 77005 392 1
Overseas price: \$20-00 excl postage

The use of key performance indicators in the benchmarking of rural water supply schemes: An aid to development of meaningful local government capacity.

Still D; Balfour F

New local authorities have limited knowledge on the nature of inspection needed to promote good management at community level. Therefore, the challenge was to develop simple and effective systems that are easily understood by water committees. These can be used to report to the community as well as to their local authority. This report provides a set of key performance indicators (KPIs) which have been tested on a number of RDP projects that are presently being transferred from Umgeni Water to relevant district councils in KwaZulu-Natal.

Report No: TT 255/06
ISBN: 1 77005 391 3
Overseas price: \$25-00 excl postage

The WRC community based health and hygiene model and implementation kit

Bolu O; Maliti N

This research seeks to support the acceleration of sanitation service delivery without improving developmental principles such as demonstration of ownership and community based participation. The study will investigate methods of improving communities so that they can earn an income which will enable them to make a partial contribution to the costs of building toilets. The study will be undertaken in selected villages in the Eastern Cape.

Report No: TT 264/06
ISBN: 1 77005 427 8
Overseas price: \$20-00 excl postage

A strategic framework for water-related human health research.

Venter SN; Mjoli NP

The report is a compilation of a framework and strategy plan to guide the future funding of priority research on the improvement of water related human health in Southern Africa. The plan had to include health related aspects of all human-water interactions. The plan further identifies research gaps for future, local, research on water related human health and a list of institutions and researchers active in health research, both nationally and internationally.

Report No: TT 257/06
ISBN: 1 77005 404 9
Overseas price: \$20-00 excl postage

1. Waste Minimisation Clubs in SA (Facilitator's Manual)

2. Waste Minimisation Clubs in SA (Training Manual)

Barclay S; Buckley C

Previous WRC Project No. 973 detailed the feasibility of waste minimisation (WasteMin) clubs as a model for achieving significant improvements in environmental performance by local industry. The aim of this follow-up project No. 1171 was to develop a methodology for promoting, managing and sustaining waste minimisation clubs, by producing inter alia guides for effectively establishing and managing WasteMin clubs, specific sectoral self-assessment guides, and training material for WasteMin consultants in a franchised operation.

The project's two technology transfer products are a Facilitator's Manual and a Training Manual. The Facilitator's Manual is aimed at a person or organisation that wishes to

initiate a waste minimisation club and requires guidelines for undertaking such a project. It addresses aspects such as how to form a club, call meetings, determine the level of contributions from companies, identify some of the problems that can occur, and explains the various roles of the people involved. It also provides sample letters and presentations, and provides sources of information. The Facilitator's Manual draws on the experiences gained in the previous WRC project no. 973 and also that gained from facilitators of other waste minimisation clubs in South Africa, facilitated by various organisations such as consultants, University researchers and, in at least one case, by the company itself as an in-house club.

Report No: TT 283/07
ISBN: 978 1 77005 493 6
Overseas price: \$30-00 excl postage

Report No: TT 284/07
ISBN: 978 1 77005 494 3
Overseas price: \$20-00 excl postage

Life cycle costing analyses for pipeline design and supporting software.

van Vuuren SJ; van Dijk M

There are various factors that influence the hydraulic capacity and pipeline designers need to take all of these into consideration during the design. For instance the estimation of roughness parameter for a pipeline has a significant effect on the hydraulic capacity and operational costs. An underestimation of this parameter can be catastrophic when the required demand cannot be met. Findings identified that the two main contributing factors of energy losses are:

- Inherent resistance against flow exerted by the fluid (i.e. viscosity) and
- The friction losses resulting from the interface between the fluid and the conduit boundary (i.e. shear), as well as secondary losses resulting from abrupt local changes in the system.
- The roughness parameters that are normally quoted by manufacturers tend to be too low.

Report No: TT 278/07
ISBN: 1 77005 449 9
Overseas price: \$20-00 excl postage

A research strategy for the detection and management of algal toxins in water sources.

Harding WR

This analysis undertaken in support of the development of a cyanobacterial and cyanobacterial toxin research strategy in South African water sources has identified two vital planning elements, viz.

- The need to create a management and support infrastructure and
- The research aspects best suited to South African cyanobacterial research needs.

In addition, there is a clear indication that successes will be limited should collaboration with overseas specialists and organizations not be implemented. To South Africa's advantage is its current involvement in both the Global Water Research Coalition (GWRC) and CYANONET initiatives, plus willingness

expressed by international specialists formerly associated with cyanobacterial work in South Africa to continue their association. Allied to this is the cosmopolitan nature of the cyanobacterial problems as experienced worldwide. This analysis was fortunate to have been commissioned during the year (2004) that saw the launch of the GWRC and CYANONET initiatives, as well as two key international conferences that allowed for the identification of globally-relevant research initiatives and emerging issues. The strategy proposed here is based on comparing and contrasting the current directions and emerging issues in international cyanobacterial research with identified South African needs. From this analysis a suite of key research issues have been formulated.

Report No: TT 277/06
ISBN: 1 77005 461 8
Overseas price: \$20-00 excl postage

Guidelines for the design, operation and maintenance of urine-diversion sanitation systems

Austen LM

If a dry toilet (i.e. not requiring water for its operation) is designed and constructed in such a way that the faeces vault can be quickly, easily and safely emptied, then one of the biggest maintenance problems will be obviated. If the processed excreta can also be productively and safely used for agriculture, the technology will become even more attractive. In South Africa, where many rural communities rely on subsistence agriculture, often in poor soils, and with urban agriculture becoming more common, this is an important aspect. Urine-diversion sanitation systems address the above opportunities. They have been successfully implemented in many countries, including South Africa where more than 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. A need has thus been identified to create further competence in this area of sanitation in South Africa, and to increase knowledge concerning the technology. The technology is increasingly being introduced in a manner which consists of faulty design, poor implementation and improper use. This study developed strategies and guidelines, through monitoring and evaluating existing schemes, which would provide fundamental answers in the sustainable management of this technology.

Report No: TT 275/06
ISBN: 1 77005 456 1
Overseas price: \$15-00 excl postage

A desalination guide for South African municipal engineers.

du Plessis JA; Burger AJ; Swartz CD; Musee N

Municipalities have to develop Water Service Development Plans (WSDP's) as part of Integrated Development Plans (IDP's) as a first requirement in their budgetary process, and have to be aware of what options are available to provide adequate water services. While 25ℓ/person/day has been set as the minimum basic water supply and while many consumers receive far in excess of this amount, there are areas of the country where enough fresh water of acceptable quality is not available for household use. However, in many areas adequate quantities of saline water may be or are readily available. This is especially

the case for coastal cities and towns. The cost of treating water is a fraction of the total cost of making water available to the consumer. This, together with the fact that membrane desalination technology is becoming more affordable, makes the overall water tariff less dependent on the cost of desalination. In other words, desalination may in many cases become a viable option to supply fresh water for domestic purposes. Therefore, DWAF identified a need to provide guidelines and procedures to select and evaluate suitable treatment options for desalinating sea water from both the Indian and Atlantic oceans, or brackish water from boreholes.

The specific objectives of the project were to identify the technologies which may currently be commercially implemented in South Africa to treat saline water to drinking water standards, to identify typical pre-treatment requirements, and to identify the most common technical, operating and environmental problems experienced in the selection and use of these technologies. An important aspect was also to provide estimates for capital and operating costs, as would be required to successfully bring the water to the accepted standards for potable and domestic use. Of particular importance for the South African application was to identify the level of skills required for daily operation of the desalination plants, the level of skills required to provide technical back-up and advice, and to identify and advise on the competencies, training needs and capacity building required at operator and management levels. Lastly, the relevant local environmental legislations governing desalination were also identified.

Report No: TT 266/06
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Overseas price: \$30-00 excl postage

Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers

Du Preez H; van Baalen

An increase in the eutrophication of surface water resources is leading to increased incidence of toxic blue-green algae growth – thereby increasing health risks when drinking water from a treatment plant which does not use activated carbon adsorption in its process train. No structured framework yet exists in South Africa to manage the supply of safe drinking water during a persistent blue-green algae bloom in the source water. The project aims to establish such a pro-active approach by means of a generic algal bloom incident management framework to effectively manage potable water supply when toxic algal blooms are present. Such a system will be widely applicable to water services providers and will reduce the risk of human incidents related to blue green algae toxins by providing this framework for informed and appropriate pro-active management measures.

Report No: TT 263/06
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Overseas price: \$25-00 excl postage

An assessment of non-revenue water in South Africa.

Seago CJ; McKenzie RS;

Municipal water use in South Africa has been under investigation for many years and the Department of Water Affairs and Forestry has been trying to establish the levels of wastage from all water

supply systems countrywide. This has proved a very difficult task due to the absence of reliable data in many Municipalities as well as confusion regarding how such wastage should be estimated. Until the wastage can be quantified accurately, it is impossible to develop and prioritise the actions that must be taken to ensure that water is used effectively and efficiently in this water scarce country. Despite many problems associated with the gathering of data from the various water utilities, the study was able to obtain information from 62 of the largest water reticulation systems throughout South Africa. It was found that the average bulk system input volume per property served for the 19 low income areas analysed as part of the study was approximately 37 kℓ per property per month. The losses (real and apparent) for the 62 systems analysed was estimated to be 623 million m³/annum or 29% of the total water supplied.

Report No: TT 300/07
ISBN: 978 1 77005 529 2
Overseas price: \$20-00 excl postage

KSA 4:

1: On-farm application of in-field rainwater harvesting techniques on small plots in the central region of South Africa : Vol 1 – Main Report

JJ Botha, JJ Anderson, DC Groenewald, NN Nhlabatsi, TBZere, N Mdibe and MN Baiphethi

Report No: TT 313/07
ISBN: 978 1 77005 595 7
Overseas price : \$20-00 excl postage

2: On-farm application of in-field rainwater, harvesting techniques on small plots in the central region of South Africa – Vol 2: Extension manual.

Botha JJ; Anderson JJ; Nhlabatsi NN

Water harvesting is the process of concentrating rainfall as runoff from a larger area for its productive use on a smaller area. A number of Water Research Commission projects on the In-field rainwater harvesting (IRWH) technique have demonstrated that rural communities can greatly benefit from this production practice. Intensive field experiments on clay and duplex soils, conducted over a period of six seasons, indicated that IRWH increased maize and sunflower yields by as much as 50%, compared to conventional production techniques (CON). Research results over a number of years have indicated that the IRWH technique is sustainable in terms of increased agronomic productivity, reduction of risk, conservation of the natural resources base, social acceptability and economic feasibility. This technology transfer project was initially planned for implementation in six rural communities around the towns of Thaba Nchu and Botshabelo in the Free State province

The technology exchange process expanded rapidly resulting in many more households and communities than initially anticipated implementing the IRWH technique that the need arose to employ a proper exit strategy that ensured continued implementation of the technique by interested communities. As the number of farmers and communities using IRWH techniques increased, a decision was taken by representatives from each group and community to form a municipal-based water harvesting interest group (MB:WHIG). This body was later named the Tswelelopele Small Farmers Cooperative (TSFC). Amongst

the organisations that were co-opted into the structure were the municipality, the tribal authority and the local agriculture office.

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Technology transfer and integrated implementation of water management models in commercial farming.

AJ Pott, N Benadé, P van Heerden, B Grové, JG Annadale and M Steyn

This integrated transfer of technology project targeted the commercial irrigation sector in particular since, according to the National Water Resources Strategy (NWRS, first edition, 2004), this sector is responsible for over 62% of South Africa's total water use. The terms of reference required the research team to (i) identify, (ii) negotiate with and (iii) select 5 to 7 Water User Associations or Irrigation Boards to participate in the technology transfer (TT) project. A key objective of the project was for the decision support models to be used sustainably after the completion of the project to increase efficiency of water use. As such, the potential participant WUAs / IBs were evaluated in terms of (i) their user needs for the respective models, (ii) the level of commitment shown and (iii) the level of infrastructure of the respective schemes. The participants were ranked in terms of these criteria, and short-listed. It is expected that the WUAs/IBs which were selected will act as centres of excellence, from which other WUAs/IBs can learn over time.

The models which were included in the TT exercise were ACRU, WAS, SAPWAT, SWB and RISKMAN. All models are driven by some form of input data, which is then transformed into information via computational processes through the models. A central approach of this integrated technology transfer project was to capture high quality data of the targeted participant Water User Associations and Irrigation Boards in a Geographical Information System (GIS). In the course of the implementation of the models, further developments were undertaken to improve the user friendliness. It was clear from earlier WRC projects that stakeholders showed a strong interest in GIS packages, largely due to the understanding that the use of GIS promotes for spatial and temporal information. This is due to the graphical (visual) nature of GIS which enables features to be viewed in a spatial context. In order to promote the buy-in from potential WUA and IB participants, a key feature of the project was the collection of data pertinent to the WUAs and IBs which would then be captured in a GIS. The data incorporated in the GIS could then be used (with other input data) to drive the models associated with the TT project.

The WUAs/IBs have shown a very high interest in the use of GIS, which is very encouraging, as the GIS data, if kept current over time, will provide valuable input data for the various models forming part of the TT project. The current user needs for some of the models is very high, resulting in the models either being used now, or the intention to use the model in the near future (e.g. WAS & SAPWAT). For some of the other models the user need is growing, and is anticipated to grow significantly once the compulsory licensing process has been completed in many of the over-allocated catchments in the country. Models like SWB and RISKMAN will be very useful to test the hydro-economic impact of various water-use and land-use scenarios. Like-wise, the ACRU-MIKE BASIN model combination is well placed to assist water resource managers and stakeholders evaluate water management scenarios.

It is recommended that the WRC and/or DWAF provide funding to support a technical user support unit, which continues supporting the use of the models associated in the TT project. Although the technology transfer project was successful, it targeted only 7 WUAs/IBs, which is a very small percentage of the total number of WUAs and IBs in the country. At some stage all water users will require assistance in the management of their water, be it a catchment scale, scheme scale, or field scale. An organisation such as the former Computer Centre for Water Research (CCWR), would be a suitable organisation to provide support and assistance for this purpose.

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Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research in Limpopo Province.

Wim van Averbek

The project was conducted as a case study of the Dzindi Irrigation Scheme. Dzindi is a canal Irrigation scheme that was constructed shortly after World War II and is found about 6 km south west of the town of Thohoyandou, in the Vhembe district of Limpopo province. Dzindi has a total command area of 135.6 ha, which is subdivided into 106 plots of 1.28 ha each, held by a total of 102 plot holders. Fieldwork was also conducted at Khumbe Irrigation Scheme and Rabali Irrigation Scheme to determine the extent to which the situation at Dzindi was unique. Both Khumbe and Rabali are canal irrigation schemes and their characteristics are fairly similar to Dzindi. All three schemes can be described as maize (summer) and vegetables (winter) schemes, but there were differences among the schemes in the types of vegetables that featured most prominently.

The overall objective of the project was to develop and implement technologies and knowledge useful for farmers in order to improve rural livelihoods. Two types of research and development activities were conducted, namely initiatives aimed at understanding management practices and initiatives aimed at improving management activities. Methods used in data collection at Dzindi included; the use of Rapid Rural Appraisal (RRA) techniques; surveys involving probability sampling and structured interview schedules; experiments in the green house, on-station and on-farm and qualitative methods. Methods of data collection at Khumbe and Rabali were largely limited to the use of RRA techniques.

The analysis of livelihood and farming of plot holder households revealed that for the purposes of developing best management practices, the 'one size fits all' perspective is not valid. At individual farm level best management practices need to be tailored to the objective of the farmer and the role of farming in the overall livelihood strategy of the household. The longitudinal study of the livelihood and farming of a selection of households at Dzindi showed that both were dynamic and subject to interaction. The development of livelihood types, farming styles and the relationship between farming and overall livelihood were shown to be useful approaches to make sense of the diversity that was observed. The study of the social and institutional domains of Dzindi showed that there was considerable room to improve the management of shared resources. On smallholder canal irrigation schemes,

the sharing of water and the maintenance of the irrigation infrastructure influence the availability of water for irrigation at the plots. Collaboration among farmers, or the lack thereof, also affects access to markets. However, the study found that state intervention (through the compulsory introduction of the co-operative model) in areas where smallholders successfully operate their own organisations should either be avoided completely or be done in ways that allow smallholders sufficient time to internalise the new concepts and adapt them to suit their own circumstances. Land tenure and farmers' interpretation of the prevailing tenure system influence land exchange among farmers, which is important for farmers seeking to expand their operations. Collaboration among farmers is also important in terms of access to land preparation services. Research and development activities aimed at improving management practices focused on production aspects and included the integration of crop and animal production systems, improvement of the production of selected indigenous crops (African leafy vegetables) and the improvement of green maize production.

The findings of this study revealed that the development of best management practices for farmers on smallholder irrigation schemes needs to consider three important domains, namely the individual farm enterprises, the irrigation scheme as a whole and the scheme and its surrounds, because these domains interact. The development of best management practices at the level of the individual farm enterprises, within the Terms of Reference for this project, is mostly technical in nature. This suits the biological and technical disciplines in the agricultural expert system. However, social and institutional issues are of cardinal importance in the domain of the irrigation scheme as a whole and its surrounds. This raises questions about the appropriateness of the composition of the South African expert system, which has long been dominated by specialists in agricultural production and agricultural engineering.

Report No: TT 344/08
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Water-use in relation to biomass of indigenous tree species in woodland, forest and/or plantation conditions.

Dye PJ; Gush MB; Everson CS; Jarman C; Clulow A; Mengistu M

Report No: TT 361/08
ISBN: 978 1 77005 744 9
Overseas price: \$30-00 excl postage

Nutritional status of South Africans with specific reference to malnutrition.

Wenhold F; Faber M

Report No: TT 362/P/08
ISBN: 978 1 77005 756 2
Overseas price: \$25-00 excl postage

Developing a land register and a set of rules for application of infield rainwater harvesting in three villages in Thaba Nchu: A pilot project

Manona S; Baipethi M

The Water Research Commission (WRC) is funding a 5 year research project in rural villages around Thaba Nchu, titled Social and economic factors affecting the adoption of rainwater

harvesting and conservation practices. The solicited project commenced in April 2006 and is being undertaken by the University of the Free State. The project follows on other WRC funded projects in the same area that aimed at the improvement of crop production, thus poverty alleviation, through the use of infield rainwater harvesting (IRWH) techniques developed by the Agricultural Research Council's Institute for Soil Climate and Water (ARC-ISWCW). There is a need for up-scaling IRWH from the household food gardens to the communal croplands. This requires the development of a land register and clear rules to gain access to land. Umhlaba Consulting have specialist capabilities in this regard to make a contribution and thereby support ongoing research efforts.

The study revealed the complex nature of land tenure and the total collapse of land administration in the three villages. The underlying drivers of the collapse of land administration can be attributed to lack of a coherent policy and legislative framework since 1994. On the one hand government discontinued the implementation of permission to occupy (PTO) legislation and did not replace it with new legislation, while other organisations that were historically key role players in land administration were removed from the functions they played in the past.

A survey conducted among the three villages showed a widespread support for extension and/or revitalization of cultivation to arable fields, albeit with conventional technologies in mind, as shown by the appeal for the provision of machinery commonly used in conventional tillage methods. The observation was not surprising since the farmers had not been exposed to the use of the IRWH techniques beyond the household food plots. Furthermore, land rights holders expressed sufficient support for an improved local land administration system that would support land exchange agreements. While fencing of the fields does not necessarily fall within the realm of land administration, it was seen to be a major constraint towards the cultivation of arable fields. This is largely because of the threat of damage to crops by livestock from within and the neighbouring villages.

Following from support to developing and/or strengthening local land administration, an initial framework of rules that would govern local land administration was agreed to by the three villages. This process was undertaken mindful of the lack of a supportive legislative framework and therefore lack of enforcement mechanisms. Nonetheless, the communities were willing to devise and revitalize some of the traditional and collective initiatives to ensure the launching of the local land administration system. There was consensus across all three villages on how a local land administration structure should be set up. The process of setting up of rules was seen as a dynamic and continuous process which should be facilitated by the local land administration structures over time.

Report No: TT 367/08
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Overseas price: \$25-00 excl postage

Training manual for small-scale rainbow trout farmers in net cages on irrigation dams water quality, production and fish health.

K Salie, D Resoort, D du Plessis and Ma Maleri

This project investigated the suitability of on-farm irrigation dams for aquaculture fish production and the effect this would have on the quality of the water for irrigation purposes. A study of irrigation

dams in the Western Cape and the Makhathini flats canal system in KwaZulu-Natal, indicated that water exchange rate and inflow water quality are main factors in determining the suitability of water bodies for fish production. While the water chemistry did not show effects of aquaculture or differences between production and control sites, the phytoplankton composition and biomass did. Especially during the winter dam turnover, overall biomass of phytoplankton was higher at all production sites. The additional clogging of filters as a result of changes in phytoplankton biomass was the most significant impact of aquaculture on the quality of water for irrigation. It was further found that a significant portion of the fertiliser requirements of the crops irrigated from the dams would become available because of aquaculture activities.

Report No: TT 369/08

ISBN: 978 1 77005 784 5

Overseas price: \$20-00 excl postage

The social/cultural acceptability of using human excreta (Faeces and Urine) for food production in rural settlements in South Africa

Duncker LC; Matsebe GM; Moilwa N

Introducing and operating sanitation systems that promote the use of human excreta in rural areas require a combination of technical and managerial aspects that fit the prevailing socio-cultural context in the specific area. An in-depth understanding of the social and mental fabric concerning people's views towards recirculation of nutrients is necessary in order to understand the motivational factors behind people's acceptance or rejection of using human excreta for food production. No research has been conducted so far in this field of study in South Africa, and therefore the scoping study is required to investigate the status quo, determine the views and attitudes of people towards the use of human excreta in food production, and to guide relevant future interventions and actions regarding use of human excreta. Use of human excreta for agricultural purposes may not only have direct benefits of protecting and improving natural resources such as water and soils and enable households to increase food crops, but also indirect benefits of improved food security resulting in improved health of the individual, greater productivity, increased economic output and opportunities, and a decreasing burden on social services.

Report No: TT 310/07

ISBN: 978 1 77005 592 6

Overseas price: \$25-00 excl postage

A Procedure for an improved soil survey technique for delineating land suitable for rainwater harvesting.

Hensley M; Roux PAL; Gutter J; Zerizghy MG

Subsistence farmers in rural semi-arid areas with low cropping potential are a category of poor people in South Africa that the Government urgently wants to assist. Their well-being is jeopardized by a low income and inadequate food security. To address this problem a number of research projects, managed and funded by the Water Research Commission (WRC), have been launched during the last ten years by the ARC-Institute for Soil Climate and Water (ISCW) located at Glen. Success in this regard was achieved, shown by the fact that large numbers of households in the region now successfully use IRWH to grow maize and vegetables in their backyards. The time is now ripe for expanding the application of IRWH to the relatively large unused

cropland areas available to these subsistence farmers. The need then arises to identify and delineate the portion of each village area that is suitable for IRWH. Because of the relatively small area of cropland allocated to each household it is essential that the soil survey be conducted on an intensive basis, at a scale of at least 1: 10 000, but preferably larger. Intensive soil surveys at this scale, carried out using the traditional grid technique, are costly. It was hypothesised that it should be possible to develop a more effective survey procedure to select suitable land for IRWH by maximising the application of tacit knowledge and employing modern and innovative technology. Aware of this need the WRC has wisely created this research project to test this hypothesis.

Report No: TT 311/07

ISBN: 978 1 77005 591 9

Overseas price: \$20-00 excl postage

A Manual for cost benefit analysis in SA with specific reference to water resource development: Second Edition (Updated and Revised)

Mullins D; Mosaka DD; Green AB; Downing R; Mapekula PG

This guideline is in the format of a manual for conducting Cost-Benefit Analysis (CBA) in South Africa with specific reference to evaluating the development and management of water resources. This evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. The CBA method, provides a logical framework by means of which projects can be evaluated, serving as an aid in the decision making process. This manual is specifically aimed at the decision maker in the public sector, but can also be used outside the public sector.

It is interesting to note a few highlights of the CBA Manual. A broader approach is followed to incorporate the relationships between CBA and other aspects of the economy. In this regard the following aspects have been included:

- The relationship between the principles of CBA and welfare economics;
- CBA as one component of the range of decision making support instruments;
- The equity and efficiency principles;

Thus it deals specifically with the uses, limitations and basic principles of CBA in order to explain the underlying conceptual framework to the reader. This manual advocates that the CBA concept needs to be widened to include the broader social costs and benefits derived from a project. Furthermore it is also accepted that CBA is only one of several instruments for evaluating proposed projects. One of the main objectives therefore was to incorporate an income weighting system. This system provides for the recognition of some of the macroeconomic policies of the government e.g. combating poverty and promoting regional development.

Report No: TT 305/07

ISBN: 978 1 77005 598 8

Overseas price: \$30-00 excl postage

Technology transfer for implementation of the FARMS system

Botha PW; Oosthuizen LK; Meiring JA

Over the last 10 years, three WRC funded research projects were undertaken to develop user-friendly models to provide decision-

support for farmers. The aims of this technology transfer project were firstly, to train agribusinesses, bureau services and advisors in the main irrigation areas of South Africa to implement the Risk Man (Risk Management), IrriCost (Irrigation Cost Estimator) and FARMS (Farm Level Agricultural Management Simulator) computer software for decision-taking support in the field of risk management, irrigation cost estimation and whole farm planning respectively; and secondly, to give these organisations and individuals the necessary support in order for them to apply the abovementioned computer software on a continuous basis.

New technology must pass through several stages before it is accepted. The five stages of adoption are awareness, interest, evaluation, trial and adoption. The implementation strategy with this technology transfer project consisted of a combination of methods, messages and approaches followed by the research team. The first step was to identify target groups to whom the three programs were demonstrated. The demonstrations were attended by the contact person of that area together with potential adopters of the technology. These demonstrations were used to create awareness and interest in the use of the models. The next step was to arrange workshops for interested persons for specific models to make further progress with the technology adoption process. The website was used to provide additional information about forthcoming courses and continuous support on larger scale adoption and application.

Report No: TT 274/05
ISBN: 1 77005 450 2
Overseas price: \$20-00 excl postage

Building capacity in irrigation management with wetting front detectors

R Stirzaker; CSIRO; Stevens J; Annandale J; Maeko T; Steyn M; Mpandele S; Maurobane W; Nkgapele J; Jovanovic N

Scheduling of irrigation does not only ensure that adequate volumes of water are applied. It also ensures that many people who rely on the limited water resource can share. Much as irrigators are aware of the importance of scheduling, very few practice it. A wide range of reasons for not scheduling exists, the common ones being the high level of management required and the costs involved. With simple and cheap scheduling tools, water savings will be achieved and farmers will soon realise the importance of irrigation scheduling and its benefits. The project is aimed at improving adoption of irrigation scheduling through the introduction of a cheap and simple technique. It also evaluates factors affecting the acceptability of this irrigation scheduling technology by resource-poor and commercial farmers.

Report No: TT 230/04
ISBN: 1 77005 138 4
Overseas price \$25-00 excl postage

Using Sapwat to estimate water requirements of crops in selected irrigation areas managed by the Orange - Vaal and Orange - Riet water users association

Van Heerden PS, Crosby CT & Crosby CP

This report serves as a user manual for the application of SAPWAT. Furthermore, it demonstrates that the estimation of irrigation requirements can be credible and that the requirements that the National Water Act (36 of 1998) sets for future water management can be met.

Report No: TT 163/01
ISBN: 1 86845 812 1
Overseas price \$30-00 excl postage

Micro-irrigation for smallholders: Guidelines for funders, planners, designers and support staff in SA

Du Plessis FJ; Van Averbek W; Van der Stoep I

The objective of this project was to assess how small-scale farmers experience the concept of micro-irrigation systems and how they cope with problems. The aim was to identify those aspects that eventually determine the success or failure of small-scale crop production, utilising these systems. During the course of the project it became apparent that external factors, generic to any small-scale farming system and seemingly unrelated to micro-irrigation, had a significant influence, and that it would, therefore, be almost impossible to evaluate the former without taking the latter into account. The aim of the guideline report is to help prevent mistakes of the past and, hopefully, it will contribute to policy-making on a small scale regarding the utilisation of micro-irrigation. Thus, the successful use of the systems is ensured.

Report No: TT 164/01
ISBN: 1 86845 824 5
Overseas price \$15-00 excl postage

Contribution of aquaculture to rural livelihoods in South Africa: A baseline study

Rouhani QA; Britz PJ

At present there is a lack of information on the importance of fish production systems in agricultural activities, the contribution it makes to household food security and constraints or opportunities which exist for expansion. This study should highlight specific topics for research projects that need attention. Particular emphasis will be placed on research of water-related issues that will lead to an improvement of rural livelihoods.

Report No: TT 235/05
ISBN: 1 77005 186 4
Overseas price \$25-00 excl postage

Guidelines for irrigation water measurement in practice.

Vd Stoep I; Benade N; Smal HS; Reinders FB

Effective management of water resources can be vastly improved if water use is measured accurately. This applies in particular to efforts to influence the quantity of water demanded by levying tariffs on the volume of water actually consumed. However, on most irrigation schemes water flow is not measured and water tariffs are presently still levied on an area and not a volumetric basis. This report is as a result of a comprehensive study of water measurement in irrigation.

Report No: TT 248/05
ISBN: 1 77005 324 7
Overseas price \$25-00 excl postage

Irrigation scheduling using the Soil Water Balance (SWB) model as a user-friendly irrigation scheduling tool.

Annandale JG; Steyn JM; Benade N; Jovanovic NZ; Soundy P

Most commercial farmers recognise that effective irrigation scheduling is a prerequisite to save on irrigation water and

to improve on water-use efficiency. However, only a small percentage of irrigation farmers currently uses any scientific irrigation scheduling aid. One important reason may have been the lack of quick, simple and reliable irrigation scheduling techniques. This aspect has been addressed to a large extent by the development of the SWB model. Although the model follows a scientifically based mechanistic approach, a user-friendly interface makes it accessible to any person with basic computer training.

Report No: TT 251/05

ISBN: 1 77005 339 5

Overseas price \$20-00 excl postage

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: A rough guide for irrigation development practitioners: Vol 1

Denison J; Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.

The 'Rough Guide' (Volume 1) is a quick reference guide that covers policy implications and revitalisation objectives, as well as recommended principles, approaches and methodologies for scheme diagnosis, participative planning, feasibility evaluation and formulation of farmer support programmes.

Report No: TT 308/07

ISBN: 978 1 77005 568 1

Overseas price \$25-00 excl postage

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: Concepts and cases: Vol 2

Denison J; Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.

'Concepts and Cases' (Volume 2) contains the theoretical rationale for the guidelines. Four major South African revitalisation initiatives are compared with international initiatives and success factors are identified. Eight farmer support approaches are documented, providing lessons of best practice as well as alternatives for programme design, and new approaches are presented. These are a tailored consultative planning approach, a land-leasing strategy for irrigation schemes and the formulation of four basic farming styles to guide planning.

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Private Bag X03, Gezina, Pretoria, 0031,
Republic of South Africa
Tel: +27 12 330 0340
Fax: +27 12 331 2565
E-mail: wrc@wrc.org.za
Web: www.wrc.org.za

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