WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW 2010/11

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Kowledge Review 2010/11
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VISION & MISSION

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.

Introduction

Dr Rivka Kfir, Chief Executive Officer,
Water Research Commission

INVESTING IN THE CREATION AND SHARING OF KNOWLEDGE

During 2010/11, the WRC continued to support the water sector and all its relevant institutions and partners. This was achieved by providing the sector with knowledge aimed at informing decision-making processes, improving monitoring and assessment tools, and making available a range of new and improved technologies related to water resource management, improved use of water in agriculture 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.

As the WRC aims to provide appropriate knowledge to further improve South Africa's ability and capacity to govern and manage its water resources, its research portfolio has to continue to incorporate various water uses in relation to applied land uses, with emphasis on issues of water quality, quantity and accessibility. Research projects will also focus on resource protection and its sustainability.

The research portfolio for 2010/11 was set on the basis of the WRC's strategic plan. The WRC continued to invest in the creation of knowledge via its four 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 research KSAs are supported by the Water-Centred Knowledge KSA. This structure continued to form the core operating framework for WRC-funded R&D and was further consolidated during the year.

Water Resource Management - The water cycle plays a key role in the chemical, physical and biological processes that sustain ecosystems and influence Earth's climate and associated global change. Clouds, water vapour, and precipitation alter heating and cooling of Earth's surface and atmosphere which, in turn, affect global circulation and precipitation patterns. Hydrological data from atmospheric, surface, and subsurface stations are critical to the development of more accurate predictions of water distribution and availability, cloud formation and precipitation in a changing climate. The Water Resource Management KSA carries out a variety of studies, workshops, and meetings and publishes numerous reports on science-policy issues related to most aspects dealing with the water cycle and its impact on the management, protection, use, control, administration and sharing of water resources. The KSA continued to follow pertinent developments taking place nationally and internationally with regards to water resources. It also continued to lead the understanding of 'wicked problems', offering a safe space for experimenting and learning to address the numerous challenges faced in water resource management. In so doing, the KSA has provided guidance for policy implementation and the development of policy instruments in areas of: water resource assessments, such as WR2005; water quality, focusing on environmental health and endocrine disrupting compounds; groundwater potential and closing

the gap between surface water and groundwater assessments models; and the management of common property resources, enforcement and compliance.

Water-Linked Ecosystems - Research in this KSA put strong emphasis on the creation of knowledge aimed at protection and ensuring the utilisation and sustainable management of water-linked ecosystems in our water-scarce country during a time of demographic and climate change. Research portfolios within this KSA promote critical issues about conservation of aquatic ecosystems in order to provide the knowledge for their sustainable functioning in terms of national legislation, commitments to international conventions, and the ongoing provision of goods and services which ecosystems deliver.
The research in this KSA develops the understanding of the ecological processes underlying the delivery of goods and services and provides the knowledge to sustainably manage, protect and utilise aquatic ecosystems. Three main research areas were addressed during 2010/11: 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, including rehabilitation and restoration of processes, form and function of estuaries, rivers and wetlands.

Water Use and Waste Management - During the year under review, 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. The KSA continued to support studies on appropriate technologies for improving the quality and quantity of our water supplies for domestic use, with a focus on water supply and treatment technology serving urban, rural, large and small systems. Greater emphasis has been put on aspects related to energy efficiency and generation in the supply of services, reuse and beneficiation from water supply and wastewater treatment, as well as adaptation and mitigation strategies at a water services level to deal with future challenges associated with climate change. Waste and effluent, as well as reuse technologies that can support and improve management in the municipal, mining and industrial sectors, were also addressed, and innovative, 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; sanitation and hygiene education, and the WaterSmart Fund which supports the demonstration and development of innovative solutions.

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, this research focused on increased biological, technical and economic efficiency of water use, the reduction of poverty through water-based agricultural activities, increases in profitability of water-based farming systems, and the sustainable use of water resources through protection and restoration practices. All agricultural sub-sectors are addressed including irrigated and dry-land agriculture; woodlands and forestry; grasslands and livestock watering; aquaculture and inland freshwater fisheries. During 2010/11 emphasis was placed, through new projects, on quantification of water use and the nutrient content of economically important food crops in diets of the rural poor; assessment of the potential of small and large storage dams for inland freshwater fisheries to produce fish for food security in rural areas; promotion of the efficient conservation of water resources and water inputs within food-value chains for emerging farmers as part of land and water allocation reform projects; developing technical and financial standards for drainage of irrigated land with high water tables and salinity levels; determination of the magnitude of pollution by agricultural chemicals and the potential risks for human health and the environment; developing guidelines for rainwater harvesting; and livestock production on natural grasslands for generation of biogas as renewable energy. This research output will support development and application of approaches, models, techniques, practices and guidelines for efficient and beneficial agricultural water management.

Supporting research projects

During the year under review, the WRC managed 328 research projects at various stages of project life cycle, of which about 79% (259 projects) were active projects and the balance were mostly projects that have been finalised and in the process of being financially closed. In the year under review (as in the previous financial year), the number of finalised projects (76) was very similar to the number of new projects initiated at the beginning of the financial year (77), providing a steady throughput of knowledge to the sector. The WRC published about 109 research reports and products in this period. The various funding streams 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. About 33% of the total number of projects were solicited projects.

During the past five years the WRC has finalised 338 research projects, indicating a significant contribution to

knowledge in the water sector. An average number of 68 projects were finalised per year, over the past five years. Over the same five-year period 324 new projects were initiated, ensuring the continuous contribution of new knowledge to the sector. An average number of 65 new projects were started per year, for the past five years.

Total investment in the support of knowledge creation, sharing and dissemination amounted to R110.7 m. This represents a decrease of 4% from the previous year (R115.8 m. total investment was reported in 2009/10). This investment includes about R2.6 m. for the Water Information Network (WIN-SA), R3.2 m. for the Framework for Education and Training in Water (FETWater), and other income leveraged for 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 62%, equal to that for 2009/10 and the planned ratio of 62%. The ratio for research support is 73%, compared to 74% in 2009/10, and is equal to the planned ratio of 73%.

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 2010/11 this drive had been fairly successful but substantial amounts were rolled over to 2011/12. The WRC income originating from sources other than the levy for 2010/11 amounted to R14.8 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 know-ledge-sharing projects. Sources of income other than the levy for 2010/11 amount to about 13% of the total income.

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 encouraging project leaders to include students on their projects, enabling them to participate in 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 now leading WRC-funded research projects and serving as members of steering committees as well as reviewers of new proposals.

Capacity building by lead organisations in 2010/11

The table below reflects the number of students involved in WRC projects, as reported for the various lead organisations contracted by the WRC, in the 2010/11 financial year.

Contract lead organisation	No. of historically disadvantaged students	Total no. of students
African Remediation Technology	1	1
Agricultural Research Council	2	5
ATL-hydro	3	6
Aquagreen Consulting	1	4
ASSET Research	0	5
Association for Water and Rural Development (AWARD)	1	1
BioAssets Consultants	0	4
Cape Peninsula University of Technology	17	22
Centre for Environmental Economics and Policy in Africa	3	3
Corporate Research Consultancy	1	1
Council for Scientific and Industrial Research	21	32
Counterpoint Development	0	1

CPH Water	0	1
DH Environmental Consulting cc	0	2
Durban University of Technology	3	3
Emanti Management	4	5
Freshwater Consulting Group	0	2
Golder Associates Africa (Pty.) Ltd.	7	7
Groundwater Africa	0	1
Hlathi Development Services	1	1
Hydrosoft Institute	1	1
Institute for Groundwater Studies (UFS)	8	11
Institute of Natural Resources	2	2
IWR Water Resources (Pty.) Ltd	1	1
Jeffares & Green (Pty.) Ltd.	1	2
Nelson Mandela Metropolitan University	3	10
Nemai Consulting	2	2
Ninham Shand Consulting Engineers (Aurecon)	2	7
North-West University, Potchefstroom Campus	2	11
Partners in Development (PID)	4	4
Pegasys Strategy and Development (Pty.) Ltd.	0	1
Pegram and Associates (Pty.) Ltd.	6	8
Prime Africa Consultants (previously CIC International)	6	7
Re-Solve Consultancy	1	1
Rhodes University	20	28
Sigma Beta	4	8
South African Weather Service	2	3
SSI Engineers and Environmental Consultants (Pty.) Ltd.	4	5
Sustento Development Services	0	1
Tshwane University of Technology	12	12
Umgeni Water	7	7
Umvoto Africa	4	5
University of Cape Town	10	32
University of Fort Hare	11	11
University of Johannesburg	1	5
University of KwaZulu-Natal (all campuses)	26	55
University of Limpopo	3	5
University of Pretoria	17	27
University of South Africa	2	5
University of Stellenbosch	23	51
University of the Free State	19	34
University of the Western Cape	21	26
University of the Witwatersrand	5	7
University of Venda	14	15
Virtual Consulting	0	1
WRP Consulting Engineers	2	2
TOTAL	**311**	**520**

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. These include support to national and local government as well as the development of new training material for different levels of learners and for academic institutions. Examples of such initiatives are given below.

Strategic meetings with capacity building organisations

As the main funder of water research in the country, the WRC's relationship with the water research community is crucial for its effective operation. During 2010/11 the WRC put emphasis on meeting with as many universities as possible, to discuss their challenges and their current and future contributions to water research. The WRC representatives visited research organisations in the country and had informal discussions with the research directors/deputy vice-chancellor for research and senior researchers. Meetings were held with:

- Tshwane University of Technology (14 July 2010)
- Cape Peninsula University of Technology (21 July 2010)
- University of the Western Cape (21 July 2010)
- University of Stellenbosch (22 July 2010)
- University of Cape Town (22 July 2010)
- University of KwaZulu-Natal (23 August 2010)
- Durban University of Technology (23 August 2010)
- Mangosuthu University of Technology (25 August 2010)
- University of Zululand (25 August 2010)
- University of Pretoria (20 October 2010)
- Rhodes University (21 October 2010)
- University of Fort Hare (22 October 2010)
- North-West University (25 October 2010)

WRC 101 for project leaders

The WRC developed an informative one-day course for aspiring and new project leaders, to increase their understanding of the WRC research cycle, research priorities and fund allocation. During 2010/11, participants were guided on how to prepare a comprehensive proposal, with tips provided as to how to improve the chances of success, as well as guiding principles on how to manage the technical, administrative and financial aspects of a WRC project. The course also includes information on contractual and financial audit requirements. The WRC 101 courses were held on 3 May 2010 in Kempton Park, on 14 June 2010 in Cape Town and on 21 June 2010 in Durban.

South African Youth Water Prize

The WRC continues to support the South African Youth Water Prize (SAYWP). The WRC intellectual property manager and knowledge dissemination officer served on the adjudicating panel of the annual national SAYWP schools competition, held at Leriba Lodge, Centurion, on 4 June 2010. The WRC also exhibited the WRC school-based material at this event.

Training courses for the Department of Water Affairs

The WRC presented a course on 'Water economics and governance in South Africa: Basic issues and operational tools' to staff of DWA at DWA's Roodeplaat Training Centre. A WRC Director presented a case study on 'Development and financing of irrigation schemes' and the available WRC guidelines on the revitalisation of smallholder irrigation schemes were explained.

In addition, the WRC presented a two-day course, on 24 and 25 June 2010, at the DWA Roodeplaat Training Centre, for DWA personnel who are tasked with training the regional offices on the South African Sludge Guidelines developed by the WRC and DWA. The course focused on the correct implementation of the sludge guidelines.

The Framework for Education and Training in Water (FETWater)

During the year under review, the WRC continued to support FETWater. This national capacity-building initiative is aimed at the development of competencies and capacity regarding water resource management. FETWater is a joint UNESCO, Belgian and South African programme, which is currently in its second phase. Phase I of this programme was successfully completed under the custodianship of the WRC.

Water Information Network – WIN-SA

The WRC continued to serve as the implementing agent for DWA for the Water Information Network (WIN-SA). WIN-SA is aimed at knowledge sharing and capacity building for local government, in recognition of the critical importance of competence at local government level.

INNOVATION AND KNOWLEDGE APPLICATION

The WRC supports the protection and transfer of innovative methods and technologies that may result from WRC-funded research, where and if required. Some technologies, processes and products require commercial involvement in order to make them publicly available and some academic organisations have required WRC support in this regard.

New innovations

Map of stable isotopes in tap water

Creating a map of stable isotopes in tap water across South Africa, for hydrological, ecological and forensic applications, is a first for South Africa. It is innovative in that it provides a link between water resource management, ecology, global climate change and forensics. The research is technically supported by Purdue University in the USA.

Early detection of environmental pollutants

The ongoing project entitled 'Pollution-induced in-vivo lipid autoxidation in fish and the subsequent development of pansteatitis in crocodiles' intends to find complementary, non-sacrificial parameters that may be used, together with existing indexes, to allow for accurate, sensitive and early detection of more chronic, sub-lethal pollution episodes, before bio-magnification and mortalities of organisms at the top of the food chain occur. A link between pollution-induced in-vivo lipid autoxidation in fish and the subsequent development of pansteatitis in crocodiles has not previously been elucidated.

Guidelines for improved irrigation water management from dam wall release to root zone

The research project on 'Standards and guidelines for improved efficiency of irrigation water use from dam wall release to root zone application' has contributed to innovative knowledge. The report promotes an investigative approach to improving efficiency, rather than relying on water accounting alone. The guidelines developed aim at improving irrigation water management from dam wall release to root zone application and will assist both water users and authorities to achieve a better understanding of how irrigation water management can be improved. This in turn will result in building human capacity, allowing targeted investments to be made with lower social and environmental costs.

New patents

The following two new patent applications were filed. Neither of these has been granted and both are still being prosecuted.

Remote data collection

This invention aims to address the requirement to install a remote data logger in a location where data is to be collected, logged and intermittently retrieved. The invention includes a data recorder and a monitoring system. A South African patent application for this invention was filed on 22 July 2010.

A membrane bioreactor

This invention relates to an immersed membrane bioreactor, and to a method for treating water. Existing membrane bioreactors have the disadvantage that they are damaged when dried, due to a change in the polymers from which they are manufactured. The membranes are also subject to damage when not handled carefully, i.e. by scouring or scratching. Existing membranes also require periodical chemical cleaning. This invention aims to address some of these shortcomings. A South African patent application for this invention was filed on 25 June 2010.

KNOWLEDGE REVIEW 2010/11

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2010/11 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.

KSA 1: Water Resource Management

Ms Eiman Karar:
Director

SCOPE

The global water cycle plays a key role in the chemical, physical, and biological processes that sustain ecosystems and influence Earth's climate and associated global change. Clouds, water vapour, and precipitation influence, among other process, heating and cooling of Earth's surface and atmosphere which, in turn, affects global circulation and precipitation patterns. Hydrologic data from atmospheric, surface, and subsurface stations are critical to the development of more accurate predictions of water distribution and availability, cloud formation, and precipitation in a changing climate. The Water Resources KSA carries out a variety of studies, workshops, and meetings and publishes numerous reports on science-policy issues related to most aspects dealing with the water cycle and its impact on the management, protection, use, control, administration and sharing of water resources and vice versa.

The realisation that water is an embedded sector means that the sector needs to be outwardly focused and furthermore it emphasises that many decisions around water are taken outside the water sector, hence expansion of the stakeholder base is important to affect decisions made around water. The urgent need for coordination is evident as the world is already facing the implications of climate change and all the amplified variability, uncertainty, disasters and apprehension it brings with it. The impacts of a changing climate and climatic variability are already being felt, with more droughts, more floods, more strong storms, and more heat waves – taxing individuals, firms, and governments, and drawing resources away from development. Other factors of pollution, population growth, urbanisation, overuse, etc., are weakening the ecosystems. Producing more and protecting better in a harsher climate with increased uncertainty will be the future challenge of this century for most developed and developing countries around the world including South Africa.

Integration of sectors, disciplines and institutions is as important as coordination for action. Integration in water resource management requires integrating surface and groundwater resources in assessments, planning, decision making, upstream and downstream parameters, local, regional and international scales, water quantity and water quality, data and information systems at the appropriate temporal and spatial scales. The integration required is both extensive and wide, which is easier to state but most difficult to practice in reality. The increased complexity places the management of water resources in the 'wicked problems' category. 'A wicked problem is one for which each attempt to create a solution changes the understanding of the problem. Wicked problems cannot be solved in a traditional linear fashion, because the problem definition evolves as new possible solutions are considered and/or implemented.' The term was originally coined by Horst Rittel (Rittel and Webber, 1973). Such complexity requires action with less predictability, review and continuous learning-while-doing (i.e. adaptive management approaches). Emerging insights from adaptive and community-based resource management suggest that building resilience into both human and ecological systems is an effective way to cope with environmental change characterised by future surprises or unknowable risks. An exciting development regarding the above is the realisation of businesses as large end-users of their role in governing and managing the resource, recognising it as key factor in their production cycle.

OBJECTIVES

The main 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 from previous business plans to reflect the needs analysis process and the alignment with the respective relevant impact area of water and society, water and the environment, water and the economy and water and health. Thus, the revised aims to support the main objective are to:

- Develop a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment, including 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 the light of the above, the KSA will continue to follow pertinent developments taking place nationally and internationally with regard to water resources. It will also continue to lead the understanding of 'wicked problems', offering a safe space for experimenting and learning to address the numerous challenges faced in water resource management. In so doing, the KSA will continue to provide guidance for policy implementation and the development of policy instruments. The importance of 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.

Since the promulgation of the NWA, South Africa has been showcased as having a progressive water law, which incorporates water as a right for domestic use and for the environmental requirements. It also calls for equitable distribution and decentralisation of the management of this vital resource. Custodianship vested in the state would provide for better assessments, compliance and enforcement of laws and policies. However, the progressive nature of the water law does not mean that it is easy to implement. For more than ten years now, policy makers, civil society and research have worked closely together to learn and improve on the implementation of this law.

With our broad base of stakeholders, the main issues of national concern regarding water resources are periodically defined, refined and prioritised into pertinent research questions. In continuation from the previous business plan and based on the needs analysis, the research focus of this KSA will continue to support policymaking 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 and encouraging partnerships through joint projects with key stakeholders.

These objectives are achieved in support of the desired impacts on the lives and health of people, on the economy and on the environment.

In view of the above, the thrusts remained the same as in the previous cycle:

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 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.

- Catchment data and information systems
- Surface water / groundwater hydrology
- Water resource planning
- New water

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 predictive tools and adaptive measures to global climate change and hydro-climatic variability
- Managing human induced impacts on water quality and quantity
- 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 resource management, with reference to point sources and 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. Scientific and technological approaches that will assist in characterising and addressing these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies, uncertainty, etc.); (3) Technological innovation and (4) Implementation approaches and technology transfer options.

- 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 2010/11

From the rigorous interaction with the stakeholders, the KSA continued to 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. Continuing to monitor the KSA's impact through research investments on society, environment, health and economy is a means to maintain focus on the true target for making a difference. Competition over scarce or inequitably allocated resources can lead to tension and insecurities. Strategies for reducing demand, increasing efficiency, and tapping into new water resources from targeted recycling, reuse, artificial recharge, etc., will be important research topics. Water as an economic good and aspects of valuing water in the South African context can be complicated due to the prevalent inequities in distribution of the resource and the large 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 water sector bringing with it tremendous uncertainty and optimism from a continued desire for improvement and self refection. This KSA will continue to be willing to support these processes for a more locally suitable and resilient institutional landscape in the water sector.

During the past funding cycle the research community has been 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 needs expressed by the Minister of Water and Environmental Affairs and the broad stakeholder inputs shared earlier, as well as the continuous interactions with various researchers and community members. New solicited calls were prompted by stakeholder inputs and some strategic partnerships, leaving a sufficient amount for non-solicited inputs which normally

bring about interesting and innovative topics, considered according to importance, relevance and budgetary allocations to each thrust.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to a committed and approved funding budget, inclusive of roll-over, of R29 464 022. Funding for new projects of R10 201 450 in 2010/11 was requested to support new projects within the four 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

To address water resource challenges which are likely to emerge in the next 10 to15 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.

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological 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 plans to contribute to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the National Information System. Furthermore, the need for integrating surface water and groundwater models has been highlighted. Concerted effort will be made to bridge this gap and to create a continuum starting from improving evapotranspiration estimates, which take into account the unsaturated zone informed by groundwater dynamics.

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 DWA framework strategy Water for Growth and Development (Version 6), 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 the KSA, research has already started and will continue to address the research issues that will contribute to this government driver of Water for Growth and Development.

The Department of Water Affairs indicated current water quality and quantity as major strategic issues. The KSA recognises the challenge and the need for further research and the provision of knowledge in this regard, as does the WRC. In addition, the KSA foresees that in future these issues will be complicated further with the advent of climate change. The issue of climate change and the linked phenomena of extreme events require both understanding and adaptability. Another linked area is the area of energy including usage of energy by the water sector and production of energy through hydropower. In the light of the above, the importance of expanding the resource via additional or alternative sources and diversifying the 'water mix' is another key challenge. The KSA will continue to support innovative research on the use of hydropower, groundwater, global circulation models and regional evapotranspiration assessments, water reuse and recycling.

The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas.

Water and society

The NWA places emphasis on stakeholder participation in water resource management which forms a blend between decentralisation and democratisation for decision making. Vast resources have been used in ensuring that adequate consultation takes place without necessarily reflecting much value from those investments. International literature confirms that empowerment is a long path which is progressive in nature and highly non-linear. Since the primary focus is to make an impact on the lives of people, the KSA has commissioned studies to establish the lowest appropriate level for decision making in water management in South Africa and the benefits thereof from such engagements and their impact on the lives of women and the poor. The role of local government as the democratic representative of South Africa in water-related decision making is an area that needs further investigation. A benchmarking exercise is currently under way to document international experience in regulations of the sector. With the numerous restructuring efforts undertaken in the sector, it is not easy to establish how the sector will look in the future. In response, scenarios are currently developed

to map out the institutional landscape by the year 2025 to ensure that current efforts are indeed in support of growing the South African economy by 6% of GDP per annum.

Water and health

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 water quality issues at the resource level. Special focus is needed on the impacts on water resources from some government policies such as rainwater harvesting and biofuels. The impacts on the health of society, especially those members with compromised immune systems, from land-use practices such as agriculture, mining and endocrine disruptive compounds found in the ecosystem will need to be further understood. The potential for the creation of new water through water recycling, grey-water use and reuse, artificial aquifer recharging, etc., can assist in meeting growing demands for a healthier society. Similarly, and in close association with the recent energy crisis, water infrastructure failings can be one major area that may affect water quality and hence create health issues, and this requires attention. An investigation aimed at quantifying and classifying all national water resource infrastructure is underway. Non-compliant wastewater and water treatment plants prompted a more focused study on the water infrastructure development financial allocation pathways in municipalities, to understand the reasons behind lack of maintenance and upgrades of consistently failing infrastructure in some municipal locations.

Water and the economy

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 rises. 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 subsequently the consequential adaptation needs for the economy; 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 this cycle, the KSA has strategically allocated all the solicited funding for the purpose of furthering the studies relating to climate change impacts on society, economy, health and the environment on majority water uses such as urban water supply, agriculture, mining, etc. 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 completely in partnership with beneficiaries and service providers.

Water and the environment

A recent review of relative investments in the different impact areas revealed the need for new research in the area of environmental degradation and mitigation especially from a water use perspective such as agriculture, mining, etc. Environmental functioning within the hydrological cycle and the integrative knowledge for ecosystem-based water resources management is another area of interest. An example of the recent crocodile deaths in the Limpopo River has created collaborative efforts between this KSA dealing with water resources and the other KSA dealing with ecosystems. The impact on the environment from the release of energy and the resulting impact thereof on water resources have formed part of a long-term discussion between WRC and ESKOM and an agreement has been signed between the two parties to conduct joint research into alternative energies and the international benchmarking of the latest technologies.

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

The KSA deals with freshwater resources and their management. In the previous business plan covering 2009/10-2011/12, the strategic intent of this KSA was drawn from wide consultation with stakeholders.

In continuation from the previous business plan and based on the needs analysis, the research focus of this KSA will continue to support policy-making 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 and encouraging partnerships through joint projects with key stakeholders. During its formal and informal consultation with the various stakeholders, the KSA has defined the following as research areas needing further attention in this business plan cycle from 2010/11 to 2012/13:

Sustainable cities: Over the past 100 years rapid growth of the world's population has been one of the most visible and dramatic changes to the world. Population growth has huge implications for all aspects of resource use, including water. Although water is a renewable resource, it is only renewable within limits. Today, more than 50% of the world's population lives in cities. As a result competing demands from domestic, commercial, industrial and peri-urban agriculture are putting enormous pressure on freshwater resources. In their bid to meet soaring demand, cities are going deeper into groundwater sources and farther to surface water sources, at costs – including environmental costs – which are clearly unsustainable. The question is: How can cities implement water technologies and approaches that are financially, socially and environmentally sustainable? If the same water use trend continues, the world will have used 40% of its freshwater resources by 2024. (Planning for new sources of water is crucial. Already innovation exists in the recycling of water from wastewater, capturing of fog, managed artificial recharge, desalination, etc. This would need to be performed in a coordinated and integrated manner to effect the desired impact.

Water and business: At a global scale business has begun to seriously consider risk around water availability and quality, with some of the more proactive multinationals having formulated the CEO Water Mandate under the auspices of the UN Global Compact. The CEO Mandate commits signatories to action in the following 6 areas: Direct Operations; Supply Chain and Watershed Management; Collective Action; Public Policy; Community Engagement; and Transparency. The World Economic Forum (WEF), World Business Council for Sustainable Development (WBCSD) and World Wide Fund for Nature (WWF) are each driving initiatives to understand corporate risk and responsibility around water, including focuses on supply chains and water footprint. Some of the new exciting developments relate to enhanced awareness of the importance of water in development resulting in enhanced participation from large end-users. SABMiller has developed a position statement on water use, analyzing risks surrounding water security and scarcity at its regional operations. The company analyses its water use using an industry metric, the amount of water used to brew a hectolitre of beer, and it recognises that in addition to saving costs, water is a material risk factor for the company, as some of its operations are located in watersheds facing water stress. The company accordingly recognises that it has a part to play in water efficiency in order to protect its resource base. Competition is around security issues which directly relates to allocations and transparency of decision making i.e. governance aspects. The significant role of the end users in ensuring good management of water resources is heightened since the realisation of the immediacy of water scarcity is amplified. Another example of how a common interest of large users to protect water can steer water development is the pilot implementation of BHP Billiton of their eMalahleni Water Reclamation Plant (EWRP). The long-term water management approach for the mine closure at the South Witbank Colliery of BHP Billiton has resulted in the EWRP, a permanent infrastructure put in place to abstract decant mine water from the deepest point in the underground workings for treatment to potable standards and reuse in the local municipality as a new source of drinking water. Further specific inputs were shared during a meeting held between the WRC and the Minister of Water and the Environment, Minister B Sonjica, in 30 September 2010; the issues identified in that meeting are captured above. The following are aspects pertaining to this KSA:

Climate change: South Africa is a water-stressed country and by 2050 the effects of climate change will be evident. However, each province is unique and the models addressing climate change should be disaggregated to provincial level. There will be a need for interventions regarding adaptation at provincial and local levels. At the same time agriculture (the biggest user of water) needs to be more efficient in using water and technologies are needed to improve agricultural productivity.

Water pollution and regulation: The Minister of Water and Environmental Affairs has stated that South Africa needs both technology-based solutions and a change in public attitude which can be achieved through education and awareness. Creative programmes are needed to address this at community level. The Minister also main-

tains that compliance and enforcement are critical. The Department has to bring back the polluter-pays practice and to establish a new guard with a clear mandate, i.e. the blue scorpions, who will control pollution with a heavy hand. Wetland protection is also of utmost importance as the wetlands play a major role in sustaining the resource and combating pollution.

Africa: The Minister is the new Chairperson of AMCOW and there is keen interest from The Netherlands in supporting AMCOW-Africa. The Minister emphasised the African Water Week and the need for partnership with Africa and supported the NEPAD initiative for building Centres of Excellence for Water Research in Africa.

Other inputs, ideas and concerns from other stakeholders included:

Monitoring: The state of monitoring infrastructure and its implications for water resource assessment and management was stated as one of the important issues which could have serious implications for research and research findings. Mapping of water footprints in the whole value chain, and its impact for specific use, is a new water accounting methodology gaining popularity here in South Africa. Application of real-time water assessment models and tools, water security (quality and quantity) to support growth, and targets for 2030 are also important issues The large water footprint associated with energy production is gaining importance as water scarcity continues to become more obvious. New energy technologies – from advanced methods of extracting fossil fuels to low-carbon renewable energy – may look appealing, but they exacerbate water concerns, creating unfavourable trade-offs between carbon and water. However, a myriad of technologies – including water reuse and recycling, increases in energy production efficiency, and large-scale distribution – can help with addressing these trade-offs. Going forward, energy technologies' water intensity will often play as great a role as their carbon footprint in determining the future makeup of the global energy mix.

Water scarcity with regards to future water supply options; new water such as water re-use, return flows, desalination; and the implications for water resource allocation options could require further research. Support methodologies for water resource planning options such as recharge, retention and recycling need be addressed in a consolidated fashion to satisfy increased demands sustainably. Augmentation options versus new water sources and feasibility studies have been the domain of national planning. Timely implementation of new infrastructure, including the planning cycle, can be enhanced through scenario building and economic valuations. Water accounting has been hailed as an instrument for ensuring the mapping of water footprints. Water footprints are an indicator of water use that looks at both direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business. The new water accounting framework can serve as a basis for developing innovative strategies to mitigate problems that relate to the increasing global freshwater scarcity. One of such strategies is to promote water neutrality among businesses, encouraging or compelling them to reduce and offset the negative social and environmental impacts of their water usage. Another instrument is to create a system of (tradable) water footprint permits, a Kyoto-protocol-like system defining a maximum global water footprint, which is allocated among participating countries, favouring the fair allocation of global water resources among the people of the Earth. Yet other instruments proposed are an international water pricing protocol, water labelling of water-intensive products and water certification of businesses. The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations and timing. The ecological or social impact of a water footprint obviously depends not only on the volume of water used, but also on where and when the water is used. Footprints of water can be further classified into:

- The **blue water footprint** is the volume of freshwater that evaporated from the global blue water resources (surface water and ground water).
- The **green water footprint** is the volume of freshwater evaporated from the global green water resources (rainwater stored in the soil as soil moisture).
- The **grey-water footprint** is the volume of polluted water, calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

Water quality has been a concern for many decades, be it urban water quality, environmental, drinking water, diffuse or point sources of pollution, etc. The research portfolio dealing with water quality has grown over the years covering many aspects of pollution control, water quality modelling, eutrophication, salinisation, nutrient loading, receiving water quality objectives and their implications on water use, total quality management, salts and residue management, etc. Non-compliance, harmful effluent discharge such as in acid mine drainage, failing wastewater works and other non-point sources of pollution are some of the pertinent water quality issues in South Africa.

Uncertainty and climate change go hand in hand. Small uncertainties in the physical processes are amplified into large uncertainties in the climate response. The challenge for policy-makers, planners and environmental decision makers is to understand how the timing and magnitude

of impacts may be affected by changes in climate and sea level rise associated with differing amounts and rates of change in global average temperature. The challenge for climate change research is to develop monitoring and observation systems; refine models to determine the impacts of climate change in a specific area; identify measures to enhance our capacity to adapt (building adaptive capacity) and take advantage of the opportunities presented by climate change; and make information available for those responsible for policy, planning and environmental decision making.

Sectoral and political cooperation: The realisation that water is an embedded sector and needs to be outward-focused emphasises that many decisions around water lie outside the water sector and hence expansion of the stakeholder base is important to affect decisions made around water. Alignment of powers and functions between the 3 spheres of government is defined in the respective laws and legislation. However, the complexity in the management of water and other resources in an integrated manner is proving to be a challenge. This requires a cooperative government functioning seamlessly between national, provincial and local governments. However, the delineation, coordination and support in this value chain have created some blind spots, mainly from a planning and financial point of view. The institutional alignment project of the Department of Water Affairs is yet to define the local provision for management of water resources and further define the role, if any, of local government. The reform of water allocations can only be successful if there is complete alignment between the responsible departments, viz, Trade and Industry, Rural Development and Traditional Affairs, Agriculture and Land Affairs, Labour, Treasury, Land Bank, etc. The new Planning Commission calls for futuristic studies which are able to project alternatives in future scenarios. This KSA will invest in research efforts to further define available options in support of national sustainable growth and development.

Public participation: The move towards a common goal for use of the water resource involves identifying conflicting needs for use of the resource, and resolving or negotiating these conflicts. This process would use IWRM tools like water demand management, water quality management, or the conjunctive use of surface water and groundwater resources. This process would also rely on water resource assessment techniques such as water resource yield models or water quality modelling. It is an iterative process of interaction with stakeholders, and of bringing conflicting stakeholders together to resolve potential conflicts. During the above meeting stakeholders indicated that the WRC provides leadership in research and is not a research follower. There is a need to balance current challenges and forecast future research needs. More partnerships with other sectors; local government, private sector and other public sector agencies are needed. There is a need to continue translating research into implementation through pilot implementation where possible. More focus on repurposing existing research information aimed at a specific target audience was identified as a crucial undertaking, especially given that the size of the knowledge repository which already exists is substantial. Based on the above, the following areas/issues were thought to be important to repackage for targeted stakeholders: water assessments such as WR2005 published in 2009: the state of the water infrastructure; monitoring technologies for infrastructure assessment: drinking water quality: regulation, compliance and enforcement manual; raw water quality: demand for water: shortage of skills: and councillor support tools.

Overview of technological trends

The National Climate Change Committee (NCCC) mandated DST to lead a Technology Needs Assessment (TNA) in relation to climate change in 2007. The TNA shows that, despite remaining uncertainties regarding the exact nature, magnitude and pattern of future rainfall changes in South Africa, it appears that water resources, already under pressure as a result of growing water demand in relation to a finite and limited supply, will be under even greater pressure in the future as a result of climate change. According to the IPCC Technical Paper on Climate Change and Water of June 2008, major gaps in observations of climate change related to freshwater and hydrological cycles were identified as follows:

- Difficulties in the measurement calculated from parameters such as solar radiation, relative humidity and wind speed. Records are often very short, and available for only a few regions, which impedes complete analysis of changes in droughts.
- There may be opportunities for river flow data rescue in some regions. Where no observations are available, the construction of new observing networks should be considered.
- Groundwater is not well monitored, and the processes of groundwater depletion and recharge are not well modelled in many regions.
- Monitoring data are needed on water quality, water use and sediment transport.
- There is a general lack of data from the Southern Hemisphere.
- More information is needed on plant evapotranspiration responses to the combined effects of rising atmospheric CO_2, rising temperature and rising atmospheric water vapour concentration, in order to better understand the relationship between the direct effects of atmospheric CO_2 enrichment and changes in the hydrological cycle.
- Quality assurance, homogenisation of data sets, and inter-calibration of methods and procedures could be important whenever different agencies, countries, etc.,

maintain monitoring within one region or catchment. Better observational data and data access are necessary to improve understanding of ongoing changes, to better constrain model projections, and are a prerequisite for adaptive management required under conditions of climate change. Progress in knowledge depends on improved data availability. Shrinkage of some observational networks is occurring. Relatively short records may not reveal the full extent of natural variability and confound detection studies, while long-term reconstruction can place recent trends and extremes in a broader context.

Satellite radar tools and applications: Wider availability and use of satellite radar in water-use and evapo¬transpiration monitoring is widely accepted. 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. 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.

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 areas where more understanding is needed for any 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.

Water accounting: Accurate information on, and understanding of, the quantity of water that South Africa has available are important for making decisions regarding sustainable and effective water use. Just as financial accounting is essential for the successful operation of a business: standard water accounting practice is needed to provide support, security and confidence in water planning, water allocations and in support of cost-effective investments in water infrastructure. To manage our water resources effectively and sustainably we need to know: how much water there is; where it is; who is using it; and what it is being used for. This will be done by building on the water resource measurement, monitoring and reporting activities already undertaken such as the National Water Resource Strategy (2004) and assessments such as WR2005 as well as other planning instruments already in existence. There is always a need to improve measurements and methodologies adopted for measurements from a quality and a quantity point of view. Having and applying national standards for measurement and metering – including knowing the degree of accuracy of each measurements system – will be a crucial step in developing nationally-compatible water accounting systems.

Key stakeholders

The major stakeholders remain to be the following five groups as in last year's Business Plan:

- The Minister of the Department of Water and Environmental Affairs
- Government departments representing a major group that has a large stake in the research conducted, especially DWA 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 according to the National Water Act
- Other departments such as the Department of Minerals and Energy, the Department of Science and Technology, the Department of Cooperative Governance and Traditional Affairs, the National Department of Agriculture, Forestry and Fisheries, the Department of Health, the Department of Rural Development and Land Reform, Working for Water, the Planning Commission in the Presidency and the related Portfolio Committees of Parliament represent the other stakeholder groups
- Major water users including farmers, mines, industries, energy, 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 fifth group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.

The research conducted within this KSA contributes to better water resource management for the benefit of all stakeholders and role-players.

Other stakeholders

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.

International player

As in previous years, the WRC maintains its peer review and best practice through continuous interactions with international role-players. A new close association will be witnessed in the following year with UNESCO IHP for which the KSA carries the position of Secretariat for the country committee. Other role-players include: CapNet, an established capacity building organisation hosted in the WRC building and a number of their extended networks such as the Philippines CapNet; SaciWATERs, South Asia Consortium for Interdisciplinary Water Re sources Studies; the World Water Council, of which the WRC is a member; and United Nations Agencies such as the UN Environment Programme, which was a partner to the WRC in two completed studies showcased in the Africa Water Week in November 2009. WRC is chairing the review of all the river basins research funded by the Global Environment Facility in partnership with the United Nations University. Waternet contributes experience on an administration of partnerships and GWP and IWMI are leaders in their respective fields. Interactions can be by sharing research projects such as the Water Research Coalition, FRIEND, African Water, and by participating in NEPAD. The KSA is an active partner in a number of EU-funded research coalitions. In other instances, KSA members are invited internationally to make technical contributions in most of the fields, mainly institutional governance, climate change, water quality (mainly in the area of endocrine disruptive compounds), groundwater research and hydrology research, mainly now-casting and innovations in new hydrology models.

STRATEGIC INITIATIVES

National initiatives

Staff members continue to occupy various leadership positions and partake in initiatives (many positions and initiatives are ongoing or set for a term of a number of years). The following are contributions made by the KSA:

- Steering Committee member for drafting National Groundwater Strategy (DWA)
- Member of the Energy and Water SETA task team
- The KSA is assisting DWA in updating the Groundwater Resource Directed Measures manual.
- Presentation to the Water and Environmental Affairs Portfolio Committee on AMD: Groundwater-related research
- Strategic meeting on water with SALGA
- Involved in the Council for Geosciences strategic review

Leadership positions

- Chairperson of the Organising Committee, Groundwater Division - International Association of Hydrogeologists Conference (September 2011)
- Member of Negotiating Team (responsible for water-related climate issues and research), National Climate Change Committee (coordinated by Department of Environmental Affairs)
- Chairperson, National Climate Change Task Team for water hosted by DWA
- Member of the Steering Committee (water issues), Risk & Vulnerability Atlas (coordinated by Department of Science and Technology)
- Steering Committee member, National Outbreak Response team (NORT)
- Steering Committee member, Multisectoral National Outbreak Response team (MNORT)
- Member, Hand washing campaign
- Member, (WASH United Local) (Water and sanitation health)
- Member, National Implementation Plan for Stockholm Convention (NIP)
- Advisor, National Water Quality Forum
- Founding Member, Country Water Partnership
- Board member, Ecolink (an environmental NGO)
- Advisory Board member, Water Research Node, Monash South Africa
- Executive Committee member, African Development Bank and African Water Facility funded project on rainwater harvesting
- Advisory member, National Institutional Realignment Working group
- User Forum Member, National Water Resources Planning Systems
- Member of the Steering Committee of the Working for

Water Research Advisory Panel
- Member of the Groundwater Division of the Geological Society of South Africa
- Member, South Africa Committee for the International Association of Hydrological Sciences (SANCIAHS)
- Member, South African National Commission on Large Dams (SANCOLD)
- Member, Vaal River System Strategy Steering Committee
- Member, Crocodile West Maintenance Reconciliation Strategy: Strategic Steering Committee

Strategic positioning

- Discussions with Advisor to Minister on strategic repositioning of the Department of Water Affairs to appropriately respond to challenges associated with climate change.
- Strategic discussions with the Forestry Climate Change Unit at the Department of Agriculture Forestry and Fisheries, addressing the problem of quantification of carbon stocks in forests, which will enhance the understanding of the link between forest degradation and climate change.
- Two MOUs were signed with DWA for consultancies to commence during 2010/2011 with the following titles:
  - Policy implementation lag time
  - The concept of public trusteeship as embedded in the National Water Act of South Africa of 1998
- An MOU was signed with Working for Water aimed at supporting the Two Streams Catchment research in KwaZulu-Natal.
- The KSA was an advisor to the study entitled: 'The State of Water in South Africa' conducted by the South African Academy of Science.
- The KSA is a member of the Energy and Water Sector Education and Training Authority's Task Team developing the Policy, Guidelines, Procedures & Criteria for the recognition of Institutes of Sectoral or Occupational Excellence (ISOE).
- Initial discussions were held on the State of Water Resources in South Africa with Aalia Ismael of the Presidency's Planning Commission, in support of the newly-appointed advisory panel meetings.
- Discussions were held with Dr Jeremiah Mutamba; Manager: Water-Centred Knowledge at TCTA, regarding potential partnerships on knowledge dissemination activities for water resources management
- A meeting was held on 15 July 2010 between the WRC and Dr Dirk Roux of Monash University South Africa and Dr Mark Pascoe of the Internal Water Centre in Australia to discuss capacity building potential.
- In his capacity as a member of the DEA-led National Committee on Climate Change, a research manager attended a planning meeting on 14 July 2010 in preparation for the UNFCCC meeting held in Mexico in December 2010.
- The WRC organised a strategic meeting between WISA and the Global Water Partnership (GWP) to discuss the hosting of the Country Water Partnership (CWP) for South Africa.
- A WRC and SALGA task team roundtable discussion consolidated the partnership between the two parties and a number of research topics were highlighted as priority to be conducted during 2011/12 cycle.
- WRC co-hosted a conference 'Water and Poverty: a dialogue for action' with DWA, Ethekweni Municipality and the Danish International Aid Department (DANIDA).
- A research manager made a presentation to the Portfolio Committee on Water Affairs on groundwater-related research during the Acid Mine Drainage briefing at Parliament.
- The KSA chaired a session on 'Freshwater ecosystems' in Cape Town during the Summit on Biodiversity upon invitation by SAEON.
- The KSA was invited to make inputs into the strategic plan of the National Department of Agriculture on flood management.
- The KSA was invited by the CEO of Rand Water to attend and participate in the strategic planning meeting of the Board on 5 November 2010 at Muldersdrift.
- KSA 1, jointly with KSA2, held a second strategic meeting with SANParks in which elaborations on joint activities were shared. The proposed use of the national parks as water resource laboratories was welcomed, as well as joint workshops on specific aquatic and terrestrial research.
- Strategic discussions with DWA, North West regional office, were held, as to how WRC can manage and steer the review and scientific evaluation of the *Harties Metsi a me* project as per request from Parliament. The review will be jointly funded by the two parties.
- The KSA participated in the Vaal River Strategy Steering Committee as a member and representative of the WRC.
- The KSA was invited to a meeting hosted by the Provincial Drought Management Centre in Cape Town, to explore potential collaboration in hosting a workshop on debriefing and a 10-year strategic plan for extreme events (such as droughts and floods).

African leadership

In Africa, the WRC plays an active role in activities aimed at building water-centred knowledge. Key initiatives include:

- The hosting of the Southern African Regional Capacity Building Centre: The WRC supports the TIGER Initiative (an initiative by the European Space Agency), a UNESCO-IHP supported programme that is aimed at assisting African countries to overcome problems faced in the collection, analysis and dissemination of water-related geo-information, by exploiting the advantages of earth observation technology. The WRC is, with effect from

December 2009, hosting the Southern Africa regional centre of the TIGER Initiative. An agreement between the TRC and the International Institute for Geo-Information Science and Earth Observation (ITC) of the Netherlands has been entered into in this regard. A WRC research manager, who coordinates TIGER activities including capacity building for aquatic scientists involved in TIGER projects, also manages the centre.

- A meeting was held with SADC Water Division in Gabo rone to discuss the collaborative potential between SDC and TIGER and WRC.
- The WRC, on behalf of UNEP-Sudan hosted a delegation of technical water professionals from the Darfur regions, West of Sudan. A follow-up delegation of 20 representatives, including Ministers of water, agriculture and land, mainly from Darfur, visited South Africa in November to learn from South African scientists about conducting regional water resource assessments and the establishment of decentralised water management institutions.
- The WRC is supporting the proposal for the establishment of the first Category II UNESCO Centre in Africa, called the 'The African Centre for Global Change and Water Resources Research', to be hosted by the University of KwaZulu-Natal.
- The WRC was invited by the Academy of Science of South Africa (ASSAf) to make a presentation on the South African water situation at the NASAC Water Programme Workshop in Nairobi. At the workshop the WRC was appointed as co-chair of the NASAC Water Programme.

Global player

The KSA took part in the following global initiatives, among others:

- The WRC continues to support SAFewater (the French-South African cooperation for research on water), and continues to act as the Secretariat for the UNESCO International Hydrological Programme (IHP) National Committee.
- The WRC continues to be an active member of the Global Water Research Coalition (GWRC), and is currently collaborating with members of the GWRC in research programmes addressing the removal of pharmaceuticals, the influence of EDCs on the thyroid and other ED functions, known, new and emerging microbial pathogens, and the occurrence of pathogens in source water with a special focus on the occurrence of enteric viruses.
- The KSA acted as a reviewer for the *Water Alternatives* journal which is a multi-disciplinary international journal on water, politics and development.
- A workshop was co-convened by the WRC and the World Water Council on 'Water for Growth and Development in Africa – Understanding and Addressing Policy Complexities'. The WRC is a member of the World Water Council and this workshop is considered as a strategic joint venture which can bring about other collaborations with the Council.
- The WRC hosted the second review meeting of the Global Environmental Facility (GEF) International Waters (IW) Science Assessment, attended by both the River Basins and the Lakes Working Groups.
- A request from the Swiss Embassy was received to host a fact-finding mission from EAWAG and the Swiss Federal Department of Foreign Affairs (FDFA) to South Africa.
- The KSA facilitated and managed the World Bank's global groundwater governance assessment.
- A research manager attended the United Nations Framework Convention on Climate Change (UNFCCC) in Cancun, Mexico, and was involved in supporting the Minister of Water and Environmental Affairs to develop a position paper that ensures that water becomes a standard item on the Convention of Parties (COP) agenda.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

The number of postgraduate students benefitting through WRC-funded research is reflected in the table below. This was in line with the set targets.

TABLE 1
Capacity building through student involvement in KSA 1 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Agricultural Research Council (ARC)	1	3
Centre for Environmental Economics and Policy in Africa	3	3
CSIR	5	10
Golder Associates Africa (Pty.) Ltd.	4	4
Groundwater Africa	0	1
Hydrosoft Institute	1	1
Jeffares & Green (Pty.) Ltd.	1	2
Ninham Shand Consulting Engineers (Aurecon)	2	7
North-West University, Potchefstroom Campus	5	12
Pegasys Strategy and Development (Pty.) Ltd.	0	1
Pegram and Associates (Pty.) Ltd.	6	8
Rhodes University	6	6
South African Weather Service	2	3
SSI Engineers and Environmental Consultants (Pty.) Ltd.	4	5
Umvoto Africa	3	4
University of Cape Town	6	9
University of Kwazulu-Natal	10	26
University of Pretoria	1	4
University of Fort Hare	6	6
University of South Africa	2	5
University of Stellenbosch	8	16
University of the Free State	17	25
University of the Western Cape	8	9
University of Venda	10	10
TOTALS	**111**	**180**

In total 16 project leaders were women (compared to 18 in 2009/10) and 17 project leaders were Black males (compared to 13 in 2009/10). Of the 180 students capacitated within WRC projects, 111 were historically disadvantaged. As part of its capacity building initiatives, the KSA was involved in hosting the following workshops, among others:

- In collaboration with the South African Weather Service (SAWS), a workshop aimed at resuscitating implementation of weather modification as a water availability augmentation option and adaptation action to climate change.
- Workshops on 'Groundwater governance' in partnership with the World Bank.
- The WRC hosted a number of workshops at *WISA 2010*,

Durban:
  - A workshop on 'Groundwater-surface water interactions'
  - Two workshops on water quality, i.e. on emerging contaminants that could have an influence on drinking water quality and another workshop on best practices to manage water quality at a catchment scale
  - A workshop was co-convened by the WRC and the World Water Council on 'Water for growth and development in Africa – understanding and addressing policy complexities'
- A workshop was held at the launch of a project between the WRC, the World Bank, the University of Pretoria and the University of Riverside, California, on 'Water governance decentralisation in Africa: a framework for reform process and performance analysis'.
- A workshop was jointly organised by WRC and DWA on 'Exploring fundamentals of water quality modelling'.
- A discussion workshop with DWA (Western Cape regional office) and National Disaster Management to chart the way forward for the potential 'Documentation of lessons from the Southern Cape drought experiences'.
- A joint WRC/ASSAf workshop on 'State of water in South Africa'.
- The WRC hosted a workshop on investigating innovative ways of incorporating climate change modelling scenarios into water resource planning processes.
- A joint workshop with the National Business Initiative (NBI) on water footprinting.

Knowledge dissemination

The KSA participated in a number of initiatives contributing to the water-centred knowledge base in South Africa. These initiatives included participation at open days and arrangement of technology transfer workshops (including participation). The following strategic capacity building interventions were undertaken to enhance representation from HDI universities:

- The KSA was invited to make a presentation within and facilitate a session at a Water Research Workshop organised by the Faculty of Science, Engineering and Technology (SET) at Walter Sisulu University. This was a follow-on workshop which came about as a result of the KSA1 initiative in September 2009 to build research capacity in former Black universities, and to encourage them to participate in WRC-funded water research. The workshop was attended by Heads of Schools and Departmental research coordinators; key research themes were identified and the group is planning to prepare research proposals in due course.
- The KSA met with the University of Zululand's Faculty of Science to explore future potential research collaboration and to encourage the University to participate in WRC-funded water research. The meeting was attended by the Rector of the University together with Deans, Heads of Department and representatives from the Faculties of Arts, Commerce and Science.
- The KSA undertook a visit to the Tshwane University of Technology to have discussions regarding research collaboration with the climate change group.
- A DVD on the water cycle was produced as an introduction to the fundamentals of water resource management. The aim is for the video to act as a general base for further elaborations of other aspects such as water use, water protection, water assessments, etc.
- DVDs were produced on Water Resources and Local Government, in partnership with SALGA and WIN-SA.
- Another DVD, *Water from Stone*, was produced on groundwater in the hydrological cycle.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- A paper was presented on the 'Value of monitoring in WRM' at the Eden Drought Summit.
- A presentation on 'water resources and the green economy' at the Green Economy Summit .
- A presentation entitled 'Urban hydrogeology in South Africa: Current status and future challenges' was made at *International Water Association World Water Congress and Exhibition*, Montreal, Canada.
- The KSA delivered the welcoming address at the *11th International Symposium on Sedimentation and Sustainable Use of River Systems*.
- Reviewer for *Hydrogeology Journal*.
- External examiner: University of the Free State and Cape Peninsula University of Technology.
- Co-authored a chapter in the book *Transforming Water Management in South Africa - Designing and Implementing a New Policy Framework, Global Issues in Water Policy 2 Series*.

IMPLEMENTATION PLAN

Research portfolio for 2010/11

The primary objective of the research in this KSA continues 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 2010/11 addresses this primary objective as reflected by the following secondary aims to:

- Improve water resource information systems and access to data.
- Achieve integration between surface water 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 2010/11 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. In this programme, the continued deterioration of hydrological gauging processes and other installed earth measurement devices will be addressed through the intensive use of new data sources from remote sensing coupled with the limited earth-based measurements.

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 un-gauged 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 as expressed in the objectives of Water for Growth and Development, as well as account for other factors which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals. Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water uses will be investigated and included as part of future water resource plans.
Programme 4: New water	**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 and water transfers, be they national or international, from desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. Solutions for supporting and complementing the processes and strategies pursued by the Water Infrastructure Agency will be developed. The initial development of research under the new theme of Water and Energy will be initiated through this programme. In this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.

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

Scope: Research in this thrust focuses on the generation of information and knowledge to improve water resource management, with reference to pollution/contamination from point sources and diffuse sources, and addressing chemical, microbial, physical and biological pollution/contamination impacts on surface water and groundwater. This thrust also addresses water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation within water bodies. Scientific and technological approaches that will help characterise and address these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies; uncertainty, etc.); (3) Technological innovation and forecasting and (4) Implementation approaches and technology transfer options.

Programme 1: Developing predictive tools and adaptive measures to global climate change and hydro-climatic variability	**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 function and ecological processes. The following key issues thus need to be considered and addressed in this programme: determination of the confidence level that can be placed on current GCM-generated scenarios of global climate change; degree to which current techniques for downscaling of scenarios from global to regional and catchment scales can be reliable and robust; detection and attribution of anthropogenic impacts on climate change in the Southern African context to distinguish those from natural climate variability and change. Choice of relevant and appropriate monitoring systems that need to be in place in this regard; determination of the frequency and magnitude of resultant extreme rainfall and flow events; use of existing conceptual and numerical models to utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely inter-related land-use, ecosystem, hydrological (including geohydrological), and water yield and water quality changes at regional/catchment level; modification of existing management strategies and tools for adaptation purposes; determining the likely socio-economic impacts for a given structure of society in Southern Africa; and appropriate technological, social and political coping strategies. This programme is also aimed at improving understanding and forecasting of the variability of rainfall, flow and groundwater recharge as the ability to forecast at very short time scales would greatly benefit flood management and disaster mitigation and adaptation activities, and on improving the understanding of global climate change impacts and vulnerability for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and adaptation actions. 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 2: Managing human-induced impacts on water quality and quantity	**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. This programme also promotes water demand management and the use of poor quality water and further seeks to investigate and apply water quality control and mitigation measures. 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. Hence, the research focus is further aimed at improving 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 water quality and quantity impacts.

Programme 3: Integrated flood and drought management	**Scope:** 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 resource management, with reference to point sources and 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. Scientific and technological approaches that will help characterise and address these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies, uncertainty, etc.); (3) Technological innovation; and (4) Implementation approaches and technology transfer options.

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.
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 various authorities to protect water resources (groundwater, dams and rivers) in a sustainable manner through the development of, among others, groundwater protection zones, pollution control and monitoring as well as improved land-use planning.
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, and 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.

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 challenges, 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. Benchmarking 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 by 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 groundbreaking 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 charge 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 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.

RESEARCH PROJECTS FOR 2010/11

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

The premise of the study is that hydrological balance of any river basin is directly and indirectly influenced by the spatial and temporal distribution of land-use and land-cover changes. Changes in land cover can modify crucial hydrological processes, such as evapotranspiration and groundwater recharge. Upstream land-use change could bring about a significant on-site effect on catchment water resources and off-site effect on downstream users. For instance, the introduction of IRWH in the upper Modder River basin catchment may result in a significant impact on the downstream water users and the ecological balance of the system if allowed to expand unchecked. Therefore, the aim of this study was to contribute to the understanding of the dynamics of human-environment interactions and decision-making processes for the sustainable use of land and water in the Modder River basin.

Cost: R357 000
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
Umfula Wempilo Consulting
No. 1212

This project aimed to satisfy the need for a simple-to-apply evaluation tool, which can rapidly assess the impact of waste load discharge permit applications and the permit conditions that would be required to meet water quality objectives. Models that were available for this purpose are generally complex and data-intensive, requiring experts to set them up and run them. The model that was developed makes good use of new water quality data; it simulates the effects of both conservative and non-conservative pollutants and takes account of both point and diffuse inputs. While the model requires experts to first set up the model, thereafter it can be used by CMA and Regional Office personnel to rapidly test a range of waste discharge options with minimal input from experts. This should reduce the cost of processing waste discharge applications and testing of alternative discharge permit conditions.

Cost: R494 890
Term: 2001 - 2010

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

Almost the whole continent of Africa is underlain by crystalline basement rocks, albeit in places under a thick cover of more recent material. Consequently, crystalline basement rocks form the largest of the four major aquifer domains or 'hydrogeological provinces' found in sub-Saharan Africa, covering about 40% of the region's 23.6 million square kilometres. Crystalline basement aquifers differ in important ways from other aquifer types, and demand specific knowledge and techniques if groundwater is to be extracted and managed efficiently. The study covered two distinct geological and morpho-structural domains within the Limpopo Province, the Limpopo Plateau in the west and the Letaba Lowveld in the east, together covering about 23 500 km^2. The basement rocks of the Limpopo Province are structurally complex, shaped by multiple tectono-metamorphic events spanning at least 600 million years. The borehole dataset compiled for the study consisted of over 8 000 boreholes contained in the Groundwater Resources Information Project (GRIP) Limpopo database of the South African Department of Water Affairs. Approximately 3 000 of these boreholes have been hydraulically tested and the lithology has been recorded for 1 200. The basement lithologies of the study area are characterised by a generally thin regolith overlying a primarily structurally-controlled fractured aquifer. Compared to the Letaba Lowveld, the Limpopo Plateau is generally characterised by deeper boreholes due to deeper water strikes, water levels, weathering and fracturing depths. Geology has a clear influence, with boreholes exploiting intergranular aquifers composed of highly permeable material showing generally higher yields. Other identified favourable groundwater targets are the metamorphic aureoles of younger granite intrusions and complexes. Despite the local importance of the regolith as a recharge and storage mechanism for the underlying fractured bedrock, no correlation between borehole yields and depth of weathering was found. A differentiated pattern of lineament, shear zone and dyke orientations in the different domains let to a more complex conceptual model of groundwater occurrence and borehole productivity. This conceptual model is inconsistent with the predicted regime based on regional stress field data and suggests that local variations have a strong influence on groundwater occurrence.

Cost: R3 500 000
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

The main hypothesis of the research was that soil properties, presented in the form of hydropedological soil maps together with the relevant soil hydrology data, can serve as indicators of the hydrological behaviour of soils in a hillslope, and therefore facilitate prediction of the hydrological behaviour of hillslopes, particularly those in ungauged catchments. Five catchments were surveyed, the Weatherly, Cathedral Peak VI, Two Streams, Craigie Burn and Bedford catchments. Soil data were used as input to ACRU, Pitman, SWAT and Waves. The soil data improved the efficiency of the models, with the greatest improvement in the models capable of simulating enhanced process complexity.

Cost: R1 873 500
Term: 2007 - 2010

Programme 4: New water

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 preliminary findings of the study show that ocean colour remote sensing provides a unique means of assessing the effects that variation in freshwater influxes have on the coastal marine environment, as it provides a cost-effective ability to routinely provide quantifiable synoptic data of phytoplankton biomass and production, as well as fluctuations of sediment and dissolved organic material from riverine input. Specifically, the MERIS C2R algorithm provides optimal products in Case 2 waters, but the default atmospheric correction and 'Algal 1' in-water products will serve users better in offshore Case 1 waters. Validation data have been gathered in 2009 and 2010, and these will form the basis for routinely providing error products along with geophysical products in the region – an important step in the effective utilisation of the ocean colour data in climate-related time series analyses.

Cost: R315 000
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 and hydro-climatic variability

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

The purpose of this project was to investigate effects of climate change on second-order impacts, viz. ecological flow indicators and water temperature parameters, with particular focus on scientific techniques and methods. This was achieved by downscaling climate output from the ECHAM5/MPI-OM general circulation model (GCM) and then using the results as input data into the daily time-step ACRU hydrological model in order to simulate the impacts of climate change, as projected by this particular GCM, on the selected eco-hydrological indicators at a fine spatial scale. The first section of the report describes how the downscaled climate scenarios were developed, the state of current knowledge with respect to the climate system and how it may evolve, as well as the context within which these climate scenarios should be assessed. The second section deals with the hydrological modelling and derivation of ecological parameters. The results are also presented by means of maps at the scale of quinary catchments. The results of the water temperature analysis for the Thukela catchment are also presented by means of maps, while time-series graphs are used to describe water temperature parameters for 15 selected quinary catchments. In the final chapter the project aims are revisited and a summary of findings and recommendations for future research are provided.

Cost: R2 500 000
Term: 2005 - 2010

Programme 2: Managing human-induced impacts on water quality and quantity

Endocrine disruptive chemical (EDC) activity and health effects of identified veterinary compounds in surface- and groundwater
University of Pretoria
No. 1686

The aim of the study was to investigate the possible impact of growth stimulants used at cattle feedlots on EDCs in water. Objectives were to screen water sources close to selected feedlots in South Africa for estrogenic and androgenic activity using bio-assays, to determine

the endocrine-disrupting (estrogenic and androgenic) activity of growth stimulants, by using a battery of screening bio-assays, to do a reproductive toxicology study, using the rat model, on the identified mixture of compounds at environmentally relevant concentrations, and to perform a toxicological study on sharptooth catfish, as well as to investigate the impacts of selected cattle feedlots on aquatic ecosystems at different sites. As most of the identified growth stimulants used in South Africa were found to be below the detection limit in the collected samples, there is a clear need for refinement of methodology and analytical techniques. The bioassays were successfully applied to measure the estrogenic and androgenic activity and potency of the selected growth stimulants used in South Africa. In addition to the rat toxicology, effects were seen in life stages of the exposed fish species. Macro-invertebrate community structures (diversity and abundance) were found to differ between upstream and downstream sites associated with feedlot activities. Seasonal differences were also observed. Evidence and observations from this study suggest the need for a proper investigation of cattle feedlots regarding the use of EDCs and other veterinary compounds as there is reason to suspect an impact on surface water and groundwater. No environmental impact studies are currently done for registration of EDCs. It is suggested that monitoring should become part of the licensing process for these potentially harmful compounds.

Cost: R1 900 000
Term: 2006 - 2010

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

This research addresses issues regarding water quality arising from land cover type change and urban sprawl in a predominantly agricultural catchment in Cape Town. The Kuils and Eerste Rivers are two important rivers that run through the eastern part of the Cape Metropolitan Area (CMA). An assessment of nonpoint source (NPS) pollution in the Kuils-Eerste River catchment in the Cape Metropolitan Authority Area (CMA) through hydrologic experiments and modelling using a geographic information system was achieved. One of the critical components of this study was to conduct hydrologic experiments at selected locations for measuring surface runoff within the catchment in order to generate date for the GIS models. Collation of existing data on stream flow measurements and water chemistry of stream and surface runoff water was conducted. The values obtained show the influence of precipitation and the seasonal variability of the rainfall as it affects the amount of discharge in the river. Such variations are likely to influence the distribution of surface pollutants in the river network, as a high percentage of the discharge in the river originates from storm runoff. The RINSPE and N-SPECT models were successfully applied to the Kuils-Eerste River catchment and to estimate NPS pollutant loads of chosen variables such as nitrate, chloride, total nitrogen, total phosphorous and total suspended solids. The success with which surface water variables such as concentrations and loads of nitrate, chloride, nitrogen, phosphorous and suspended solids may be simulated in surface water using the above two models depends largely on the quality of input data available, such as rainfall, runoff distribution and a digital elevation model.

Cost: R765 000
Term: 2006 - 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

One of the most difficult hydrological variables to collect and interpret is soil moisture. It is more spatially variable than rainfall because of the spatial variability of soil type and depth, local slope of ground and vegetation. Local estimates of soil moisture are valuable in the vicinity of the measurement. However, to interpolate this information spatially is difficult. This project aimed to address this challenge. For the purpose of corroboration two independent approaches were used to estimate soil moisture at the scale of a region-sized catchment (Liebenbergsvlei, 4 625 km2, South Africa). The Soil Saturation Index (SSI) was derived from the physically-based hydrological modelling of the catchment using the TOPKAPI model, and the Soil Wetness Index (SWI) was derived from the remotely-sensed observations of the scatterometer on board the ERS satellite; these indices were compared and found to have good agreement. A website was designed to make these valuable data readily available to practitioners in agriculture, catchment management, drought monitoring and flood forecasting.

Cost: R2 483 200
Term: 2006 - 2010

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and ground¬water quality

Importance of groundwater in the hydrological cycle and the relationship to surface water bodies
University of Zululand (Department of Hydrology)
No. 1168

The study describes the many different methods and techniques that were evaluated in an attempt to understand and quantify the interaction between surface water and groundwater of Maputaland. The study focussed primarily on surface water resources, such as lakes and rivers that have been identified as important management areas, principally for water allocations. However, the concepts and methods described in this report can be applied to all exposed water bodies to determine their level of interaction, which is required as a precursor to the determination of the importance of the groundwater in sustaining the functions (ecological or otherwise) of the systems. The conceptual model of groundwater and its relationship to surface water bodies has been presented in a generic sense but has been illustrated in the five case studies. The case studies describe specific features of the surface water - groundwater interaction, highlighting the role and importance of groundwater to surface water features and methods of analysis.

Cost: R770 000
Term: 2000 - 2010

Groundwater management functions
Umvoto Africa (Pty.) Ltd.
No.1917

Strengthening the capacity of the catchment-based authorities to manage groundwater effectively is an important challenge. This can be achieved by identifying local needs and trends, facilitating communication and cooperation, and promoting best management practices. The success of any groundwater management plan depends on the effectiveness of the responsible authorities and is also a prerequisite for integrated water resource management. The main aims of this project were: (1) Define the functions of planning, organising, directing and control, in terms of groundwater management; (2) Develop and incorporate the appropriate management functions into a groundwater management framework for improved resource management, targeting local municipalities, and (3) To establish the value of groundwater for different users and to determine a tariff strategy for groundwater which will consider both the actual supply costs (fixed and variable) and the value of water.

Cost: R398 600
Term: 2009 - 2010

Programme 3: Integrated river flow and catchment hydraulics

Sedimentation and sediment yield maps for South Africa
University of Stellenbosch
No. 1765

This is a report of work on the revision of the sediment yield map of Southern Africa. The current sediment yield determination methodology for Southern Africa was developed in 1992 (Rooseboom et al., 1992). Continual revision of sediment yield prediction methods is necessary in the wake of changing environments, additional data, advanced analysis tools, increased experience and current technological advancements in the sedimentation field. This report presents the revised methods for the prediction of sediment yields from ungauged catchments for South Africa and Lesotho.

Cost: R1 400 000
Term: 2007 - 2010

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

The criteria necessary for the success of women in the water sector
Palmer Development Group
No. 1762

This study set out to gain an understanding of how women in the water sector have achieved positions of seniority and leadership, and to explore the lessons that can be drawn from their experiences to inspire other women aspiring for leadership in the sector. From the experiences and lessons shared the study distilled a set of criteria for women to achieve career success in the water sector. The study's departure point was to focus on those women who have achieved levels of leadership and senior management in the water sector; to establish how they made it; and to explore the ways in which they cope with the responsibilities of their high-ranking positions.
The study represents a focused analysis of women working in the water sector, specifically women occupying senior positions (Director level and above) within public sector water institutions. A study population of 40 people, women and men, was identified and face-to-face interviews were conducted. It was decided to include men in the study population and sample, in order to gain a perspective of their role in supporting women in the sector. Due to challenges of access 34 of 40 people identified were interviewed, that is, 26 senior women and 8 senior men. The research methodology was qualitative and the interviews were carried out according to five broad categories that included background, challenges encountered, support mechanisms, policy environment and women's leadership in the sector.

Cost: R691 385
Term: 2007 - 2010

Exploring the lowest appropriate level of water governance in South Africa
University of the Western Cape; University of Botswana
No. 1837

Arriving at appropriate structures and forms of water governance is particularly important in South Africa. South Africa remains a highly divided society. The early focus on water delivery, facilitated through the Water Services Act (Republic of South Africa, 1997), and on equitable, efficient and sustainable water resource management through the National Water Act (Republic of South Africa, 1998), highlighted the central importance of water in socio-economic development. The catchphrase 'some, for all, forever, together' developed by the Department of Water Affairs (DWA) is simple yet powerful. It stands in contrast to the facts of water resource access, use and development across South African society, which may be accurately captured in the phrase 'almost all for some'. Moving beyond 'almost all for some' has proved exceedingly difficult, for many reasons, many of which are highlighted in this final report.

Cost: R1 000 000
Term: 2008 - 2010

The impact of IWRM on the lives of women and the poor in South Africa
Ninham Shand (Aurecon); University of the Western Cape; Groundwater Africa; North-West University; Rand Water; The Rural Action Com¬mi¬ttee; Mbumba Devel¬op¬ment Services; Um¬hlaba Consulting Group; FAO; Gavin Quibell (independent consultant); Roger Short (independent consultant); DANIDA/DWA; PLAAS (Institute for Poverty, Land and Agrarian Studies, UWC)
No. 1839

Integrated Water Resource Management (IWRM) is a conceptual guideline for the use, development and management of water resources, as such it seeks to guide activities such as land use and resource use and minimises impacts on the environment, thus maximising resultant economic and social welfare, in an equitable manner without compromising the sustainability of vital ecosystems. The focus of this was to evaluate the impact of IWRM on the lives of women and the poor in South Africa. The evaluation focused on the potential impacts of IWRM, such as sustainable water resources that are accessible for domestic and environmental needs, for international obligations/requirements, and for productive use, rather than on an assessment of the success of implementation of IWRM to date. The aims of this project were 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
- Develop indicators for assessing how IWRM will impact the lives of women and the poor and apply these indicators to South African case studies
- Build research capacity locally and internationally on approaches to implement and monitor IWRM

Cost: R1 000 000
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

The water services sector has a number of attributes that determines its financing. Firstly, there are many decision-makers within the water services sector. Secondly, there are many sources of finance, including the national equitable share, conditional grants, loans and tariff income. Thirdly, financial and human capacity within the sector varies considerably. Because of the many institutions involved in all of the processes, a complete picture of financing in the sector has not emerged. In order to analyse finances in the water services sector, this research project, following a well-known concept from business management, has postulated a 'value chain'. This envisages the adding of value through a number of sequential functions (or phases), as the technical and institutional arrangements change to match the challenges of each function. This also allows the examination of each function to determine the contribution of the institutions that lead it to overall efficiency and effectiveness. What is important in the context of regulated markets and prices is that 'value', 'cost' and 'price' are not equivalent. (Theoretically they only come together in a perfectly open market.) The purpose of this analysis is, on one level, to guide policy formulation in the water services and municipal sectors and, on another level, to assist all decision-makers to be better informed in making financial decisions concerning matters such as financial grant allocations, tariffs, capital expenditure, operations and maintenance expenditure.

Cost: R2 500 000
Term: 2008 - 2010

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

The SADC Protocol on shared watercourse systems is a

key milestone toward establishing international cooperation to manage water resources in the region. The revised SADC Protocol outlines a number of institutions that are necessary to achieve integrated management of transboundary river basins in the region. The management of transboundary river basins directly impacts on stakeholders at national and local levels in riparian states. The SADC Protocol, however, does not address stakeholder involvement in these water management institutions. The overall objectives of the project were as follows:

- To investigate the extent to which the SADC protocol is applied in South Africa, with special focus on the roles and inter-relationships of national institutions vis-à-vis international commissions and authorities.
- To conceptualise how national development agendas and activities are factored into international agreements.
- To review international literature on similar aspects
- To map out a desired future state for interactions between national and international institutions responsible for management and development of water resources

The involvement of stakeholders in the establishment and management of the river basin organisations formed an integral part of the investigation at both national and international level.

Cost: R3 000 000
Term: 2007 - 2010

CURRENT 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

The preparation of a hydrologically improved digital elevation model for South Africa based on the SRTM data set
ARC
No. 1908

The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of the earth. This data set is currently in use in most hydrological studies. The data come with several errors that require processing. The worst of these errors are sinks, which are cells whose flow direction cannot be assigned. This study will develop methods for producing hydrologically correct SRTM datasets with gaps and sinks filled. The research will also re-interpolate hydrologically corrected SA DEM to 30 m and do a comparative analysis for a small study over the USA area where both 30 m and 90 m SRTM datasets are available.

Estimated cost: R350 000
Expected term: 2009 - 2011

Reducing uncertainties of evapotranspiration and preferential flow in the estimation of groundwater recharge
CSIR
No.1909

This project proposes to develop improved process-based estimates of groundwater recharge. Attention will be focused on the determination of two important components of the water balance, in particular, evapotranspiration and water movement through preferential flow. Improved recharge determination will allow more accurate estimates of associated processes, such as, for example, transport and transformation of possible contaminants, leaching, etc., as well as predictions of possible climate change impacts on the groundwater resource. The main outcome will be to develop improved methodologies for the estimation of recharge, by reducing uncertainties in evapotranspiration estimates and preferential flow.

Estimated cost: R2 000 000
Expected term: 2009 - 2011

The hydrogeology of ground¬water Region 10: Karst Belt
R Meyer (private consultant)
No.1916

The following reports in this series have thus far been published by the WRC: Region 1 (Makoppa Dome) and Region 3 (Limpopo Granulite-Gneiss belt) in 2000, Region 7 (Polokwane/Pietersburg Plateau) and Region 19 (Lowveld) in 2003, and Region 26 (Bushmanland) in 2007. The Karst Belt, also referred to as Region 10, has been identified as the next region for which the current state of hydrogeological knowledge should be documented. This region was selected for the following reasons: (a) the importance of the dolomitic/karst aquifers as potential sources of good quality groundwater in large quantities, (b) the vulnerability of these groundwater resources to contamination from a wide range of human and land use activities, and (c) the need to collate in a single reference a synthesis of the current knowledge and understanding of these hydro-geological systems.

Estimated cost: R550 000
Expected term: 2009 - 2011

Programme 2: Surface water / groundwater hydrology

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

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 upcaling 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 useable 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

The use of isotope hydrology to characterise and assess water resources in South(ern) Africa
University of the Witwatersrand
No.1907

This project will be used to assess the water resources of selected areas, building on new, existing and earlier, uncompleted studies, information and data. The other main aim is to re-establish and develop the required capacity to analyse and interpret isotopic data and information. This will be achieved through the re-interpretation of available isotope data in South(ern) Africa as well as developing new studies whereby the usefulness of isotope hydrology is demonstrated.

Estimated cost: R2 009 200
Expected term: 2009 - 2012

Modelled sea-surface temperature scenario considerations and Southern Africa's seasonal rainfall and temperature predictability
South African Weather Service
No.1913

The objective of this project is to investigate an optimal model configuration that includes the best available description of the surface boundary conditions, as reflected in the projected global sea surface temperature, in order to force global circulation models (GCMs) to produce seasonal rainfall and temperature over South Africa at lead times of several months. A comprehensive analysis between one-tiered and two-tiered forecasting systems will be conducted to inform decisions on development of a fully coupled forecasting system for the region. The model will then be implemented and run to generate required data. Seasonal predictability will also enhance adaptive water management capacity.

Estimated cost: R 488 625
Expected term: 2009 - 2012

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: New water

Review and update of the SANCOLD guidelines for the design of freeboard of dams
University of Stellenbosch
No. 1759

A DWA 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

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

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); DWA; 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 four 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

Water resources in rural communities in the Limpopo Province: Social, chemical and microbiological quality evaluations and interactions
University of Venda
No.1910

In most rural areas, river water is consumed without any treatment. Previous studies in the Limpopo Province have indicated high levels of bacterial indicators in river waters; however, the occurrence of parasitic organisms has not been investigated, as well as the interactions between human activity, groundwater, river water and wastewater. Such information is important and will advise on the involvement of the community in water governance crucial to the protection of water sources. This study will investigate the possible interactions between rivers, borehole water and wastewater, through the analysis of the chemical and molecular profiles of parasitic organisms isolated from the different sources.

Estimated cost: R600 000
Expected term: 2009 - 2011

Investigation of unsteady flow conditions at dam-bottom outlet works due to air entrainment during gate closure
University of Stellenbosch
No.1914

The behaviour of dam outlets that are located in the conduit passing underneath the dams, for large volumes of water releases, is not adequately understood in practice and dam design. Potentially dangerous unsteady flow patterns were experienced during the commissioning tests of the Berg River Dam in June 2008. Air that was sucked into the outlet conduit and released at high flow rates with water resulted in unsteady outflow conditions which could have led to damage and failure of the outlet works, with devastating consequences. This study will investigate in more detail the behaviour and role of air-vent pipes at gates at bottom outlets of dams, to ensure the safe design and operation of outlet works in future.

Estimated cost: R872 800
Expected term: 2009 - 2011

Programme 2: Managing human-induced impacts on water quality and quantity

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

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

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

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 (CH_3Hg) 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 CH_3Hg. 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

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

DWA 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

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

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

Programme 3: Integrated flood and drought management

A comprehensive short- term heavy rainfall forecasting system for South Africa with first implementation over the Gauteng Province (SHORTRAIN)
University of Pretoria
No.1906

The project is aimed at developing an ingredients-based heavy-rainfall forecasting system for RSA, with emphasis on the forecast period from 0 to 24 hours, for use in flood-forecasting systems. The specific objectives include: providing multi-model ensemble forecasts based on numerical weather prediction models; verification of the accuracy and skill of the short-range multi-model ensemble forecasting system; investigation and analysis of characteristics of heavy rainfall over Gauteng at very short time-scales ranging from 5 minutes to 1 hour, as well as at daily, monthly and seasonal time scales. Convective Initiation (CI) climatology for Gauteng and South Africa will also be developed and weather prediction models will be used for forecasting of CI over South Africa. Lightning features associated with heavy rainfall will be examined as well as attempting to understand changes in its characteristics.

Estimated cost: R965 900
Expected term: 2009 - 2011

Development of a system dynamics model for the implementation of IWRM in South Africa: Phase 1 - deriving performance indicators for IWRM implementation on a catchment scale
Jeffares & Green (Pty.) Ltd.
No.1911

The aims of this project are: to optimise the approach to integrated water resource management; fostering of successful cooperative governance in the water sector; integration of existing information management systems within the water sector; synergising existing research and other related activities within the water sector; development of a comprehensive water sector database; development of a performance management system for catchment scale IWRM; capacity creation and development in IWRM within the SA water sector; and information dissemination and knowledge creation in the water sector.

Estimated cost: R488 255
Expected term: 2009 - 2010

Programme 4: Water resource quality management

Nutrient and organic carbon fluxes from small-scale agriculture
University of KwaZulu-Natal
No.1904

The understanding of the sources and pathways of water in a catchment is essential for successful prediction of water quality impacts on receiving streams as well as for the evaluation of remedial measures proposed to abate unacceptable water quality loads. This is especially true for sediment and nutrient fluxes in agricultural catchments. The research will quantify impacts on larger scale catchment sediment, nutrient and organic carbon loading from extended small-scale agricultural land use changes. Nutrient management advice for small-scale farmers, as well as to downstream water resource managers, will be available through this project. Carbon flux evaluation will contribute to quantification of the global carbon budget and implications for climate change.

Estimated cost: R1 639 600
Expected term: 2009 - 2012

The Manual of Guidelines for Projects on EDCs in Water Resources: Volume 1: Monitoring and Assessment Guide
University of Pretoria
No.1915

The EDC research programme has been developed with the aim to provide aid to stakeholders and the Government in the monitoring and management of EDCs. During the first phases the analytical methodologies have been

developed and the programme is now in the phase of developing guidelines on how to monitor and manage pollution to improve water quality or prevent further degradation of water quality. This volume will give guidance on when to monitor, how to do monitoring and, after receiving the data, how to assess and interpret the data for follow-up actions. This will be in line with the National Toxicant Monitoring Programme of DWA. This project will be the first volume of the series of guidelines, and will provide a general background and definitions as well as key issues related to planning and executing an EDC study in a catchment, to be able to make informed decisions to prevent pollution.

Estimated cost: R 1 500 000
Expected term: 2009 - 2012

Guidelines for EDC Management in Water Resources: Volume 4: Management Options for EDCs in Catchments
Golder Associates Africa (Pty.) Ltd.
No.1933

The EDC research programme has been developed with the aim to provide aid to stakeholders and the Government in the monitoring and management of EDCs. During the first phases the analytical methodologies were developed and the programme is now in the phase of developing guidelines on how to monitor and manage pollution to improve water quality or prevent further degradation of water quality. This project will give guidance on how to identify, investigate and develop possible management options. This will be in line with the National Toxicant Monitoring Programme of DWA. This project will run parallel to WRC Project No. 1915 (Volume 1 of the management options for EDCs) and will use the first volume to build on and deal with issues arising after analytical results have been submitted to the relevant institution/project leader/ organisation.

Estimated cost: R 1 500 000
Expected term: 2009 - 2012

THRUST 3: WATER RESOURCE PROTECTION

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

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 DWA 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

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; DWA; 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; DWA; 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 (DWA) 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

Investigation of the fate and transport of selected microorganisms in two simulated aquifer conditions in the laboratory and in the field
CSIR
No.1905

The detailed behaviour of microorganisms in groundwater is not well understood. There are many kinds of micro-organisms and many processes that affect their fate and transport, and these vary from one aquifer type to another. The National Microbial Monitoring Programme for groundwater has been developed for DWA. Besides the movement of groundwater, there are processes such as natural die-off, formation of biofilms, adsorption, etc., which are taking place, and there is inadequate local understanding of the nature and extent of the chemical, physical, biological and microbiological processes that control the fate and transport of micro-organisms in South African aquifers. This project aims to develop a sound database and monitoring protocol upon which future comprehensive fate-and-transport modelling of micro-organisms in dolomitic aquifers can be based, and which would enable more detailed modelling (inevitably scenario-based) and could contribute significantly to the development of appropriate strategies that mitigate associated human health risks.

Estimated cost: R 1 500 000
Expected term: 2009 - 2012

Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach
Golder Associates Africa (Pty.) Ltd.
No.1912

This project follows on from WRC Project No. 1769, entitled 'Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach'. The earlier project indicated that the management framework under current legislation is inadequate when evaluated against the integrated catchment-to-consumer cycle. The regulatory process is indistinct in the sense that water resources and water services are managed under different Acts and different institutional structures. The current management framework is, furthermore, reactive rather than proactive since it is primarily focused on the monitoring of raw and drinking water quality. The project produced a structured conceptual model for integrating water quality management, taking into account the current legislative gaps, as well as indicating required changes to the legislative framework that will strengthen the regulatory framework for integrated management. This project will implement the conceptual framework model for the regulation of water quality in an integrated, preventative management approach, and test it at the various management boundaries that have been identified (e.g. catchment, WSA, industrial zone).

Estimated cost: R857 120
Expected term: 2009 - 2011

Scoping study on the management of microbial contamination (taking also chemical quality in consideration) in water resources in CMAs
University of Pretoria
No.1934

Developing countries experiencing a growing demand for housing and sanitation provision are placing a burden on local authorities to provide for the need. The growing informal settlements around towns and cities are often also near water resources in South Africa. Due to the lack of sanitation the water sources are receiving great loads of microbial pollution making the source water unfit for direct consumption and recreation activities, as well as for irrigation. These sources are often also used for laundry purposes and children play in this water. The sewage treatment plants can often not handle the extra burden of sanitation projects, resulting in these plants not performing to standards and overflows occurring during heavy rainstorms. The study will investigate available management options and models to determine and manage the microbial pollution on a catchment scale. This will include the possible effect of the chemical quality of the receiving waters in the catchments. The project will make recommendations on research needs and follow-up projects.

Estimated cost: R250 000
Expected term: 2009 - 2010

Programme 2: Urban and rural water resource management

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

Programme 3: Integrated river flow and catchment hydraulics

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

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 unserviced 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

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

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

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: 2009 - 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 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

NEW PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Developing climate change adaptation measures and decision-support system for selected South African water boards
Rhodes University
No. 2018

This project is aimed at identifying potential impacts and threats to sustainable water service delivery, posed by climate change and associated uncertainties. The work will be done through application of existing estimation tools. Methodologies for assessing risks and vulnerabilities, monitoring strategy, and decision support framework for adaptive management will be developed. Thresholds of potential concern for water quality and quantity issues will also be derived.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

Enhancements to WR2005 study (completed for the WRC in December 2008)
SSI
No. 2019

The main objective of this study is to enhance the Pitman Model in order to generate patched observed streamflows for areas where rainfall gauging stations have unreliable records (or records are non-existent). It is envisaged to create a complete database of the actual monthly patched observed monthly flow volume for each streamflow gauge.

Estimated cost: R450 000
Expected term: 2010 - 2011

Delineating Quinary catchments for South Africa and modelling their associated hydrolog
CSIR
No. 2020

This study is intended to delineate quinary (rather than altitudinal quinary) catchments, to develop a nationally accepted quinary catchment GIS layer, and to model the associated hydrological data for each quinary catchment.

Estimated cost: R295 000
Expected term: 2010 - 2011

Programme 2: Surface water /groundwater hydrology

Hydrology of South African soils and hillslopes (HOSASH)
University of the Free State
No. 2021

It has been recognised that there is an intrisic and interactive relationship between soil and hydrology; thus hydrologists acknowledge that spatial variations of soil properties significantly influence hydrological processes. Attempts have been made previously to link different hydrological behaviour of different soils at a pedon (or small) scale. This study focuses on upscaling this pedon classification system towards hillslope hydrology then to catchment scale and thereby improving our understanding of hillslope hydrology. The main aim of the study will be develop a hydrologically-based classification system of South African soils and hillslopes which will assist in hydrological modelling especially in un-gauged basins.

Estimated cost: R 5 000 000
Expected term: 2010 - 2015

The long term impact of Acacia mearnsii trees on evaporation, streamflow, low flows and groundwater resources. Phase II: Understanding the controlling environmental variables and soil water processes over a full crop rotation
CSIR
No. 2022

The hydrological processes of deep-rooted trees need to be understood in order to improve the granting of licences to water users and for water allocation. Thus this study aims to quantify the long-term effects of deep rooting Acacia mearnsii on deep soil water profiles, streamflow and evaporation over a full crop rotation. It will also quantify the controlling environmental and soil water processes and provide a modelling framework for the catchment water balance to improve streamflow predictions (specifically low flows).

Estimated cost: R800 000
Expected term: 2010 - 2012

A method of 3-D fracture connectivity determination and its hydrogeological application
University of the Western Cape
No. 2023

In a fractured rock dominant environment in South Africa, fracture geometry and other features are sometimes measurable in the field. Based on these field measurements, a novel method of 3-D fracture connectivity determination and its hydrogeological application will be developed based on statistical and 3-D geometrical principles.

Estimated cost: R300 000
Expected term: 2010 - 2011

Programme 3: Water resource planning

HYLARSMET: A Hydrologically consistent land surface model for soil moisture and evapotranspiration modelling over Southern Africa using remote sensing and meteorological data
Pegram and Associates (Pty.) Ltd.
No. 2024

This study aims to address the acute need for accurate

and timely updated estimates of soil moisture (SM) and actual evapotranspiration (Eta) using remote sensing. The estimate of these variables is valuable for flood forecasting, catchment management and planning, crop modelling and drought monitoring. The study attempts to estimate SM over the entire country at 1.2 million square kilometres (a scale never feasible before).

Estimated cost: R1 423 000
Expected term: 2010 - 2013

Structural health monitoring of arch dams using dynamic and static measurement
University of Cape Town
No. 2025

This is a joint WRC-DWA project whose purpose is to develop best practices in ambient vibration testing of arch dams as part of the broad structural health monitoring and surveillance of concrete dams.

Estimated cost: R1 500 000
Expected term: 2010 - 2013

Optimal utilisation of geothermal water resources
UNISA
No. 1959

The principal aim of the project is to determine the optimal uses of thermal springs in South Africa. The project will address the suitability of South African springs for: tourism; balneology; bottling; aquaculture; agriculture; space heating; geothermal energy production; mineral extraction. In addition, this project will be the first study on microbial diversity, including thermophilic organisms, of hot springs in South Africa. Hot spring assessment and characterisation will also be completed.

Estimated cost: R2 380 655
Expected term: 2010 - 2013

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

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

Extreme events: Past and future changes in the attributes of extreme rainfall and the dynamics of their driving processes
University of Cape Town
No. 1960

Flooding caused by extreme rainfall often results in fatalities, damage to and loss of property and infrastructure. The project is aimed at identifying attributes of extreme rainfall and historical trends thereof. Then relate the extreme rainfall data to synoptic mode of circulation, identify geographic regions that have experienced extreme rain and develop a framework for application of extreme analysis to downscaled projections of future climate.

Estimated cost: R420 000
Expected term: 2010 - 2012

Projected impacts of climate change on water quantity and quality in the uMngeni Catchment
University of KwaZulu-Natal
No. 1961

Based on the need for suitable assessment and adaptation measures in planning and disaster risk management for possible impacts on water in Umgeni, this project was conceptualised. Hence the purpose is to determine potential impacts of climate change on runoff in the catchment, potential impacts on water quality and dam yield.

Estimated cost: R1 492 000
Expected term: 2010 - 2012

Implementation of the rule based agent for *Microcystis* in Rietvlei Dam
North-West University
No. 1962

Microcystis aeruginosa has been identified as a common form of cyanobacteria in South African impoundments such as hypertrophic Rietvlei Dam, and has potential to form toxins that can cause illness or death. The project is aimed at determining the effect of solar bees on algal growth and then set up a model for prediction and control of cyanobacterial and other algal blooms.

Estimated cost: R175 000
Expected term: 2010 - 2014

The role of local community institutions in the adaptation of rural and urban communities to the impacts of climate change on water access and use
UNISA
No. 1963

This project should focus on the identification and development of existing policy frameworks for examining adaptation practices in the context of rural institutions' role towards livelihood needs. This will be based on analytical approaches that take into account increases in environmental risks, reductions in livelihood opportunities and stresses on existing resources and social institutions. Investigations into likely responses such as migration or

mobility, diversification and other adaptation options in light of climate impacts should also be undertaken. The project includes piloting in a rural setting and at urban community levels. The piloting should advise policy discourse on recommended parameters that can reduce these impacts.

Estimated cost: R3 000 000
Expected term: 2010 - 2013

Modelling daily rain-gauge network measurement responses under changing climate scenarios
Pegram and Associates (Pty.) Ltd.
No. 1964

Monthly streamflow modelling should be complemented with stochastic rainfall runoff modelling that is coupled with predicted future climatic variability or change. The purpose of this project is to establish a link between rainfall and climate change. The meso-scale scenarios that are typically generated by GCMs will be disaggregated into small spatial and temporal scales using probabilistic-stochastic methods. The methodology will entail identifying a subset of available Global Circulation Models (GCMs), whose meteorological time series outputs are plausible in a hydrological context, with particular emphasis on Southern Africa. It will then determine links between climate variability (as modelled by GCMs) and daily rainfall as recorded in meso-scale to regional gauge networks and demonstrate the plausibility of generating stochastic ensembles of future multisite rainfall time series, reflecting plausible future climate changes.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

Developing water related climate change adaptation options to support implementation of policy and strategies for Water for Growth and Development
University of KwaZulu-Natal
No. 1965

The research is aimed at developing a framework that reflects an integrative adaptive management approach for facilitation of strategies for taking account of vulnerabilities and impacts of climate change in relation to water planning and management. The study will entail analysis of climate change related risks on the development of techniques for integrating long-term climate risks into short- to medium term development of policy decisions and projects. The objective is to develop methodologies for providing support to the Department of Water Affairs in mainstreaming climate change issues into water management as part of the implementation of the Water for Growth and Development strategy.

Estimated cost: R3 000 000
Expected term: 2010 - 2013

Programme 2: Managing human-induced impacts on water quality and quantity

A large scale study of the human-induced impacts on the microbial and physico-chemical quality of ground- and surface water in the North-West Province, South Africa
North-West University
No. 1966

The water resources of the North West Province are deteriorating in quality through pollution and this has impacts on the microbiological as well as chemico-physical dynamics of such a source. It is thus logical that when human-induced impacts on source waters are investigated that both these sets of parameters be included. In a scoping study on the quality of groundwater and surface water in the North-West Province, (K8/853), this is very well illustrated. What the preliminary results of this study are already indicating is that impacts from human activities have, over an extended period, negatively affected the quality of groundwater and surface water. Health statistics for the province indicate health burden increases, e.g. in 2002 statistics showed that diarrhoea among the under five-year age group was third highest in the country. There was also a general increase in HIV prevalence to over 10 % by 2002 (DoH, 2002). The aims of the study would be to broaden the scope of the previous study and determine the water quality of surface water and groundwater in the North-West Province from chemico-physical and microbiological perspectives and to investigate potential risk of consuming such water without any prior treatment. The team will also investigate the best available analytical methodologies to be used in the province for monitoring of water quality.

Estimated cost: R1 204 800
Expected term: 2010 - 2012

Investigations into the existence of unique environmental Escherichia coli populations
University of Pretoria
No. 1967

A variety of pathogenic and non-pathogenic Escherichia coli are found in association with the gastrointestinal tracts of warm-blooded animals. The presence of E. coli in other environments is apparently maintained by the constant input of isolates from the primary habitat. For this reason E. coli is used as an indicator of recent faecal contamination. This is the basis for using presence of faecal coliforms as indication of faecal pollution. A number of studies have shown that specific E. coli strains are capable of surviving in sand and sediments of freshwater systems for longer pe-

riods than previously thought. Further evidence suggests that E. coli multiply in both tropical and colder waters in the apparent absence of any faecal contamination These recent findings question the use of E. coli as an effective indicator organism of faecal pollution. The overall goal of the proposed study is to investigate whether natural populations of E. coli are structured according to habitat, and if so whether unique environmental strains of E. coli exist in nature. It is hypothesised that any imposed separation in terms of habitat would reflect at the genetic and genomic levels.

Estimated cost: R600 000
Expected term: 2010 - 2013

THRUST 3: WATER RESOURCE PROTECTION

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

Assessment of the prevalence of human viral and bacterial pathogens in some recreational beaches and rivers in Amathole District Municipality of the Eastern Cape Province of South Africa
University of Fort Hare
No. 1968

In the Eastern Cape Province (which is mostly non-urban, poor and without adequate infrastructure) a significant proportion of the rural communities lack pipe-born water, and as such depend on beach water, streams, rivers, groundwater and other available water bodies for drinking, recreation and domestic purposes. Many of these water bodies are often impacted by inadequately treated effluents from municipal wastewater treatment plants as receiving water bodies. The consequences of the impact of such negative practices is the compromising of the primary health of people especially with death threatening diarrhoeal diseases, caused by invasive viral pathogens and other microbial pathogens. The overall aim of this study is to assess the prevalence and distribution of human viral pathogens together with coliphage and faecal indicator bacteria in relation to the physicochemical qualities of selected recreational waters and rivers in the Eastern Cape Province.

Estimated cost: R680 000
Expected term: 2010 - 2012

THRUST 4: WATER RESOURCES INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Water governance decentralisation in Africa: a framework for reform process and performance analysis
University of Pretoria
No. 1969

The aim of this project in partnership with the World Bank is to provide knowledge about water decentralisation processes in Africa, in particular to understand which variables have a positive or a negative impact on the implementation of decentralisation processes in the African water sector, and which variables could be affected by policy interventions and how. It is also aimed to enable water sector decision-makers to identify and treat properly those hurdles hampering a transfer of water management actions to the lowest appropriate level.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

The optimisation of available human, institutional, technical and financial resources to strategically approach deteriorating water quality in SA through innovative and collective effort focussing on sources of pollution in prioritised fashion
Golder Associates Africa (Pty) Ltd
No. 1970

The project is aimed at identifying the major sources of pollution that contribute to deteriorating water quality in SA at catchment, provincial and national levels, and will then prioritise the sources based on some criteria, in order to develop approaches that reflect collective effort among role players (i.e. regulator, regulated community and research institutions).

Estimated cost: R500 000
Expected term: 2010 - 2012

The Development of an Institutional Adequacy Index using the Multi-dimensional Poverty Approach
University of the Western Cape
No. 1971

This project aims to establish a set of indicators to measure the adequacy of water management institutions, to identify what domains - and what indicators within these domains - are required to measure the adequacy of an institution to perform its task, to increase dialogue between different disciplines (social scientists and engineers) by bringing more rigour and numeracy to the social science dialogue (speaking a common language), to bring more rigour to discussions about poverty, to put the spotlight on 'intangible assets' and wellbeing and to introduce the Capability Approach and notions of multi-dimensionality into discourse on IWRM.

Estimated cost: R1 590 000
Expected term: 2010 - 2013

Prospects and processes for the establishment of stakeholder-initiated catchment management agencies

University of the Witwatersrand
No. 1972

This project aims to establish the potential for stakeholder-initiated catchment management agencies and related arrangements, and to determine the knowledge and perceptions of stakeholders about their opportunities to establish catchment management agencies and related arrangements. The project will determine the factors that would influence stakeholders to initiate the formation of a CMA or to oppose such a process as well as identify interventions that could address obstacles that may be identified to the establishment of stakeholder-based catchment management agencies, specifically measures to ensure that the interests of disadvantaged communities are adequately addressed, and will eventually produce recommendations to guide decisions of different stakeholders and regulatory authorities about the establishment of stakeholder-initiated CMAs.

Estimated cost: R600 000
Expected term: 2010 - 2012

Development of a system dynamics model for the implementation of IWRM in South Africa: Phase II: Pilot implementation and design of the PMS
Jeffares & Green (Pty) Ltd
No. 1973

The aim of this project is the optimisation of the operationalisation of integrated water resource management through: fostering of successful cooperative governance in the water sector of the pilot catchment, capacity creation and development in IWRM within the water sector of the pilot catchment, fostering stakeholder buy-in and active participation in the IWRM strategy for the Mega-Reserve, identification of problems with IWRM implementation, identification of solutions to problems identified with IWRM implementation and production of an IWRM implementation guide.

Estimated cost: R442 750
Expected term: 2010 - 2011

Programme 3: Pricing and financing WRM

Determining the socio-economic value of groundwater in the TMG Aquifer
University of the Western Cape
No. 1974

This research is intended to produce knowledge regarding the socio-economic value of groundwater that is derived from the TMG Aquifer through various use and non-use activities. This will be achieved through identifying and quantifying direct use value, indirect use value, option value, existence value, bequest value and altruistic value generated by the TMG Aquifer to determine its Total Economic Value.

Estimated cost: R300 000
Expected term: 2010 - 2012

Programme 5: Future scenarios

IWRM - from theory to practice
University of the Western Cape
No. 1975

The aim of this analytical project is to investigate to what extent the different ways of knowing water is influencing the implementation of the 1997 water policy in South Africa.

Estimated cost: R1 005 000
Expected term: 2010 - 2013

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KSA 2: Water-Linked Ecosystems

Dr Stanley Liphadzi:
Director

SCOPE

The glossary of the Environmental Health Centre of the National Safety Council defines an ecosystem as: The interacting synergism of all living organisms in a particular environment; every plant, insect, aquatic animal, bird, or land species that forms a complex web of interdependency. An action taken at any level in the food chain, use of a pesticide for example, has a potential domino effect on every other occupant of that system. Note that the term 'all living organisms' does include people.

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river), groundwater and water table-dependent (dependent on a water table, but not on surface water). This KSA will continue to focus on the protection and sustainable utilisation and management of the aquatic environment and biota (instream, riparian and ground¬water). 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 by rural communities).

In the light of local needs and international trends in research, the portfolio of research by which the scope of this KSA is addressed will be adjusted when deemed necessary. However, the primary objective remains 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, taking into consideration demographic dynamics and threats due to climate change, alien and invasive species. This will 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, with a focus on the DWA National Water Resource Strategy (NWRS)and Government outcomes. Special attention will also be given to emerging strategies and plans of Government departments such as Human Settlement, Planning Commission, Rural Development and Land Reform, Science and Technology, and Agriculture, Forestry and Fisheries.
- Building of capacity in both research and management to sustainably manage aquatic ecosystems.
- Bridging societal needs (livelihoods) and resource protection.
- This KSA will work closely with KSA 5 in developing a KSA2-specific knowledge dissemination and uptake plan to ensure that the research knowledge produced under this KSA is broadly utilised in South Africa and Africa.

OBJECTIVES

In the light of international trends in research, the portfolio of research falling within the scope of and addressing this KSA will not change. The primary and secondary objectives

of this KSA have been found to address future research need scenarios appropriately. 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 services from the water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

This will be achieved through the following (secondary) objectives which aim to:

- Develop an understanding of the ecological processes underlying the delivery of goods and services.
- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems.
- Transfer the knowledge to appropriate end-users through the development of innovative tools and methods for effective knowledge dissemination. These will be developed in conjunction with other KSAs within the WRC.
- Strategically align research with the WRC mandate and government priority areas/projects and the Water for Growth and Development framework, where relevant.
- Promote good science and 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's plan. 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 resources
- Socio-economic considerations
- Ecosystem governance

THRUST 3: ECOSYSTEM REHABILITATION

Scope: This thrust addresses the rehabilitation of aquatic ecosystems (including both the abiotic and the biotic components) which have 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 and impoundment rehabilitation
- Influence of instream-constructed barriers

RESEARCH PORTFOLIO FOR 2010/11

This KSA focuses on the protection and sustainable utilisation of the aquatic ecosystems (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. It addresses national research needs (strategically of long-, medium- and shorter terms) as well as those of international conventions on environmental management (e.g. wetland conservation (Ramsar) and the Convention on 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 has also 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 2010/11:

Impact of sediments as a physical water quality variable on macro invertebrates: South Africa, like many semi-arid countries, transports large amounts of sediment into the oceans via rivers. This is due to high erosivity of our soils and unpredictable storms following long periods of droughts or dry seasons. The sediment eroded from the catchments and within river courses is transported downstream with serious potential impacts on the biota, clogging/abrasion of fish gills leading to fish mortality, loss of habitats, and consequently loss of biodiversity. Eroded sediments also affect siltation of dams, temperature and light penetration changes in the systems, primary production, transportation of sediment-adsorbed toxicants, closure of usually open-mouth estuaries, and many other factors. Although the extent and quantification of sediments and related hydraulics have been studied under the Water Resource Management KSA, very few of the abovementioned aspects have been researched. The information to be generated holds a key to the development of sediment water quality guidelines, which are urgently required. The project will supplement the sediment toxicity bioassays currently underway.

Application of aquatic ecosystems (natural wetlands) knowledge to constructed wetlands (bio-mimicking): This study will be undertaken in collaboration with the Water Use and Waste Management KSA and will focus on applying natural wetlands ecosystem knowledge to artificial or constructed wetlands. The idea is to tap into existing knowledge generated from wetland studies and use that in constructed wetland systems as tools to introduce and enhance the efficiencies of wetlands processes. Biological components and processes will be introduced to the constructed wetlands to enable the constructed wetlands to function as natural wetlands and be able to provide goods and services that are associated with aquatic (wetland) ecosystems.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to a committed funding budget of R12 635 883 (excluding roll-over), with R3 731 020 requested for new projects.

CORE STRATEGY

Healthy people depend on a healthy environment. This is particularly true in the case of the rural poor who rely directly on the environment for their livelihood. For instance, while poor quality water can be improved in treatment works (at increased cost); those directly dependent on the resource will suffer the consequences of drinking water containing pollutants or disease-causing organisms. At the same time, the flow of goods and services such as fish, fibres, cultivated and medicinal plants from a poor quality ecosystem will be less than it should be. For these and other reasons, sustainable management of the ecosystems making up the environment is central to an improved quality of life. The scale of ecosystem benefits varies from individual, for example fibre for mat- and basket-weaving or medicinal benefits for individual livelihoods, to universal, such as good quality water for abstraction and urban use and intact wetlands to aid in improvement of water quality and flood attenuation. In short, society cannot survive without the underpinning support from the environment.

The core strategy is fundamentally unchanged from 2009/10 but focus will be given to development of innovations that will help in speeding up implementation of relevant policies. The KSA will furthermore internalise national strategies such as Presidential priorities (government MTEF). Research funded from within this KSA will continue to address, within the mission and vision of the WRC, the three legs of sustainability (society, economy, and environment) as defined by the 2002 Johannesburg Summit and the needs of the legislation and international conventions (e.g. biodiversity conservation planning – Convention on Biological Diversity and Wetland Integrity – Ramsar) of South Africa.

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 strengthens the notion of promoting ecosystems as natural water infrastructure that should be valued by everyone. The KSA research further addresses the commitment to 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. Various aspects of climate change (including, adaptation and mitigation) are addressed by the KSA and this entails developing an understanding of the impact of global warming (water temperature) on aquatic biodiversity (ecosystems). This knowledge will enable societies (especially rural, poor people) depending on goods and services from the environment to improve their resilience to climate change.

The KSA is closely linked to the overall objective of the WRC, aiming at making a difference through research in society, economy, health and the environment.

Water and society

Knowledge is developed by the KSA to improve social-cultural dynamics or perspectives to understand and promote protection of biodiversity and its ecosystems. The KSA is involved in studies that are aimed at improving understanding of the societal factors or aspects affecting implementation of the National Water Act of 1998. The shared-rivers objectives that the WRC has funded address social (as well as political) aspects that are critical for implementation of environmental legislation.

Water and the economy

Ecosystems have an economic value and their appropriate utilisation is not only key for a sustainable environment and healthy and sustainable water resources, but also creates goods and services that can create wealth and empower communities. The KSA continues to support studies that improve understanding of the economic value of ecosystem goods and services. Methods and tools will be developed for use by water authorities to suitably use freshwater ecosystems.

Water and the environment

Most of the research studies funded by this KSA address mainly this impact area. The knowledge generated by the KSA studies is needed to improve protection of ecosystems and suitable utilisation of goods and services coming from aquatic ecosystems.

Water and health

The KSA has studies that address the health aspect of water or aquatic ecosystems. The research relating to the impact of environmental flows manipulation on water-associated vectors and diseases, the endocrine disrupting compound studies, and general water quality studies that the KSA is supporting will provide knowledge in this area.

Needs analysis

This KSA closely supports DWA in its strategy for Water for Growth and Development, and other Government departmental initiatives. The needs expressed by the Minister of Water and Environmental Affairs will be addressed in different KSA's thrusts. However, the specific need to sustainably manage and protect wetlands has been, and will be, fully addressed by both existing and new solicited projects.
The KSA will internalise relevant outcomes from the WRC's stakeholder workshop. Effort will be made to introduce and promote ecosystem knowledge to local government institutions, especially SALGA, portraying ecosystems as natural (water) infrastructure that provides humans with different benefits such as flood control, and improvement of water quality and quantity. Other stakeholders' needs, and the manner in which KSA 2 will respond to those needs, will be addressed later on in this documents (stakeholders' views). 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 reflected yet as needs in South Africa. There is also a need for repackaging of both the existing and new knowledge that will help in both water management, training and public awareness. 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 KSA will continue to support research that addresses the longer-term needs of the country. Funding research to contribute to 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 implementation of research findings requires specific attention and this will be addressed within the KSA through a WRC-wide initiative which will be implemented during the year. The KSA will also strengthen its technology transfer initiatives aimed at building capacity in communities and of the decision makers. The KSA will seek and pursue opportunities to build a knowledge-base of the officials, especially in relevant new government departments and other institutions.

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. In recognition of this, the KSA has begun more

research initiatives in selected areas in order to ensure that our knowledge remains ahead of the need to apply it.

Water quality deterioration has reached crisis levels in the country's heavily used catchments, with fish kills in the Vaal River and Olifants River (Mpumalanga) and crocodile deaths in the Lower Olifants River. A multidisciplinary approach is necessary to address this problem adequately, and to resolve these challenges this KSA has completed a scoping study which is being used to facilitate the formation of a larger research programme in conjunction with SANParks and other organisations. The KSA has also solicited a research project focusing on linking land use to water quality.

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. The KSA, in collaboration with DWA and DEA, will continue to pay special attention to the effectiveness and efficiency of RDM methods and tools, particularly those used in the Reserve determination with the intention to meet the needs of users and beneficiaries.

Overview of technological trends

Several important 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. Since the Strategic Plan presented herein addresses a number of years in a continuous manner, some of the trends mentioned in the previous year which are of importance to the future research portfolio are given in this Plan, with special reference to studies already undertaken in the current financial year.

- **Climate change:** Current 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 vulnerability and adaptation. 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. Research in this field has developed methods for continual monitoring of river water temperature, and this will be piloted in a new project. Moreover, the KSA is currently completing some preliminary studies on the effects of climate change on aquatic ecosystems, which will be finalised in 2010. One of those studies, as an example, has identified hydrological parameters or drivers with potential to determine the response of aquatic biota to the impact of climate change. Methods of assessment and interpretation of climate change data have been developed by this study. However, it was recognized that, for the methods and data to be more useful at a local scale, ecologists' views and their interpretation of data is important. The KSA will initiate a process of taking the study forward to implement recommendations of the current climate change studies. Further research work is likely to emanate from these studies, such as the fate of threatened species and ecosystems, the fate of alien and invasive species in view of increasing temperature regimes and methods or technology required to manage and control alien and invasive species.
- **Payment for ecosystem services (PES):** This is a new trend. The development of a PES scheme and related economic tools are important and require attention in a developing country like South Africa. An appropriate PES scheme has potential to leverage business opportunities that can benefit poor people (especially rural people) in areas with ecosystems that supply goods and services. Another important aspect attached to a PES scheme is benefit-sharing mechanisms, which still has to be researched and developed in the context of the South African environment. While a scoping study in the form of a consultancy is planned for 2010/11 to address the aspect of benefit sharing, project K5/1978 will lay technical and theoretical foundation needed in developing a PES scheme appropriate to South Africa and Africa.
- **Aquaculture:** Aquaculture has been accepted globally as a cheap source of protein, particularly to the most vulnerable rural communities. Though the economic benefits of saline groundwater use in aquaculture are unknown in South Africa, cost-benefit analysis and feasibility scoping study will be started in 2010/11 as a consultancy. The study will support government efforts relating to rural development and those relating to fisheries.
- **Ecohydrology:** The science of ecohydrology is gaining momentum in many countries. Research conducted in this KSA and in the Water Resource Management KSA addresses aspects of ecohydrology, and these linkages will be further explored in all WRC projects relating to environmental flows or water.
- **Ecological limits on hydrological alterations (ELOHA):** This is a new trend. The KSA will interact with international researchers and institutions that are advancing this field or concept with intention to make a meaningful contribution in this emerging field. However, the KSA has found that the concepts upon which this field is based stem from past WRC research studies on environmental flows or environmental water requirements. The KSA will take advantage of the working relationships fostered during the February 2009 international conference organized and hosted by the KSA in Port Elizabeth.
- Application of natural wetland knowledge to constructed wetlands will be explored in collaboration with the KSA addressing Water Use and Waste Management. This will require assembling of experts in artificial wetland construction and those researchers with better under-

standing of wetland form, function, and process. There is a solicited project planned that will start in April 2011.
- **Capacity for sustainable utilisation** in the context of sustainable development is a key intervention in this regard and is being built through initiatives (projects) in this KSA.
- **Shared-rivers:** The KSA has initiated a long-term initiative that focuses 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. The second phase of the study, which aims to look into compliance with the NWA, starts in 2010/11 and the output will assist government in strengthening its monitoring programmes and prosecution of the defaulters.
- **National freshwater priority areas (NFPA):** The WRC is working closely with its stakeholders (K5/1801) to carry out a study on national freshwater priority areas (NFPA) of South Africa, in recognition that these areas are water production (factories) of the country and the region in some cases.

Key stakeholders

The key stakeholders remain largely unchanged. In addition to the Departments of Water and Environmental Affairs (DWA and DEA), other Government departments such as Agriculture, Fisheries and Forestry (DAFF), Science and Technology (DST), and Rural Development and Land Reform (DRDLR), are of importance. This KSA closely supports DWA, specifically at this time when they are implementing new strategies such as Water for Growth and Development. Provincial and local govern¬ment form another group of stakeholders, and the needs of the catchment management agencies (CMAs) which are currently being established influence research direction. Other end-users of the research are water boards, and 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. The IUCN, WWF and Wetlands Inter¬national (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 players

There are 2 main groups in this category nationally, funders and end-users of research not mentioned above. DWA give some funds for research, although this is largely for the purpose of consultancies aimed at addressing 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 IWMI (currently mainly through their Challenge Programme), WWF, UNEP and the World Bank.

There are a number of other end-users of research such as South African National Parks 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.

Research providers

There is basically no change in the providers of new knowledge in the field covered by this KSA. Researchers are located at the universities (Limpopo, Venda, North-West, Witwatersrand, Johannesburg, Free State, Zululand, KwaZulu-Natal (both Pieter¬maritzburg and Durban), Fort Hare, Rhodes, Nelson Mandela Metropolitan, Stellenbosch, Walter Sisulu, Western Cape and Cape Town), science councils (in this field predominantly the CSIR and the ARC) and within various consultancy firms. Efforts will continuously be made to build research capacity in historically-disadvantaged individuals, especially at the academic institutions.

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

- A highly successful and well-attended seminar in celebration of the *International Year of Biodiversity* (2010) took place on 17 September 2010 at Tswaing Nature Reserve and Heritage site. The WRC initiated and led the organising committee including DWA, DEA and SANBI.
- Collaboration with IWMI continued, with the Gamampa Wetland in Limpopo (one of the anchor points for IWMI research) earmarked to be a case study on development and testing of the 'Wetlands and Livelihoods' framework/management guidelines. Expertise will be shared

between IWMI, the Gamampa community, SANBI, DAFF, University of Limpopo and the WRC.
- Adopt-A-River Programme: KSA collaboration with DWA continued. The WRC provides Mini-SASS brochures and other water science materials which are used and distributed at the events relating to the Adopt-A-River programme, which is linked to the River Health Programme (RHP) of DWA.
- Leading FETWater Phase 2.

Leadership positions

- Board of the Institute of Water Research, Rhodes University
- Member, Executive Committee representing the Science Council Sector, National Science and Technology Forum (NSTF)
- Chairman of NSTF Science Councils & Statutory Bodies Sector
- Member of the Board of Sci-Bono Discovery Centre
- Member, South African Mercury Association (SAMA)
- Member, NSTF Awards Adjudication panel for 2010/11
- Member, Wetland Inventory Advisory Committee – Working for Wetlands
- Member, Steering Committee of the Working for Wetlands programme
- Member, Executive Committee of DWA's 'Adopt-a-River' programme
- Member, National Steering Committee of the River Health Programme
- Member, National Wetlands Action Group and Limpopo Wetlands Forum
- Member, Ramsar Scientific and Technical Review Panel (STRP) Focal Point for South Africa.
- Member, Advisory Committee to Ramsar Focal Point

Strategic positioning

- The KSA held **two strategic meetings with DWA**, which facilitated the start of five DWA-funded projects worth R11 million in the 2010/12 year. In addition, two more DWA-funded projects worth R2.5 million will start in the 2011/12 financial year.
- The KSA held **two meetings with DEA which** brought about a collaboration and partnership relationship between DEA and the WRC, and resulted in sponsorship by DEA for the First Ramsar STRP workshop in Africa, which organised by the WRC.
- **Ramsar STRP Focal point for South Africa:** The KSA 2 Director was nominated and appointed by DEA as the Focal Point for STRP in South Africa. The STRP focal point facilitates knowledge implementation and advises the government on matters relating to the implementation of Ramsar's COP decisions. The STRP Focal Point plays an important role in issues relating to wetlands.
- Planning and refocusing the **Shared Rivers Initiative Programme:** The re-designed programme plan is now in place and ready for discussion with key role players with regards to implementation of the Reserve as defined in the National Water Act. These key role players are the National Office of DWA, specifically RDM, the Mpumalanga DWA Regional Office, Inkomati CMA Board and Kruger National Park (KNP) CEO. The programme has now expanded in scope to cover Mozambique and Swaziland.
- The KSA has begun a mission to establish working relationships with aquatic scientists in different cities in South Africa, and met with the eThekwini municipality and the City of Johannesburg managers and scientists. The KSA intends to enter into collaborations and partnerships with those cities that require knowledge on managing ecosystems and water resources in urban and peri-urban areas. This is proving to be a good platform to share and disseminate knowledge.
- KSA2 (together with KSA 1) is involved in the establishment of a collaborative initiative with KNP Scientific Services.
- The WRC is liaising, through providing ecosystem health assessment tools produced by the WRC, with the Orange-Senqu River Commission (ORASECOM), a joint basin study involving four countries sharing the Orange River. The countries involved in the agreement are: Botswana, Lesotho, Namibia and South Africa.
- **FETWater:** Phase II of this programme was implemented by the WRC until May 2011. The programme has had many achievements relating to capacity building in the water sector in South Africa, e.g. the development of curriculum and training in areas such as groundwater, resource directed measures, estuary management, catchment management, and beneficial use of water.

Impact studies

The following two impact studies were completed in the 2010/11 financial year:

- **The wetlands research impact study** was completed and the report is available on the WRC website. The study revealed that the WRC has been a main role player in the research and development of wetlands in South Africa. The report also estimated the monetary value of the wetlands research funded by the WRC and developed an assessment framework.
- **The estuarine research impact study was** also completed. The study shows that the WRC is a key player in the generation and dissemination of estuarine research and knowledge that is important in promoting estuary protection and sustainable use.

African initiatives

- **The first Ramsar Africa STRP Focal Points Workshop** was held in Johannesburg from 30 November to 2 December 2010. More than 40 African countries were represented by their STRP focal points and wetlands experts. The Department of Environmental Affairs (DEA) sponsored the event, which was used to share experiences on wetland issues (opportunities and challenges) faced by African countries. WRC knowledge and innovations with regard to wetlands were shared at the workshop.
- A research manager is a team member of the UNEP-IWMI committee that evaluates wetland projects in Africa.

International player

- Member, Technical Advisory Committee: *5th International Conference on Environmental Science and Technology* 2010.
- Reviewer for the following journals: *Agriculture, Ecosystems, and Environment; Hydrological Sciences Journal; Journal of Hazardous Waste; Chemosphere Journal; Environmental Pollution Journal; Archives of Environmental Contamination and Toxicology; Science of the Total Environment.*
- Two presentations were made at the *5th International Conference on Environmental Science and Technology*, Houston, Texas, USA, 12-16 July 2010.
- A research manager was invited as a panel member at a workshop on the basin management of wetlands in the Olifants Water Management Area, organised jointly by IWMI and the WRC and held in Pretoria.
- Member of RAMSAR's Scientific and Technical Review Panel (STRP) representing the African Region. This has given the WRC a platform to influence wetlands research and technology transfer throughout the African continents through collaboration with RAMSAR focal points appointed in each member country.
- The WRC was one of the official sponsors of the *International Society of Limnology Conference* (SIL) that took place in Cape Town from 15-20 August 2010.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

Table 1 gives a breakdown of the students employed by each of the agencies with which KSA 2 has research contracts for the year 2010/11.

TABLE 1
Capacity building through student involvement in KSA 2 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Association for Water and Rural Development (AWARD)	1	1
BioAssets Consultants	0	4
CSIR (Natural Resources and Environment)	1	2
DH Environmental Consulting cc	0	2
Freshwater Consulting Group	0	2
IWR Water Resources (Pty.) Ltd.	1	1
Nelson Mandela Metropolitan University	0	3
Prime Africa Consultants (previously CIC International)	7	6
University of Cape Town	0	4
University of Johannesburg	0	4
University of KwaZulu-Natal	0	4
University of Limpopo	3	5
University of Stellenbosch	0	3
University of the Free State	4	10
University of Venda	4	5
TOTALS	**22**	**60**

The KSA had 60 students that worked or participated in WRC-funded research projects in the 2010/11 financial year, of which 22 were previously disadvantaged individuals (PDI)

The following strategic capacity building interventions were held:

- Twenty students (12 PDI) were sponsored by the WRC to attend the *2010 Southern African Society of Aquatic Scientists Conference* (SASAQs) that took place in June 2010. All of the students presented oral papers based on their research studies.
- The WRC was one of the official sponsors of the *International Society of Limnology Conference* (SIL) that took place in Cape Town from 15-20 August 2010. The WRC sponsorship funds supported South African students who presented oral papers.
- The KSA has continued to support the relocation and transfer of the South African diatom collection from the CSIR to South African Environmental Observatory Network (SAEON).

The KSA led, participated in and/or supported the following nine technical workshops:

- 'Consolidation of wetland integrity assessment methods for South Africa', April 2010.
- 'Reviewing existing information on the ecology and status of the lower Mfolozi and Msunduzi Rivers, with particular emphasis on future re-linkage to the St. Lucia system', May 2010.
- 'Wetland conservation targets', May 2010.
- 'Wetlands and livelihoods: Restoration of the wetland ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods' (K5/1986), June 2010.
- 'Planning and refocusing the **Shared Rivers Initiative**', July 2010.
- 'Biodiversity and heritage workshop in celebration of the International Year of Biodiversity – IYB: 2010', September 2010.
- Ramsar '1st Africa National Focal Points workshop', November/December 2010.
- National Freshwater Ecosystems Priority Areas workshops were held throughout the country.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- A session was chaired of the *River Health Symposium*, organised by DWA, in Botswana, October 2010. The WRC is one of the co-founders of the programme and has funded most of its biomonitoring indices. The symposium was attended by all provincial coordinators, as well as staff working on transboundary issues.
- An abstract was submitted entitled 'Implementation of the Adopt a River Programme and lessons learnt in the Republic of South Africa' which was accepted and published in the proceedings of the *30th International symposium of the North American Lake Management Society*, 3-5 Nov 2010, Oklahoma.
- A keynote address was delivered at the ARC Institute for Soil, Climate and Water (ISWC) during World Wetlands Week, 18 February 2011.
- Attended and participated in the 4-day *International Workshop on Local Action in Biodiversity*, held in Cape Town, Berg River View Municipality, from 30 January to 4 February 2011.
- Two papers were presented at the *5th International Conference on Environmental Science and Technology,* Houston, USA, 12-16 July 2010. The titles of the presentations were: 'Investing in our natural capital, biodiversity and ecosystems' and 'Remediation of pollutants in the environment'.
- A presentation entitled 'The role of the Water Research Commission of South Africa in the water sector' was made at the *Brazil-Africa and Americas Scientific Meeting on Water*, 13-17 September 2010, São Carlos, Brazil.
- A presentation on the 'Alignment of the WRC to DWA' was given in the DWA Strategic Session, 14-15 December 2011 at the CSIR Convention Centre, Pretoria.

IMPLEMENTATION PLAN

Research portfolio for 2010/11

In essence, the implementation plan follows 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. The research portfolio for 2010/11 (broken down into thrusts and programmes) is presented in Table 2.

TABLE 2
Overview and description of thrusts and programmes for the research funded within KSA 2

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 that informs policy and management.

Programme 1: Estuarine processes	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	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	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	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	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. Support will be provided in building the capacity to implement the research findings.

Programme 1: Ecological Reserve	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 DWA.
Programme 2: Estuary management	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, DEA.

Programme 3: Ecosystem health	The River Health Programme (RHP: custodians are DWA, WRC and DEA) 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. As such the programme covers all water resource types, hence the inclusive name of: National Aquatic Ecosystem Health Monitoring Programme is used, with RHP focusing only on rivers. This programme links to the WRC crosscutting domain **Water and Health** and includes resource management actions which may affect human health.
Programme 4: Environmental water quality	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 WRC crosscutting domain **Water and Health**.
Programme 5: Endocrine disrupting compounds in water resources	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 three phases, of which the first phase is already completed.
Programme 6: Socio-economic considerations	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	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. Support will be provided in building the capacity to implement the research findings.

Programme 1: Wetland rehabilitation	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 DEA and DWA. 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 and impoundment rehabilitation	The research conducted within this programme aims to provide protocols for the rehabilitation of rivers and impoundments, with the emphasis on urban rivers and the impoundments that they feed, that have been degraded as a result of anthropogenic activities or invasive biota.
Programme 3: Influence of instream-constructed barriers	This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems.

RESEARCH PROJECTS FOR 2010/11

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

Deriving conservation targets for freshwater systems
Ground-Truth; Ezemvelo KZN Wildlife; Albany Museum; ARC (Range and Forage Institute)
No.1796

Freshwater ecosystems are the most threatened ecosystems globally, experiencing the fastest loss of biodiversity and the greatest number of species extinctions. The last national report of South African freshwater ecosystems estimates that over 80% of South African river ecosystems are threatened. The intimacy between catchment condition and river health is one reason why freshwater systems are amongst the most threatened systems globally. Systematic conservation planning has been applied to numerous regions in many different countries, and provides a structured approach in identifying biologically significant areas which require conservation action. Surrogates for biodiversity are typically used to predict areas of unique biodiversity. Owing to their complexity as fluid, longitudinal systems which show continuous gradients and relatively high variability, conservation planning for freshwater systems is conceptually at least a decade behind the application of this process to terrestrial systems. In this study, alpha, beta and gamma diversities of aquatic macroinvertebrates and fish were assessed in nine rivers, though fish were later taken out of the study due to their long distribution rendering analyses inconclusive. The study revealed that the blanket 20% target for river types is inadequate. In recognition of the fact that the upper river zones are the key sections of river length driving species patterns, they should therefore be weighted more heavily in conservation planning than lowland zones. The study recommends an adjustment with at least a 20% target in lowland zones and a 40% target in the upper zones.

Cost: R404 015
Term: 2008 - 2011

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

The South African National Water Act, Act 36 of 1998, requires that the environmental Reserve be determined for each significant water body before water-use licenses may be issued. Methods currently available for the determination of environmental water requirements in South African rivers are based on perennial rivers and need verification for use on non-perennial rivers. This research programme began by identifying which existing methods, i.e. those being used on perennial rivers, might initially seem to be suitable for use and where further work would need to be done. It then took this research a step further with an overarching objective to develop a prototype methodology for determining the environmental water requirements for non-perennial rivers. In accordance with the study's objectives, research was conducted in five phases: selecting a suitable river system; preparing the sampling sites for field visits; sampling in the field; developing a trial methodology; and testing the trial methodology. The first three phases served to develop an understanding of an ephemeral river ecosystem, while the last two phases focused on the development and testing of the prototype methodology, respectively. The prototype method clearly places an important emphasis on creating an understanding of the nature of the river and its catchment. The method makes provision for a small core team to use available data and information on the physical catchment, together with the issues and concerns pointed out by stakeholders, to develop a preliminary basic understanding of catchment processes which will inform and guide subsequent project planning.

Cost: R2 737 000
Term: 2005 - 2010

Programme 2: Estuary management

Valuation of estuary services in South Africa
Nelson Mandela Metropolitan University
(Department of Economics)
No. 1413

Estuaries yield many benefits, of which recreational value is an important one. Five primary hypotheses relating to this value were tested in this project. The contingent valuation method is a credible method by which to determine these values, albeit not without problems. The validity of the contingent valuation method has been and continues to be challenged from many angles and quarters, but estimates are acceptable guidelines when they are properly generated. The average and standard deviation values of the relevant predicted median estimates were found to be 11 and 44 cents per cubic metre of water, respectively. When three outlier (unreliable) estimates are excluded, the average and standard deviation of the mean drops to 7 cents, and the average and standard deviation of the medians drops to 3 and 4 cents, respectively. There are many people with an interest in using estuaries, but the primary demand is for the recreation services they yield. There are two different user populations at the estuaries: people engaging in recreation activity and people engaging in subsistence activity. The former tend to be wealthy and the latter poor. The latter derive much of their value indirectly, by supplying services to those engaged in recreation activity. There are also many factors that explain the economic value of river inflows into estuaries. The first factor is the enhancement this inflow gives to the recreational appeal of the estuary. For some estuaries, a little water has a big impact, with the result that the water is highly valued. The second factor is the income of the people that use the services supplied by the estuary. High income earners correlate with high demand. The project found the demand for river inflows into estuaries to be best predicted by the number of Whites and the number of male users, the climatic zone in which the estuary falls and the length of time the estuary mouth is open.

Cost: R2 160 000
Term: 2004 - 2010

Programme 3: Ecosystem health

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

This report details the results of a desktop investigation into the relationship between regulated river flow, flow manipulation and the invertebrate hosts of malaria, bilharzia and liver fluke disease in South Africa. A literature review yielded several international case studies which informed the study and, together with expert input, all information was gathered and documented in order to understand the relationship and suggest possible flow manipulation mechanisms which may be used to control transmission of these diseases through control of their invertebrate hosts. The possible effectiveness of these flow-related control mechanisms was also assessed and the number of 'people at risk' who may benefit from flow related control was estimated. The report also documents estimated costs of the diseases to South Africa, the ability to predict the occurrence of the parasite and invertebrate host and the effect of river rehabilitation and water service provision on transmission of the diseases.

Cost: R400 000
Term: 2006 - 2010

Conservation model for threatened fish species
University of Venda
No. 1677

The presence of dams, weirs and alien fish also poses a major threat for freshwater fish species survival. A substantial number of freshwater fish species from South Africa are listed in the IUCN Red List, and it is possible that, apart from the species listed, many other fish species in Southern Africa are also threatened. The study was aimed at developing a conservation framework applicable to threatened fish species of Southern Africa's highly diverse and important freshwater ecosystems. Because of its sensitivity rating and conservation status the Southern Barred Minnow, *Opsaridium peringueyi*, was selected as a candidate species. The report consists of three sections. Section 1 is a generic framework which explains the methodology for developing conservation plans for threatened fish species. Section 2 is the conservation plan (biodiversity management plan for species) for the test species, *Opsaridium peringueyi*. Section 3 is the background report for the test species. The study recommended that the genetic status of the different *O. peringuyeyi* populations is still critical information that is needed for the BMP-S and further research on this aspect is encouraged. Moreover, the BMP-S process makes provision for the conservation plan to be endorsed by the Minister and thus formally incorporated into legislation. This gives the conservation plan a more formal status which could prove beneficial for the successful implementation of the plan. It is recommended that the *O. peringueyi* BMP-S be taken through this process in order to formalise the plan and give it legal status.

Cost: R1 078 170
Term: 2006 - 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 National Water Resource Strategy aims to strike a balance between the use of resources for livelihoods and conservation of the resource. This process invariably requires negotiation of trade-offs. These trade-offs are principally between the resource quality on the one hand and the beneficial use of water on the other. The framework developed through this project to achieve this is explicitly congruent with methods used by DWA in the determination of Resource Directed Measures and Source Directed Controls. Definition of the benefits yielded by an ecosystem have been based on the Millennium Ecosystems Assessment framework and comparative risk assessment methodology is used to develop the causal chains linking ecological production to the defined ecosystem services. Two case studies have been developed to illustrate the framework. This Framework and Manual explores how these scenarios and their associated trade-offs should be evaluated.

Cost: R750 000
Term: 2006 - 2010

Knowing, caring, and acting: making use of socio-cultural perspectives to understand and improve conservation
CSIR (Natural Resources and the Environment)
No. 1800

The project's key findings indicate that the two disconnects, i.e. between conservation planning and an understanding of societal values and behaviours, and between values espoused by policy and held by societal (user) clusters, can be attributed to an array of factors that centre around the lack of societal support, community buy-in, the recognition of constantly changing mental models, and the 'diversity within diversity' (or the degree of heterogeneity). These include:

- The dynamic and inter-subjective meaning of conservation
- Analytical tools not being reflective of reality
- The social sanctioning around water conservation
- The compartmentalisation of conservation
- The juxtaposition of water as utility versus water as aesthetic value
- Conservation not being internalised in the mental models of many participants
- The normative aspect of conservation, and specifically, deciding what ought to be 'good' conservation behaviour
- The 'knowing, caring, acting' dynamic being non-linear and non-sequential, with the 'knowing' dynamic pronounced

A key connection made between participant responses and policy interventions, was the expressed perceptions that appropriate water conserving behaviour means saving water. Policy interventions that are based on this definition of appropriate water conserving behaviour ignore the inability by some people to use any less water than they already have due to limited access, priority given to using water for key household tasks and less for others, etc. It is argued in this report therefore, that water scarcity is not just physical, but also manufactured and constructed, which means that uneven access to water or varying perceptions about water use and water availability, also come into play when discussing water scarcity. Conservation planning and management efforts should therefore work to produce policy interventions and implementation strategies that factor into it the range of socio-cultural and socio-economic perceptions around water use and water availability, the range of water access challenges borne out of poverty, and a distinction made between different

groups (especially those who have to function within a context of poverty) and the stipulations made on them to curb their demand for water in order to conserve water.

Cost: R500 000
Term: 2008 - 2010

Programme 7: Ecosystem governance

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

Based on the findings of the study, achieving ERs – and indeed the Reserve - does not reside within the environmental domain alone; it is a collective action involving participation by multiple stakeholders in specific learning and training forums. Indeed, achieving the Reserve is predicated on water reform and IWRM and the collective contribution and synergies of a number of strategies, plans and practices. Of utmost importance is the recognition of the fact that achieving the Reserve cannot be done in isolation; the Reserve is but one of the key components of IWRM which is required for proper integral management of water resources at basin level. Progress towards this complex goal varies widely between catchments and at different scales. Cases where systems show a better balanced approach need strengthening – especially where this is achieved through collective action, good governance, strong leadership, feedbacks, learning and regulation. These can offer lessons and frameworks for weaker situations. If a people-centred approach that is guided by sustainability is to be sought, then there is a need to find new ways of understanding, collectively, the benefits associated with water resource protection measures (such as through the Reserve). Such thinking needs to extend across boundaries – be they upstream-downstream, sectoral or international. This is critical in ensuring mechanisms of sharing our scarce freshwater resources collectively.

Cost: R810 760
Term: 2007 - 2010

THRUST 3: ECOSYSTEM REHABILITATION

Programme 2: River and impoundment rehabilitation

The potential of food-web manipulation for the restoration of eutrophic South African impoundments
DH Environmental Consulting cc
No. 1643

Work done within this project examined the fish assemblages of six dams to examine the hypothesis that impounded eutrophic waters tend to be dominated by coarse fish. It was hypothesised that the ecological state and water quality of eutrophic dams could be improved through the re-shaping of imbalanced fish populations, brought about by the deliberate harvesting of target species. In this project fish assemblages in six dams of known trophic status in the same region were examined. The fish biomass in all of the dams was dominated by sharptooth catfish. By contrast, the contribution made by common carp was less than expected. The canary kurper was numerically dominant in two dams. Fish assemblages of South African dams are fundamentally different to those occurring in lakes where biomanipulation has been successful. All of the dams supported fish populations that exceed areal biomass levels commonly associated with a swing towards algal dominance.

Cost: R1 649 360
Term: 2007 - 2010

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Biochemical processes in a groundwater-fed intertidal 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

A framework for the classification of drainage networks in savanna 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

An assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park (KNP) and the physical and chemical factors affecting their distribution
Bioassets cc
No. 1928

Amphibian population declines and species extinctions are being recorded around the world (amphibians are proportionally the most threatened group of vertebrates). The declines cannot be attributed to any single causative factor because complex mechanisms involving abiotic and biotic interactions are responsible for this phenomenon. These declines have been attributed to a combination of factors, including climate change, chemical pollution, habitat loss and disease. This research project is aimed at determining the current status of the amphibian biodiversity in the Kruger National Park main rivers and associated wetlands.

Estimated cost: R1 036 500
Expected term: 2009 - 2012

Biomonitoring the fish health of two impoundments in Olifants River, Limpopo Province
University of Limpopo
No. 1929

In South Africa pollution of aquatic ecosystems can be linked to diffuse surface runoff and point-source discharges. As a result of these anthropogenic activities, organisms, including people, may be exposed to harmful contaminants which may affect their health and livelihood. The research will focus mainly on generation of information about the water quality of Flag Boshielo Dam and the Phalaborwa Barrage by testing selected abiotic and biotic parameters to determine the ecosystems' health.

Estimated cost: R674 500
Expected term: 2009 - 2012

Programme 3: Wetland processes

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
Expected term: 2007 - 2010

Establishing ranges of water quality variables in wetlands and their relationship to land use and ecosystem response: towards refining the ecological Reserve
University of Cape Town (Freshwater Research Unit)
No. 1921

Wetland water quality data, especially long-term datasets, are limited and, in addition, wetlands are naturally more variable in terms of water chemistry than rivers, both spatially and temporally. We have a poor understanding of the range of values of water quality parameters that occur in wetlands, both under natural conditions and in the impacted state and how this varies with different types of wetland. The research will further our understanding of the relationships between catchment environmental condition (and land use), water quality in wetlands and biotic response.

Estimated cost: R1 070 064
Expected term: 2009 - 2011

Regional wetland processes of the Maputaland coastal aquifer on the Zululand coastal plain
ARC (Institute for Soil, Climate and Water)
No. 1923

Previous studies about the wetlands on the Zululand coastal plain could not use environmental attributes to explain the wetland type and distribution on a regional scale. There is no clear classification and characterisation of wetlands which addresses the interaction of environmental factors and processes on a broad scale. An understanding of environmental factors and processes is required before human-induced changes can be evaluated. The research will provide a workable framework that will link environmental factors and processes for different wetland types and distributions on the Zululand coastal plain and enable the prediction of the response to land-use and water-linked ecosystem change on a regional scale.

Estimated cost: R893 364
Expected term: 2009 - 2011

Evapotranspiration from the Nkazana Swamp Forest and the Mfabeni Mire
CSIR (Natural Resources and the Environment, Pietermaritzburg)
No. 1926

There is general consensus amongst wetland scientists in South Africa that wetland evapotranspiration (ET) has not been adequately quantified. This research project will complement the WRC-funded project (K5/1704) at the Isimangaliso/Greater St Lucia Wetland Park by quantifying seasonal wetland evaporation using state-of-the-art ET measurement techniques.

Estimated cost: R908 000
Expected term: 2009 - 2011

Identifying relationships between soil processes and biodiversity to improve restoration of riparian ecotones invaded by invasive acacias
University of Stellenbosch
No. 1927

Invasive alien plants have now become weeds in conservation areas and agricultural land, threatening the country's biodiversity and agriculture. In addition, they can reduce runoff from water catchment areas, thus diminishing flow in streams and adversely affecting the water table. The research is aimed at finding ways to improve restoration of riparian areas invaded mostly by alien plants and the output of this work will provide knowledge needed in catchment management for holistic water resource management.

Estimated cost: R1 978 000
Expected term: 2009 - 2012

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

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 (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 licenses 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 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
Expected term: 2008 - 2010

Development of methods for Reserve determination of wetlands. Phase 2: Intermediate and full Reserve determination
To be solicited

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 this phase will concentrate on the methods for the determination of the intermediate and comprehensive ecological Reserve.

Estimated cost: R2 000 000
Expected term: 2009 - 2012

Environmental water requirements for non-perennial systems: Phase III
University of the Free State
No. 1798

Non-perennial rivers are distinguishable from perennial rivers, in that their hydrology is spatially and temporally much more variable, creating high levels of disturbance for stream communities. Previous WRC research has shown differences in Reserve determination between perennial and non-perennial systems using existing methodology, e.g. the relevance of groundwater in relation to surface water. Furthermore, standard hydrological models cannot predict along the whole hydrological spectrum, from perennial to episodic systems; therefore, water licensing will

have to be based on a new understanding or model of the non-perennial hydrology. This study is aimed at testing the prototype methodologies on different river systems.

Estimated cost: R3 000 000
Expected term: 2009 - 2012

Shared Rivers Initiative: Phase II: Analysis of the ecological Reserve implementation scenarios with the intention to design an effective implementation approach/plan
AWARD
No. 1920

There are conflicting views among communities with regard to the use and management of water resources, which has complicated the implementation of trans-boundary water resource management, particularly the ecological Reserve, in RSA. In spite of all the challenges, there are situations where implementation of the ecological Reserve has been successfully executed. There are also situations where implementation has not been successful. Effective planning needs to critique these case studies, to identify the strengths and weaknesses (gaps) of the implementation approaches and methods and the policy itself. The results or output will be used to design 'a new way of doing things' as far as implementation of the Reserve is concerned. The output may also suggest refinement of the policy if need be.

Estimated cost: R800 000
Expected term: 2010 - 2013

Review and update of resource directed measures (RDM) for estuaries
Anchor Environmental Consultants
No. 1930

The increase in understanding of the RDM methodologies for estuaries, together with the increased variety of systems studied in the RDM process, has led to the realisation that some areas of the RDM methodology are problematic and need further refinement. The conducted modelling study, run in conjunction with the research and RDM study of the East Kleinemonde estuary, highlighted several issues of concern regarding assumptions made in scoring present condition and future scenarios. This research study will investigate and improve the alignment of the RDM process with the classification process.

Estimated cost: R604 400
Expected term: 2009 - 2010

Decision support system for determination of environmental water requirements
Southern Waters
No. 1873

Current methods for the assessment of environmental water requirements need the input of subject specialists, and this is a process that is both expensive and difficult for water managers who are not specialists to interact with. The feasibility of the decision support system (DSS) to be developed has been researched and shown to be possible. This DSS will enable water managers to set scenarios and to run the system themselves. In this way they will be able to predictively test different scenarios themselves, and thus select the scenario which best suits their needs, without ongoing specialist input. This will empower managers to make decisions themselves.

Estimated cost: R1 800 000
Expected term: 2009 - 2011

Programme 2: Estuary management

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

The application of choice modelling techniques to guide the management of estuaries in South Africa – case studies at the Kromme, Bushmans, Sundays and Keurbooms estuaries
Nelson Mandela Metropolitan University
No. 1924

The research to be undertaken during this follow-on project will support managers in their decisions on the inflow of freshwater into estuaries, through the provision of in-

formation on the economic value of the flow of ecosystem goods and services provided by estuaries and linked to the quantity of freshwater flowing into the estuary. Research conducted during the previous projects has developed the contingency valuation method for the valuation of freshwater inflows into estuaries, and the research proposed in this project will, working together with estuary managers, apply the methods developed to four specific estuaries, in a way that will provide the interface between the method developed during the previous research and the information requirements of the estuary managers.

Estimated cost: R770 000
Expected term: 2009 - 2011

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

Programme 4: Environmental water quality

Development of a diatom-based bio-monitoring 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 DWA 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 DWA 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 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
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

A study of the interactive effects of pesticide mixtures in water on selected species
University of Stellenbosch
No. 1932

Scientific research revealed that all major aquatic wildlife groups are experiencing endocrine disruption (ED) in contaminated sites, and that at many sites this is caused by a complex mixture of substances. Our ability to predict higher-order effects is still weak, and the imperfect state of our knowledge about the effects of EDCs on ecosystem structure has implications for environmental risk assessment of EDCs; therefore ecosystem-based research is much needed. Only in a few cases could a causal link between EDCs in freshwater systems and altered endocrine activity/function in exposed fish or amphibians be established. This study will be a laboratory study to investigate the explicit ED effects of mixtures of at least two pesticides, used in agricultural areas of intensive and concentrated crop-cultivation practices, which could contribute to the ED effects seen in the environment (thus not taking the effects of industrial or other pollution into account).

Estimated cost: R1 600 000
Expected term: 2009 - 2012

Programme 6: Socio-economic considerations

Establishing the fishery potential of the Nandoni Dam in the Luvuvhu River, Limpopo Province
University of Venda
No. 1925

Nandoni Dam was completed in 2004, and is ideally suited for both an extensive commercial fishery and an aquaculture industry. However, in order to manage the resource sustainably it is necessary to know what the productivity of the impoundment is. Impoundments typically go through a period of high productivity just after filling, as a result of the release of nutrients from the recently flooded land. This then settles down to the long-term level once the ini-

tial nutrient release is over. Nandoni Dam is reaching this stage and the level of fishery that the impoundment can sustain needs to be determined in order that the management target can be effectively set. The research conducted during this project is aimed at providing this information.

Estimated cost: R823 200
Expected term: 2009 - 2012

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

Wetlands and livelihoods: Restoration of the wetlands ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods
University of KwaZulu-Natal
No. 1986

We understand the biophysical nature of wetlands fairly well. We understand how they have evolved, but not their roleas integral parts of social-ecological systems. We continually strive to establish 'stable' wetland states rather than resilient social-ecological states. As long as we continue to take a simplistic view of such complex systems and adopt reductionist approaches we are not likely to progress with our understanding of the roles of the interactions between wetlands and livelihoods in the context of promoting resilience. Sustainable use cannot be understood or promoted unless we strive to achieve social-ecological resilience. This research proposal is premised on the assumption that 'wetlands and livelihoods' should be contextualised as dimensions of social-ecological systems. This encourages a more inclusive, holistic and dynamic ap-

preciation for the 'institutional configurations the interactions among resources, resource users, public infrastructure providers and public infrastructure' (Anderies et al., 2004). Inherent in this assumption is the notion that we need to manage the social-ecological system for resilience and not manage the wetland alone for either the supply of services or resilience. Inherent in this interpretation is the critical role of evidenced-based analysis for co-learning, assessing risk and making tradeoffs that are supported because they are perceived to be legitimate. The aims of the research are: to adapt the Anderies et al. social-ecological system framework (currently being applied in an estuaries context) and other supporting frameworks for application in a livelihoods context on freshwater wetlands; to test the framework(s) through field and/or desktop application at four wetlands and refine accordingly; and to develop a decision support system that supports management action aimed at improving resilience in social-ecological wetland systems.

Estimated cost: R800 000
Expected term: 2010 - 2013

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

Programme 2: River and impound rehabilitation

Conservation of tigerfish, Hydrocynus vittatus, in the Kruger National Park with the emphasis on the establishment of management plans for the protection of its riverine habitat
University of Johannesburg
No. 1922

The tigerfish is a flagship species in tropical and subtropical environments. It is also a species which requires healthy environmental conditions and as a result it is vulnerable to declined environmental quality. South African National Parks are charged with the maintenance of biodiversity, both aquatic and terrestrial, and so need to manage their parks to maintain conditions suitable for the biota. The rivers flowing through the Kruger National Park (KNP) are all heavily utilised upstream and these activities impact on both the quality and quantity of water in the rivers. Under the National Water Act the ecological Reserve has been determined for these rivers, and research conducted during this project will ascertain the state of the tigerfish population in the KNP and will investigate whether the ecological Reserve, as determined, is sufficient to maintain a viable population of tigerfish in the rivers flowing through the KNP.

Estimated cost: R1 844 120
Expected term: 2009 - 2012

Food-web manipulation Phase II: Food-web interactions in South African reservoirs traced using stable isotopes
DH Environmental Consulting
No. 1918

A number of the impoundments in and around Gauteng are highly polluted, and the pollution loads are increasing with the increasing load that urbanisation is placing on the treatment of effluents. Management of this pollution demands a multipronged approach, both in the catchment and in the impoundment itself. Elsewhere in the world it has been shown that the control of the numbers of zooplanktivorous fish species in the reservoir allows for an increase in the phytoplanktivorous zooplankton biomass. This in turn acts as a control of the phytoplankton, so reducing the retention time of nutrients, particularly phosphorus, in the water column. In this way the effects of eutrophication can be controlled to an extent. The research conducted in this follow-on project will investigate whether the removal of selected fish species may be effectively used as part of the suite of methods needed to bring eutrophication, and its deleterious effects on these water bodies, under control.

Estimated cost: R1 500 000
Expected term: 2009 - 2011

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Primary producers as sinks for nitrogen and phosphorus in the Great Brak estuary
Nelson Mandela Metropolitan University (Botany Department)
No. 1982

The study will provide knowledge of the processes that regulate nitrogen and phosphorus cycling in a temporarily open/closed estuary. The previous Great Brak Ecological Water Requirements Study recommended that further studies are needed to determine the loads of nitrogen and phosphorus flowing through the estuary and to determine how effective the estuarine flora, macro-algae and macrophytes, are at trapping and removing these nutrients from the system. Understanding this aspect has become critical in view of the increased water requirements from PetroSA and Mossel Bay and the related decreased inflow to the estuary. Less river inflow to the estuary translates into more closed mouth conditions, which in turn will cause more nuisance algal blooms in the system impacting on both the sense of place and biota of the estuary. The main aims of the study are: to identify the sources and determine the loads of nitrogen and phosphorus entering the estuary, through point-source discharge (e.g. river, sea and storm drains), diffuse discharge (e.g. groundwater seepage from septic tank overflow and golf course irrigation water), atmospheric deposition (rain water) and remineralisation from organic material trapped in the sediment; measure the flux of nutrients between the water column and the benthos; measure the nitrogen and phosphorus content in living plant material; describe the environmental conditions in the estuary that favour macro-algal blooms; provide recommendations to be included in the Great Brak Estuary Management Plan; and to compare results from the Great Brak Estuary, an estuary dominated by macrophytes and macro-algae, to estuaries dominated by phytoplankton (e.g. the permanently open Sundays Estuary).

Estimated cost: R955 000
Expected term: 2010 - 2013

Programme 2: Riverine processes

Linking hydrology and lateral riparian vegetation zones
Southern Waters Ecological Research & Consulting
No. 1981

The research will focus on standardising the number of lateral riparian vegetation zones, their names and their links to aspects of the flow regime. This has been proposed by Mackenzie et al. (1999) and underlies the recommended data collection approach for riparian vegetation in the Building Block Methodology (Kemper and Boucher 2008). Possibilities for standardising zone definitions have been explored to some extent in other work done on rivers in the Kruger National Park and also arose out of the previous WRC project (K5/1407), which proposed a biological description of four lateral zones but did not formalise the links with any hydrological data. This initial description requires testing on rivers elsewhere in the country. Therefore, a concise account of lateral zones with consensus on their names and predicted locations; descriptions of their floristic and other attributes, and an assessment of their correlation with flows of different return periods will be invaluable to specialists involved in Reserve determinations, practitioners involved in using VEGRAI under the NAEHP and, importantly, to new entrants to the field of riparian botany. The main objectives of the study are: to identify the number and composition of lateral zones in riparian vegetation communities in a selection of rivers around South Africa; suggest standardised names for the identified lateral vegetation zones; explore the relationships between these lateral vegetation zones and aspects of the daily flow hydrology and, if possible, link the identified zones to flows of particular return periods; and to seek simple methods for the identification of the lateral vegetation zones.

Estimated cost: R1 765 310
Expected term: 2010 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Linking of daily and monthly hydrological time series for use in monthly water resources models in support of the determination of ecological water requirements
Water for Africa (Pty.) Ltd.
No. 1979

The purpose of this study is to develop an effective methodology which utilises the daily hydrology available from the ACRU model to generate statistical parameters which describe the incremental daily flow for any quaternary catchment in South Africa and utilize this within existing monthly models to address the shortcomings of existing in monthly EWR determination methodologies. The outcome of such a method would be a stochastic simulated streamflow time-series of daily natural discharges for all quaternary catchments which is consistent with Pitman monthly hydrology. The daily time-series will not necessarily be a true representation of the flow on any particular day but will be statistically the same and will be of tremendous

value to the EWR ecologists. The main aim of this research is to incorporate daily natural stream flow time-series into existing monthly water resource system modelling tools in order to enhance the ability of ecologists to determine the ecological flow requirements of rivers, specifically to: establish regression relationships between ACRU daily flows and the existing nationwide monthly naturalised flows (Pitman); incorporate these relationships into an existing monthly water resource model so as to provide a modelling tool which can estimate the change in daily flow (statistically) at any point in a catchment under various development scenarios; and to incorporate daily output tools for use by the ecologists.

Estimated cost: R378 000
Expected term: 2010 - 2012

Programme 3: Ecosystem Health

Genetic diversity studies on selected taxa in the Klip River System: Towards the assessment of the usefulness of genetic diversity as an indication of ecological health
Sinelwati Scientific Research & Management
No. 1976

Whilst a lot of progress has been made towards developing various indices for assessing the ecological health of aquatic ecosystems, little is known about the organisation of genetic diversity in wetland and other ecosystems. There has been increased interest in rehabilitation of heavily impacted wetlands and in future this may require reintroduction of various biota. This study will focus on generating basic knowledge needed to strengthen understand of the partitioning of genetic diversity as well as the responses to pollution at the molecular level. The main aims of the research are: to determine levels and patterns of genetic diversity among some biota on the Klip River Wetland and other selected sites; to assess the potential for genetic diversity for use as an indicator of water quality; and to determine correlations, if any, between particular genotypes and physico-chemical properties at selected sites.

Estimated cost: R1 650 000
Expected term: 2010 - 2013

Expanding on a National Wetland Vegetation Database for the purpose of conservation planning, monitoring and wetland rehabilitation
University of the Free State (Plant Sciences, QwaQwa campus)
No. 1980

This is a follow-up of a scoping study (based on three provinces; K8-789) on building a national database on wetland vegetation. It addresses the critical need for baseline data on the biodiversity of South Africa's wetlands. Furthermore, it will support the Working for Wetlands Programme by establishing a method by which wetland biodiversity can be monitored after rehabilitation. In that sense it will supplement the Wetland Health and Integrity Programme already produced.

Estimated cost: R1 951 000
Expected term: 2010 - 2013

Programme 4: Environmental Water Quality

Survey of potential ecological and human health risks posed by persistent organic pollutants in aquatic environments in a densely industrialised and urbanised areas
University of KwaZulu-Natal (Chemistry Department)
No. 1977

A group of contaminants that is receiving ever- increasing attention in water and sediment quality surveys and monitoring programmes in many regions of the world is persistent organic pollutants (POPs). This attention is related to the fact that these compounds and/or their breakdown products are widely acknowledged as a significant health risk (e.g. direct toxicity, endocrine disruptors, carcinogens). Urbanisation is recognised as a far more significant source of contaminants to surface waters compared to agriculture, and surface waters in these areas are often the sole source of drinking and washing water to informal communities. Estuaries are the ultimate sinks for contaminants introduced into upstream waters and hence should provide an integrated understanding of potential problems at the catchment scale. The research has another aim in the context of costs of laboratory analyses and implementing monitoring programmes, namely, to assess whether the monitoring of estuaries (especially those in cities and towns) would be simpler and cheaper than for rivers. The overarching aim of the research is to perform a survey for an extensive suite of persistent organic pollutants in aquatic ecosystems from a highly industrialised and urbanised area and to assess the potential ecological and human health risks of measured concentrations.

Estimated cost: R1 543 176
Expected term: 2010 - 2013

Linking land use and water quality for effective water resource and ecosystem management
CSIR; Ground-Truth cc; UKZN
No. 1984

The effect of land use (especially mining and agriculture) on water quality and quantity is of concern and must be given special attention in order to ensure water security for South Africa. There is a need to begin with new ways

of managing our water resources to abate water quality challenges that South Africa has been battling with for a long time. The investigation will generate knowledge on the effect of various land-use practices on water quality, sedimentation and river health. The study will have to integrate disciplines such as terrestrial and aquatic resource management. The research should reinforce the principles of IWRM and the importance of catchment management as the ideal way to protect water resources and ensure sustainable utilisation of aquatic ecosystems.

Estimated cost: R1 500 000
Expected term: 2010 - 2013

Programme 5: Endocrine disrupting compounds in water resources

Guidelines for the Management of EDCs in Water resources: Volume 2: EDC Sampling Guide
Golder Associates Africa (Pty.) Ltd.
No. 1983

The endocrine disrupting contaminants (EDC) research programme of the Water Research Commission (WRC) has been developed with the aim of providing aid to stakeholders and the Government in the monitoring and management of EDCs. Work on the Assessment and Monitoring Guide (Volume 1) and the Management Guide (Volume 4) started in 2009. The Bio-assay Toolkit Guide is currently being finalised and this will be followed by the Organic and In-organic Analytical Methods Guidelines; all three will be incorporated as Volume 3.It is therefore necessary to develop the Sampling Guide in parallel with these guidelines to make sure that the guides include all relevant aspects necessary for EDC management in water resources. This project would give specific guidance on the sampling and preservation procedures, transport and storage of sediments and water that need to be followed in taking and handling the samples to be analysed for EDCs for treated water, raw groundwater and surface water.

Estimated cost: R1 000 000
Expected term: 2010 - 2013

Programme 6: Socio-economic considerations

Extracting scientific evidence for the development of ecosystem services production functions for the Resource Directed Measures
Prime Africa
No. 1978

The project will attempt to get a new interpretation from existing study results, by placing relevant socio-ecological work into a production function framework, and by highlighting the ecosystem service functions. The rationale is that water resource management decisions, particularly as they relate to a scarce and precious public good, need to be justified by good scientific evidence. This study is on the proposition that evidence-based ecology (EBE) should be a mechanism for increasing support to experts and practitioners by improving the information flow to stakeholders and decision-makers within an evidence-based framework (Pullin and Knight, 2003). In EBE, information-mining is described as 'systematic review'. The main aims of the study are: to gather scientific evidence (data and information) from past and ongoing WRC studies, DWA- RDM studies and other studies in a format that is useful in the development of ecosystem services production functions; to seek to influence the manner in which evidence accumulates from future studies, such that it is more amenable to incorporation in the procedure set out in the previous WRC project (K5/1644). This will include (a) guidance on how data/knowledge should be captured or documented in the future in order to provide input into this additional step and (b) analysis of the requirements for establishment of a centre of evidence-based aquatic ecology for South Africa; to identify areas of weakness in production function evidence, and encourage more research to address practical issues in these areas; and to provide outputs that are useful and highly accessible to the community of practitioners in this field

Estimated cost: R500 000
Expected term: 2010 - 2012

Programme 7: Ecosystem governance

The Shared Rivers Initiative Phase 2: Implementation of the Reserve (NWA)
AWARD
No. 1920

Research conducted will develop a dynamic synthesis of the reasons for the lags in the implementation of the National Water Act (NWA) of 1998, focusing on the ecological Reserve. It will not be a blueprint for solving the problem, but it will provide the principles and framework to guide water practitioners and managers in solving context-specific problems. Key to the whole programme is the building of capacity amongst the people involved in all levels of water resource and service management (relevant spheres of government, agriculture, mining, etc.) through action research. A means of working in this study is through collective action, networking, self-organisation and practice-based feedback loops, the aim being to develop these features where they do not already exist. It is anticipated that this will be a collaborative process and some of the outcomes will need to be negotiated. The overall aim of the Shared Rivers Initiative is to understand and effect change in the implementation of policies and legislation, specifically the ecological Reserve, relevant to the wise use

of the Lowveld river systems. In addition, the study will design and implement a series of actions that will build capacity and confidence in the legal competence to enforce obligations associated with environmental water requirements in the region and specifically the ecological Reserve in South Africa. This must be done in such a manner as to allow a generic way of introducing ongoing change which is consistent with adaptive learning.

Estimated cost: R2 500 000
Expected term: 2010 - 2013

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Wetlands and livelihoods: Restoration of wetland ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods
University of KwaZulu-Natal (CEAD)
No. 1986

Wetlands are highly productive and are important for the conservation of biodiversity as well as water resource protection. They are also used by people in both formal and informal (subsistence) agriculture as well as for various forms of recreation. Wetlands are susceptible to alteration through various forms of land use and upstream activities such as water abstraction and mining. Ecosystem goods from wetlands such as fisheries have been shown to be closely correlated to the area flooded, and so knowledge of the environmental water requirements (both quantity and quality) of wetlands is important. Recognising that certain uses impact negatively on the ecosystem goods and services that these wetlands provide, this project aims to define those ecosystem goods and services, to indicate the management activities (including rehabilitation where necessary) required to deliver the goods and services on which various activities (for example: those mentioned above) depend, and to describe interventions for the rehabilitation of impacted wetlands to suit specific uses and users.

Estimated cost: R800 000
Expected term: 2010 - 2012

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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 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, while 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. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, and reuse and treatment of wastewater from domestic to industrial and mining activities, has been and is of even greater importance to our country, especially in the light of problems related to the deteriorating quality of our water resources and the rising costs and reliability of energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond to the issues of poor O&M, competency and capacity constraints, reuse, energy efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

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

The objectives of the KSA are orientated towards making a difference and impact in the areas of health, economy, environment and society. These are achieved through a portfolio of focused thrusts:

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 6: WaterSmart Fund (new)

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, 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 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, and 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.

THRUST 6: WATERSMART FUND

Scope: Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments. Thus, this fund will support research, demonstration and development of any innovative, idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PORTFOLIO FOR 2010/11

The KSA's continuous activities, supported by needs analysis, and needs expressed by the Minister of Water and Environmental Affairs as well as through the variety of strategic workshops and seminars with DWA and other stakeholders, ensures that the KSA's objectives and thrusts are aligned to the priorities and are well supported. The External Review 2006 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, there is a need 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 2010/11 the portfolio will continue to build on the strategic changes, as well as strengthen the portfolio towards making greater impacts on the social welfare, health, environment and economy of the country. In summary, we do not foresee any major changes to the KSA strategy and portfolio of thrusts over the next few years. This KSA will continue to build on and strengthen the strategic direction implemented over the recent years, which has resulted in foresight orientating the portfolio to emerging and new issues. Thus the portfolio of thrusts and programmes remains; however, we have redirected the scopes of the following thrusts and programmes to give us the flexibility to be more inclusive of emerging issues. Specifically, we have included the element of 'water footprints' into Thrust 4, and in some of the programmes we have put greater emphasis on the aspects related to policy and finance, as well as reuse and recovery. These 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 (as presented in KSA 3 Business Plan 2009/10) 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 the Department of Water Affairs' strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the new framework strategy Water for Growth and Development (Version 6).

It is now 3 years since the KSA has been directing its activities towards its new strategic portfolio of thrusts. The modus operandi used during the last few years has been to direct most of the KSA resources through solicited projects. This has greatly and successfully affected the strategic direction and the required changes in scope have been achieved. The research sector has embraced this direction to allow greater development and innovation. Strategically, this has paved the way to a changed approach where the research areas can be addressed through funds of both solicited and non-solicited projects. Thus in the portfolio we will continue to place emphasis on the following areas:

- Asset management of water services infrastructure
- Drinking water and wastewater quality
- Small water and wastewater treatment systems

- Energy efficiency and generation from water and wastewater systems
- Nanotechnology
- Water and wastewater beneficiation and reuse technologies (mine and industrial water)
- Water for growth and development
- Water conservation and demand management
- Investigating alternative energy and biofuel potential from wastewater and sludge
- Climate change
- Improving regulation of water use in the sector

The WaterSmart Fund

In South Africa, this water resource is limited, and thus can become a limiting factor to the development and growth of the country. Added to the aspects of a limited water resource and droughts, is the variability of climate and global warming which will place an additional burden on the availability of water. Water is a finite and precious natural resource. It underpins the prosperity of our communities and the health of our environment. Together as a community our challenge is how we can use our water smarter. Achieving sustainable management of South Africa's water resources is essential for current and future generations. This includes balancing the ever-increasing demand to meet the needs of industry, individuals and the environment. Use of our precious water resources is influenced by many factors, including – population growth, housing types, population densities, water consumption habits, droughts and weather patterns. These factors place pressures on our precious water resources in terms of residential, commercial, industrial and agricultural water uses. With the growth in our cities and economy, domestic and industrial water use continues to grow rapidly and put demand on our scarce water resources. This situation will also add pressure for building more infrastructure to meet this high assurance, as well as increasing the unit costs of water. Further, the downstream impacts will also increase. These sectors can play a meaningful role by improving their efficiencies in their use, postponing these large investments and reducing pressures on the scarce resources.

The objective of the fund is to bring about a paradigm shift in the use and management of water, as well as the use of energy in water, from a supply-side toward a demand-side approach. It can be generalised that the SA population is ignorant about water conservation, water efficiency and reuse. This fund and process is a small step in stimulating research and innovation in the smarter use of water and in energy-efficient water processes, and in this way can be a catalyst for bringing about awareness and behaviour change in the way the country uses its water. It also aims to bring industry, entrepreneurs and innovators into the re-search environment to support the cause of efficient water use.

The fund will support research, demonstration and development of any innovative idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to a committed funding budget of R 34 001 420, including R8 920 852 for 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 continue 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 poses 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.

Although the water requirements for domestic (rural 4% and urban 23%), industrial (3.5%), power generation (2%) and mining (2.5%) sectors are a fraction compared to total water availability and water consumed, it is the assurance (98%) 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. The commercial use of water in the domestic urban areas accounts for 20% of the total urban water use. With the increase in population and the economy, it is projected that by 2025 water demand in the domestic sector will increase to between 30 and 35%. Any future peaks in water demand will affect the assurance levels, resulting in demand being exceeded and vulnerability increasing.

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 devel-

opment 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 service delivery that contribute to 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 low 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 these 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 un-ser¬viced high-density settlements and seepage from mine slimes dumps or mine workings).

A situation of growing dichotomy created by past practices, the current challenges for the water services sector are split into bridging the gap between the poor and unserved, in terms of access to water and sanitation services, and supporting the growth of the economy through improving infrastructure and services to industry. The rate of urbanisation is fundamentally affecting the provision of water services and is beginning to result in regular failure of existing infrastructure. The increased migration from rural areas and influx to urban areas is continually putting demands on existing systems. In the rural areas, traditional settlements present significant challenges to service delivery. While many achievements have been made by the water sector over the years in addressing these issues, the greatest and most elusive challenge is the aspect of sustainability of these achievements. The lack of investment in infrastructure operation and maintenance over the years, coupled with a skills shortage and lack of investment in replacement of infrastructure, is resulting in many systems failing to meet the requirements of good service delivery. This situation is escalating and is evidenced by the increase in reports highlighting problems.

The situation is further compounded by climate change; shortages of high-quality water sources, growing megacities, growing informal settlements, capacity and financial constraints, energy shortages and higher expectations for water, which are challenging the sustainability of the water industry in the long term. 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 of 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.

As water consumption continues to rise, Government will face the huge challenge of meeting increasing water supply and wastewater treatment demands. 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.

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 must be in place, supported by sound technologies and methodologies. The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas:

Water and society

In the impact area of **Water and Society**, the KSA contributions are made through understanding the effective demand for water services and the value society attaches to water. It is imperative that in dealing with challenges of water quality and availability, society is fully informed and participates in the management and use of water into the future. Initiatives delve into creating a good understanding of social scarcity and social vulnerability, people's usage of water and establishing a platform for involving society in the local regulation of water services. Some examples of projects which contribute to this impact area are: investigating the social vulnerability of people and their livelihoods and their response to water infrastructure; investigating operational and indigenous knowledge of water use and waste management; and establishing ways to integrate them into water services.

Water and economy

The costs and the price of water and water services have a significant impact on the economic growth of the country, since water is considered to be both a social and economic good. Providing affordable water services allows the sector to effectively meet the basic water supply needs of society and stimulate economic growth. Impacts in the area of **Water and Economy** are achieved by undertaking projects which create an understanding of the role of water in economic development at all levels, development of economic instruments for the management of water and stimulating water efficiency. Some examples of projects which contribute are: investigating the mechanisms and processes used in setting water services tariffs; guidelines on pricing and debt management; investigating the mechanism and processes used in setting water services tariffs; value of water to the industry.

Water and environment

All activities related to the use of water have a direct and indirect impact on the water environment. The health of our ecosystems and quality of water are key requirements for sustainable water management, and thus the understanding of linkages between the natural environmental components and their interaction with the anthropogenic components within the water cycle are crucial. The KSA contributes to the area of **Water and the Environment**, by influencing the reuse of effluents through developing cutting-edge technologies, establishing monitoring techniques to enable better regulation, introducing pollutant recovery and minimising processing techniques to minimise the impact on the environment. Some initiatives in this regard are: 'Health for Purpose' in wetlands treating waste streams; beneficiation of agri-industry effluents; development of a zero-effluent mathematical model for wastewater minimisation in a pharmaceutical facility; protocol for quantitative assessment of industrial effluents for discharge permitting; mass balance modelling for wastewater treatment plants; nanotechnology in water treatment; pilot application of a dual stage membrane bioreactor for industrial effluent treatment.

Water and health

Eradicating all forms and types of water and sanitation-related diseases, resulting in improvement in the quality of life of people and an increase in productivity, is ideally what is to be impacted through the area of **Water and Health**. Good, clean, safe drinking water and safe sanitation technologies are key ingredients, together with strong institutional support to realise this objective. The KSA achieves this through the development of innovative technologies, improved testing protocols for measuring water quality, identifying emerging pollutants and their consequences on human health, developing sound educational materials and communication techniques and undertaking risk assessments. Some examples of projects which contribute are: the development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply; the development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters; assessment of WatSan and hygiene in relation to home-/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas; development of more user-friendly structures for home-based treatment in rural areas; development of more robust and lighter VIP structures.

Needs analysis

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 to strengthen the portfolio of priority research topics and areas requiring attention. We believe that the continuous process of analysing and reviewing our strategy ensures that the KSA remains on a strategic path, as well as responding to challenges of the sector. The new DWA framework Water for Growth and Development has set priority imperatives for the water sector and the KSA portfolio is aligned to respond to the challenges posed.

During the year, interaction with the Minister of Water Affairs highlighted the following areas of priority of relevance to the KSA activities:

- **Climate change:** need for interventions at provincial and local levels
- **Water conservation and demand management:** more emphasis at a domestic and industrial level
- **Water pollution:** development of technology-based solutions and changing public attitude, as well compliance and enforcement
- **Rainwater harvesting:** Raising its profile, with the need for new technologies and awareness

Similarly, a strategic session with a broad representative group of stakeholders highlighted the following areas of concern:

- Better understanding and management of the water crisis
- Skills development
- Non-compliance issues
- Water security and availability
- Carbon footprint vs. water footprint debate
- Water pollution
- Cost of water to industry

- Water footprint
- Improved knowledge dissemination and transfer

We also acknowledge that the impending changes to the institutional environment will have an impact on the KSA strategy and focus. DWA is going through a water services review process, as well as an institutional realignment process. The component of sanitation will effectively be transferred from DWA to the Department of Human Settlements from 1 April 2010. Similarly, CoGTA is also going through an institutional review process and is considering the effectiveness of the three tiers of Government process, and National Government is establishing the planning commission. We are conscious of these developments and anxiously await outcomes from these processes such that we are able to align our portfolio and projects to support the needs emerging from them.

In reviewing the wealth of information generated through the various processes, including consultation with DWA and other stakeholders, it is clear that the key challenges facing the water sector in South Africa,, remain unchanged and warrant greater emphasis and support. The orientation of the portfolio in the 2009/10 Business Plan gives the KSA the ideal platform to deal with the current and future challenges and thus we see no change in the portfolio. 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 Shared Growth Initiative for South Africa) and the recent DWA framework strategy Water for Growth and Development. These objectives are:

- 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, the 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), 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 MDG targets, and in the case of South Africa, eliminating the water and sanitation backlogs.
- 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.
- 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 two 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, models for sanitation delivery and O&M, and improving the legislation and policies that contribute to an enabling environment. The sustainability of low-cost and on-site 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 energy crisis 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, three 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. 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 the needs.
- Gearing the sector towards the impetus created 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 a 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 water footprint, 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 covering 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 assets need 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.
- Industry and mining is facing increasing pressure on the rising cost of water, but also increased scrutiny on the sustainable use of the resource. The concept of a 'water footprint' is an emerging and effective tool being developed to assist industry to scrutinise their activities and continuously strive to reduce their footprint on the environment.

In this regard, we will continue to build on these imperatives and will put greater emphasis in the years 2010 to 2013 in the following areas:

- Asset management of water services infrastructure
- Drinking water and wastewater quality
- Sustainability of basic sanitation
- Small water and wastewater systems
- Energy efficiency and generation from water and wastewater systems
- Nanotechnology
- Water and wastewater beneficiation and reuse technologies (mine and industrial water)
- Water for growth and development
- Water conservation and demand management, including water footprints
- Investigating alternative energy and biofuel potential from wastewater and sludge
- Climate change
- Improving regulation of water use in the sector

Overview of technological trends

At an international level there is a continuous move towards new approaches to the provision of water services and adaptation of new approaches to improve domestic water quality and improve 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 service delivery, it is becoming more and more important to include these two 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 role. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries where 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 on 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 byproducts 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 to be on breaking the transmission cycle of water and faecal-oral related diseases through understanding the practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

In the quest for improving the water quality delivered to consumers, there are growing needs for improved analytical methods to analyse for undesirable and emerging contaminants. In this regard new improved methods are continuously being investigated, keeping up with the international trends. 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, 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 improve technologies to minimise their effect.

Key stakeholders

The Minister of Water and Environmental Affairs is the shareholder of the WRC, and DWA and 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. They comprise both internal and external stakeholders. Over the years, our inter¬national partners and business partners have also proven valuable to us.

The internal stakeholders are the WRC personnel, Executive Management and the Board, the shareholders being the Minister of Water and Environmental Affairs and DWA.

The external stakeholders include:

- Government ministries and departments (Environmental Affairs, Cooperative Governance and Traditional Affairs, Health, Mineral Resources, Science and Technology, Human Settlements, etc.)
- Beneficiaries (i.e. the users or potential users of research, development and knowledge products produced through WRC funding)
- SALGA, local government, provincial government units
- Development Bank of Southern Africa
- Water boards, water service 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), International Resource Centre (IRC), Water Research Fund of Southern Africa (WARFSA)
- The business sector

Research providers

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

Contributions to national initiatives included:

- The WRC continued 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 serves on the Advisory Board and the new water niche area strategic framework task.
- The WRC continued research with Anglo Platinum into treatment of mine-water currently held in indefinite storage.
- The WRC, through the WISA Small Wastewater Treatment Division, continued to support knowledge sharing and capacity building initiatives on appropriate technologies for small wastewater treatment works (SWWTW). A research manager is the chairperson of the SWWTW Division.
- The WRC continued to play a role in DST's initiative on technology-based solutions for accelerating delivery of water services.
- Launch of the National Business Initiative: A meeting was held with NBI on 8 November 2010. Both groups agreed that there were opportunities to work together on the new Water Disclosure Project that industries in South Africa are part of, as well as on further avenues to disseminate WRC research outcomes.
- A research manager is a panel member for Tshwane University of Technology's Quality Review process which will look at reviewing programme offerings, teaching and learning facilities and resources and professional practice.
- The KSA is assisting the DWA in the Water Research Institutional Review process. To this effect a national workshop was held with DST and the science fraternity on 10 March 2011 to chart out a national scenario for water research.
- The WRC, in partnership with SALGA, launched the new cycle of Benchmarking of Water Services on the 24 March 2011. The partnership will enhance municipal performance and contribute to national outcomes.

Leadership positions

KSA 3 staff members continue to undertake various national leadership positions, including the following:

- Chairperson, Water Institute of Southern Africa Small Wastewater Treatment Works Division.
- Member of UNEP and DEA National Forum Steering Committee for National Programme of Action on Protection of Marine Environments.
- Member, Steering Committee of DST/DWA initiative on Accelerating Services Delivery.
- Member, SALGA Sanitation Technical Advisory Committee.
- Member, Advisory Committee on Water Services Infrastructure Asset Management Strategy, DWA.
- Member, Advisory Committee on the DWA projects on Water Tariffs.
- Member of the National Water Conservation and Water Demand Management (WCWDM) Reference Group. The main aim of the Reference Group will be to provide strategic thinking and advice to the water sector, through the Water Sector Leadership Group, on how to promote and enhance the role of WCWDM throughout South Africa.

- Member of the Water Sector Leadership Group (WSLG).
- Advisor and member of the Steering Committee of the IWA – International Development Agency.
- Member, Water Institute of Southern Africa (WISA) Board.
- Member, Task Team on Water Boards Water Institutional Review Process.
- Member, Coaltech Surface Environment Steering Committee.
- Member, Department of Science and Technology Nanotechnology Innovation Centre Advisory Board.
- Member, Water Institute of Southern Africa Council.
- Vice-chairperson, Water Institute of Southern Africa Mine Water Division.
- Convener of WISA Mine Water Division task team on capacity building in mine water management.
- Members, DWA Task Team on Water Services to Informal Settlements.
- Member, Task Team to Review the Sanitation White Paper on Basic Household Sanitation – Department of Human Settlements.

Strategic positioning

- A research manager is a member of the Coaltech 2020 Surface Environment Committee. This Committee deals with the acid mine drainage issues that are also a major focus area of WRC research initiatives.
- A research manager is a member of the International Water Association Specialist Group management team on Nanomaterials and Water.
- A meeting was held with SABS and SANS on 6 April 2010, at the SABS offices, to discuss participation and involvement of the WRC in the processes of the SABS and SANS. Institutional changes at SABS had resulted in the breakdown of links and agreements with the WRC and the new management teams are in agreement that these processes need to be re-established.
- A meeting was held with two representatives of the National Business Initiative (NBI) on 30 July 2010 with representatives from KSA1, KSA 3 and KSA 4. It was agreed that there are several activities that the NBI is doing with its member organisations which WRC research (KSA 3) can steer and add value to.
- A Thrust 4 strategic workshop was held on 2 August 2010 with key stakeholders to help define key research priorities and potential programmes for 2011 and beyond. This process was followed by questions relating to the thrust and programmes to other stakeholders via e-mail to ensure good feedback before finalising a new or updated strategic research agenda for industrial and mine-water management.
- The WRC is a member of the Inter-Ministerial Task Team on Acid Mine Drainage for the Departments of Water Affairs and Mineral Resources.

African leadership

In Africa, the WRC plays an active role in activities aimed at building water-centred knowledge. Key initiatives include:

- Through an initiative hosted by WIN-SA as part of the Sanitation Knowledge Node, a meeting was held in Swakopmund, 27-28 May 2010, to discuss modalities of partnership and knowledge sharing with Namibian representatives.
- Delivered a keynote address and shared WRC research on franchising of water services, at the first IWA 'Meeting of African Utility Managers', a platform created to share knowledge between African leaders, Swaziland, 8 October 2010. WRC will support the IWA initiative with its products and tools and support other capacity building initiatives in Africa.
- Hosted the first 'Regional Seminar on Faecal Sludge Management' in March 2011, in partnership with WIN-SA, SALGA, SAKN.
- Founder Member, African Water and Sanitation Network.
- Editor: Sanitation Matters.
- Founder Member, IWA Water Safety Plan Network: Africa.
- Task Leader for South Africa and Work Package 5 Leader for African partners, Kenya, Ethiopia, Morocco and Burkino Faso, for EU CLARA Project.

International player

- Founder Member, Management Committee of the International Water Association Nanotechnology Specialist Group.
- Advisory Committee Member, IWA – GDA.
- Member, Planning Committee IWA Resilience Conference – Australia 2012.
- Member, Planning Committee IWA Development Conference – Malaysia 2011.
- The WRC continues to be an active member of the Global Water Research Coalition (GWRC). The WRC is currently collaborating with members of the GWRC in research programmes addressing algal toxins and asset management, as well a programme on Energy Efficiency in the Water Industry: A Compendium of Tools, Best Practices and Case Studies. The WRC has contributed several case studies to the GWRC project 'Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies'. The objective of this research study is to develop a Compendium of best practice in the energy efficient design and operation of water industry assets.
- The WRC will also be linking with the GWRC 'Water Footprinting' initiative.
- WRC is part of a new initiative coordinated by the WERF - USA, called 'Next generation of used water' which entails assessing the sustainability of current water management practices, identify those that are projected to be least sustainable over the next 20 years, and defin-

ing a new vision for conveying, treating, and reusing water that would address the shortcomings.
- The WRC is part of the new GWRC project 'Brine handling in desalination'.
- The WRC is to be a partner member in the EU-FP7 research programme CLARA: Capacity-linked water supply and sanitation improvement for Africa's peri-urban and rural areas. The WRC is one of 16 global partners involved in the project.
- Member, IWA task force on Water Quality and Health.
- Member, Scientific Programme Committee of the *IWA Nano and Water 2011 Conference*, May 15-18 2011.
- Contributed to case studies on South African experiences on water reuse for the EPA guidelines on water reuse, and invited to give a keynote address at the workshop hosted by the EPA/USAID in Jordan on March 30, 2011.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

Of the 145 students engaged in KSA3 projects in 2010/11, 106 were previously disadvantaged individuals (Table 1).

TABLE 1
Capacity building through student involvement in KSA 3 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Africa Remediation Technology	1	1
ATL-HYDRO	3	3
Cape Peninsula University of Technology	17	20
Corporate Research Consultancy	1	1
CSIR	5	5
Counterpoint Development	0	1
Durban University of Technology	3	3
Emanti Management	1	3
Emanti Water & Environmental Engineering Services	2	2
Golder Associates Africa (Pty.) Ltd.	2	2
Hlathi Development Services	2	2
Nelson Mandela Metropolitan University	3	7
Nemai Consulting	3	3
Partners in Development	4	4
Re-Solve Consulting	0	1
Rhodes University	2	5
Sinelwati Scientific Research & Management	1	1
Sustento Development Services	0	1
Tshwane University of Technology	4	4
Umgeni Water	7	7
Umvoto Africa	1	1
University of Cape Town	3	12
University of Johannesburg	1	1
University of KwaZulu-Natal	3	3
University of Pretoria	3	4

University of Rhodes	9	12
University of Stellenbosch	4	9
University of the Western Cape	14	18
University of the Witwatersrand	5	6
Virtual Consulting	0	1
WRP Consulting Engineers (Pty.)Ltd.	2	2
TOTALS	**106**	**145**

The KSA was involved in hosting the following workshops, among others:

- The WRC co-hosted a workshop with CSIR on urine separation, to foster debate and discussions around source separation of wastewater from large complexes, new estates and office buildings, for improved functioning of wastewater treatment plants.
- The WRC co-hosted a workshop with Digby Wells and Associates on 'Cleaner production in the mining industry', April 2010.
- The WRC co-hosted a workshop with WISA Oxidation and Disinfection Division on Oxidation and Disinfection of Drinking Water, April 2010.
- The WRC co-hosted a workshop with the Southern African Young Water Professionals on 'Transdisciplinary issues in the water sector', April 2010.
- The WRC co-hosted a workshop with WIN-SA, DWA, and COGHSTA in the Northern Cape, Kimberley on 8th April 2010 on Infrastructure Asset Management and Operation and Maintenance. The workshop was well attended by 25 delegates from local and district municipalities. The NC is seen as a possible case study for the DWA IAM strategy.
- The WRC hosted a workshop on 'Franchising of water services O&M, in partnership with CSIR, during *WISA 2010*.
- KSA 2 and KSA 3 co-hosted a workshop on natural and constructed wetlands, May 2010.
- The IAM Reference Group, compromising the WRC, DBSA, DWA, Joburg Water and WIN-SA initiated a workshop in KwaZulu-Natal on 20 July 2010, which introduced infrastructure asset management (IAM), and shared the Northern Cape IAM/O&M case study with delegates with the aim of driving twinning amongst provinces and municipalities.
- The WRC hosted a TECHNEAU workshop, October 2010, on 'Water reclamation in Southern Africa: monitoring systems and risk assessment'.
- The WRC hosted a TECHNEAU workshop, October 2010, on 'Risk management of drinking water systems in Southern Africa'.
- The WRC and DWA hosted a 'Wastewater Risk Abatement Plan' workshop, December 2010.
- The WRC co-hosted an 'Anaerobic digestion' workshop with eThekwini municipality and UKZN, February 2011, to open discussions around the state of anaerobic digestion in South Africa.
- The WRC hosted the first ever regional seminar on Faecal Sludge Management in association with WIN-SA, SKN and SALGA, March 2011. The event captured five years of WRC investment and outcomes on managing dry pit latrine sludges.

Strategic capacity building interventions

- Exploratory meetings were held with Unilever, WRC, eThekwini and the Pollution Research Group on 25 May 2010 to look at future collaborative opportunities.
- An exploratory meeting was held with SAPPI Innovation Hub to re-establish links with pulp and paper stakeholders. Contact has also been made with Paper Makers Association of SA (PAMSA) Research Co-ordinator, to discuss a partnership in promoting water research.
- An initial meeting was held with DST on 28 January 2011 to explore synergies with a potential centre of competence for environmental technologies within the DST.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- A WRC research manager chaired a session on water and was a member of the panel in a debate at the South African Institution of Civil Engineering conference, *Engineering Planet Future*, at the CSIR ICC, 16-17 March 2010.
- A paper was presented at the *WISA Small Wastewater Treatment Division*, 21 April 2010, on gaps and challenges for SWWTW and the vision and objectives of the newly formed WISA Division.
- A paper was presented on 'Biosorption and bioaccumulation of copper and lead by *Phanaerochaete chrysosporium* and *Pleurotus ostreatus*' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper was presented on 'Energy Efficiency in the water industry: a compendium of best practices and case

studies' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper was presented on 'Quality of domestic water supplies guidelines: 10 years of relevance to the sector' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper entitled 'Biosorptive recovery of platinum from metal refining wastewaters by immobilised Saccharomyces cerevisiae' was presented at the *IWA World Water Congress 2010* in Montreal, Canada, September 2010.
- A paper on 'Franchising principles for the operations of water services' was presented at the *IWA World Water Congress 2010* in Montreal, Canada, September 2010.
- A paper was presented on 'Web enablement of a Water Safety Plan via the South African municipal-based electronic Water Quality Management System (eWQMS)' at the *International Water Association / World Health Organization Water Safety Conference: Managing Drinking Water Quality for Public Health* and an associated meeting of the WHO International Small Community Water Supply Network in Kuching, Sarawak, Malaysia in November 2010.
- A paper was presented on 'Franchising of water services O&M' at the *IWA Water Utility Managers Conference,* Swaziland, 18 October 2010.
- A keynote address on 'Greywater - the invisible problem' was delivered at the *UNC Conference on Water Quality and Health*, Chapel Hill, USA, 23 to 26 October 2010.
- Co-authored a paper entitled 'Biosorptive recovery of platinum from platinum group metal refining wastewaters by immobilised *Saccharomyces cerevisiae*' in the journal *Water Science and Technology* (63 (1): 149-155).
- Co-authored a chapter entitled 'The Water Research Commission' in the book *Transforming Water Management in South Africa - Designing and Implementing a New Policy Framework, Global Issues in Water Policy 2 Series.*

IMPLEMENTATION PLAN

Research portfolio for 2010/11

The KSA's continuous activities, the results of the strategic needs analysis and its review, needs expressed by the Minister of Water and Environmental Affairs through the variety of workshops and seminar, engagement with DWA and other stakeholders, with regard to its objectives and thrusts have been well supported. The External Review 2006 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, there is a need 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 20010/11 the portfolio will continue to build on the strategic changes, as well as strengthen the portfolio towards making greater impacts on the social and health aspects, environment and economy of the country. In summary, we do not foresee any major changes to the KSA strategy and portfolio of thrusts over the next few years.

The primary objective of this KSA (as presented in KSA 3 Business Plan 2009/10) 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 the Department of Water Affairs' strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the new DWA framework strategy Water for Growth and Development (Version 6). We believe that the programmes and projects are strongly orientated to the challenges. This is receiving, and will therefore continue to receive, greater attention.

The new portfolio of projects continues to 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 grey-water 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
- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology

Thirty-one (31) new projects have been approved for funding, all being non-solicited projects. The scope and expected outcomes of the thrusts and programmes are provided in Table 2.

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 programme 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 for 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 produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.
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 support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water 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 and 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, 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. The aim of this thrust is quantify waste, its impacts (footprint) and the methods of prevention, reuse, recovery and beneficiation at source. This thrust also provides 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 waste 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, policy and financial 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 almost exclusively to manage water quality. 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: Reuse, recovery, 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, recovery, reuse and disposal of industrial and mining effluents, with an 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.

THRUST 6: WATERSMART FUND

Scope: Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments. Thus, this fund will support research, demonstration and development of any innovative, idea, technology or process which supports the efficient use, reuse and conservation of our precious water and related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PROJECTS FOR 2008/09

COMPLETED PROJECTS

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

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

Currently South African water services authorities (WSAs), i.e. those municipalities tasked with governance of water and sanitation provision, and water services providers (WSPs), i.e. those organisations or individuals tasked with the actual provision of water and sanitation on behalf of the WSA, face numerous challenges in providing sustainable services. This is because of reasons including enormous services backlogs; scarcity of technical and other skills; aging and deteriorating infrastructure asset base; non-alignment of political will with technical priorities; and an inability to always maximise cost efficiencies through benefits of scale and scope.
This difficult and complex situation is exacerbated by the fact that WSA decisions to set up institutional arrangements are guided by legislation that is onerous, and that articulates a decision making process, but does not provide sufficient guidance on content and configuration of institutional arrangements, or a rationale for choosing one arrangement over another. Furthermore, institutional arrangements are viewed in terms of whether they are 'centralised' or 'decentralised'. However, these terms are used loosely and, since all water services provision takes place within a decentralised governance framework, they are sometimes misleading in their application. This study has found that it is important that the South African water services sector explores issues of 'centralisation' and 'decentralisation' in a much more nuanced way, and within the decentralised institutional framework for water services provision. Institutional arrangements for water services provision in South Africa may be described as 'more consolidated' or 'less consolidated' in terms of how functional areas within the institutional arrangement are configured. They will generally be a mix of consolidated and non-consolidated functional areas, supported, as appropriate, by consolidated auxiliary services. All institutional arrangements should be viewed as context-specific, guided by the needs of the functional areas and challenges as presented at the time of the section 78 assessment, and by opportunities for benefits of scale and scope. Politicians have a responsibility to understand the water services business, and to enable sustainable water services provision through whatever institutional arrangement they have chosen for their WSA. The link between integrated catchment management and water services provision needs to be further explored and developed in terms of the institutional realignment and reform process.

Cost: R600 000
Term: 2008 - 2010

Programme 4: Regulation of water services

Investigating the mechanism and processes used in setting water services tariffs
Nelson Mandela Metropolitan University
No. 1871

Prosperity in South Africa depends, among other things, on the sound management of water, but with expanded aspirations and political commitments, municipalities and central government in South Africa have found themselves in a challenging situation with respect to the provision of water services for the last decade. The municipalities depend heavily upon central government assistance to meet their mandate to provide water services to the local communities they serve. To address the above-mentioned challenges, the South African Local Government Association (SALGA) and the Department of Water Affairs and Forestry

(DWAF) established a need for a framework to be developed for municipal water service tariff setting. In response, this study has found that the primary current influence on municipal tariff design is compliance with water and municipal governance law and policy, and that for many of South Africa's municipalities meeting the compliance goals is challenging, to the point of being almost overwhelming. Further, many municipalities use limited (if any) accounting information to determine the availability tariff and thus there is uncertainty within South African municipalities as to the underlying economic rationale of the water service tariff (price) structure.

Estimated cost: R600 000
Expected term: 2009 -2010

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 2: Water treatment for rural communities

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 some small and medium-sized water treatment plants in terms of the provision of a potable standard of drinking water to the end consumer is suspect, mostly due to inadequate management. South African studies have shown that in non-metropolitan communities with adequate water supply services the drinking-water quality is often poor. While effective water treatment is accepted as necessary, the need for monitoring and management of water quality from raw water supply to point-of-use is less recognised and often superficially performed. Although ensuring water treatment is already the focus of various initiatives, further attention is urgently required. One of the reasons for this is the lack of an adequate and efficient management information system. Water services providers either have their own system or do not use a system at all. This project developed a simple and user-friendly system of a set of standardised, active sheets (analogous to log-sheets) to be filled in by operations and management staff. The sheets are in electronic format, but also available in hard copies for plants without computers. It is possible to enter all categories of information that require immediate action or storage for later manipulation and use, such as flows, levels, qualities, chemicals, assets, human resources, finances, stock, maintenance schedules, etc. The operational information tool also links up with the WRC manual and training aids for sustainable operation and maintenance of small water treatment plants (WRC Project K5/1599). The tool fits into present municipal systems, and the information tool is integrated with the DWAF information systems, such as the Drinking Water Quality Framework and Management Tool. The information tool is also integrated with the eWQMS. Training aids comprising interactive media and wall-posters indicating step-by-step processes for using the tool are available on CD as well as on the Technical Assistance Centre (TAC) website.

Cost: R800 000
Term: 2007 - 2009

Programme 3: Drinking water quality

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

Beta-N-methylamino-L-alanine (BMAA) is produced by free-living cyanobacteria, with one of these being marine. BMAA has also been identified as a potential risk to human health as it is implicated in Alzheimer's disease, Parkinsonism and Amyotrophic Lateral Sclerosis (ALS). The possibility of sustained exposure to BMAA via drinking water supplies prompted the establishment of local analytical capacity for the neurotoxin, urgent verification of the production of BMAA by free-living cyanobacteria, the evaluation of the distribution of BMAA producing free-living cyanobacteria in South Africa and the extent of BMAA contamination of surface waters. In the case of freshwater cyanobacteria BMAA would be released into raw water which may be used as a potable water source. The efficacy of current treatment systems for BMAA removal is unknown. The potential risk to consumers was therefore also unknown but could be determined by addressing the extent of raw water contamination and treatment efficacy. Since biotoxins are often present in low concentrations, large volumes of water needed to be concentrated to be able to quantify BMAA. In order to assess the extent of free BMAA contamination of water, a concentration method needed to be developed. A culture collection of South African cyanobacterial isolates was established, expanded and maintained as part of this project. BMAA analysis was optimized using a commercial chloroformate derivitization kit (EZ:faast) with gas chromatography - mass spectrometry (GC/MS) and high performance liquid chromatography - mass spectrometry (LC-MS) analysis of derivatized amino acids. The GC-MS BMAA detection developed for this project was 15 times more sensitive than previously published fluorescent 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate-derivatized BMAA detection methods and the LC-MS BMAA detection method is 50-fold more sensitive. The lower limit of sensitivity for detection was below 100 pg per injection, and quantification was possible at 148 pg. BMAA was detected in 97% of all culture collection

strains examined. A concentration protocol based on a strong cation exchanger with hydrophobic interaction was developed for extraction and concentration of BMAA from raw water samples.

Cost: R1 000 000
Term: 2007 - 2010

Situation and gap analysis of water quality testing in South Africa
Jeffares & Green
No. 1720

There are a limited number of laboratories that undertake water quality testing in South Africa. More significantly, many of these laboratories have capacity limitations. These laboratories are a critical link in the value chain that ensures safe drinking water for consumers and unpolluted water in our water resources. Until recently there has been little focus on the quality control of the laboratories utilised in the testing of water. This has resulted in municipalities and the Department of Water Affairs (DWA) using both centres of excellence and those with little evidence of being able to produce reliable results. However, the most startling issue is that although the problem was acknowledged within the sector, it could not be quantified. This WRC project has begun the process of quantifying these gaps in the sector. A database was developed of existing laboratories that undertake water quality testing and, through a survey, obtained information on their capability and credibility. Nearly 200 laboratories were identified and 50% of these completed the survey. The geographic spread of the laboratories correlated to their testing capability has provided a useful tool in establishing if there are sufficient laboratories across the country, and where additional credible laboratories need to be established. The survey submitted to all water quality testing laboratories was based on staff capacity, laboratory capability, equipment, accreditation methodology, quality assurance methodology, area served and general remarks. By critically analysing these categories, a holistic gap analysis has been portrayed, providing a base for improvement in the water quality testing sector and thus improving water service delivery. The DWA will be the custodians of the database, using it to build a list of recommended/approved laboratories for use by municipalities in their water quality monitoring programmes, and also maintaining the information so that it remains current.

Cost: R800 000
Term: 2007 - 2011

EDC bio-assay toolbox
Biostream; University of Pretoria; A Burger (independent consultant); North-West University, CSIR (Natural Resources and the Environment)
No. 1816

The presence of estrogenic compounds in drinking waters, source waters and wastewater is of international concern because of potential adverse health effects on wildlife and humans. Chemical analysis in environmental matrices has been problematic due to both the large numbers of compounds with endocrine-disrupting capabilities that may be present in the environment and the ultra-low concentrations that have been reported in the literature to cause estrogenic effects. Biological methods are becoming increasingly popular as screening tools because the specific chemical nature of an environmental sample is not always known. As the effects of chemical mixtures cannot always be inferred from their concentrations, bioassays are an important component of examining the presence of and integrating the effects of complex mixtures of endocrine-disrupting chemicals. The project investigated a suite of bioassays suitable for laboratory screening in one or more of the matrices outlined above. Initial method selection was based on parameters such as local and global applicability, sensitivity or limits of detection, reproducibility, robustness, ease of use, application to more than one matrix, appropriate sample preparation and isolation procedures, environmental relevance, cost, repeatability and others as determined during the study. Receptor binding, reporter gene, cell proliferation and in vivo bioassays should be representative of potential adverse effects that could impact aquatic ecosystems and/or animal health and be applicable for future evaluation of water and wastewater treatment technologies. After completion of the initial evaluation of the bioassay suitability, YES Assay, T47D-Kbluc, E-screen and VTG ELISA were identified for inclusion in the manual. The complete standard operating procedures (SOPs) have been developed. The availability of such tools will allow the regulator / health authorities to make decisions based on sound scientific data when faced with a new water quality problem or the presence of new chemicals with unknown properties and to base decisions on the precautionary principle.

Cost: R870 000
Term: 2008 - 2010

Programme 4: Water distribution and distribution systems

Investigating private on-site water use and its impacts
University of Stellenbosch
No. 1819

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 eight-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: R300 000
Term: 2008 - 2009

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies

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

The current discharge requirement of ammonia-nitrogen in secondary sewage effluent is 10 mg/ℓ. This discharge requirement may be reduced to 6 mg/ℓ in future. Municipal biological treatment plants have experienced that it is sometimes difficult to produce treated effluent containing less than 10 mg/ℓ ammonia-nitrogen. This project investigated the potential of reducing ammonia-nitrogen via inclusion of a selective ion-exchange system to the existing treatment train. Ammonia-nitrogen can be removed from wastewaters by selective ion-exchange using clinoptilolite, biological nitrification and denitrification, liming to pH 11 followed by air (or steam) stripping, breakpoint chlorination followed by treatment with activated carbon and treatment in algal ponds. Biological nitrification and algal ponds may not be suitable where low temperatures are encountered. Stripping and breakpoint chlorination are considered to be too expensive for the high ammonia-nitrogen concentration levels encountered in secondary effluent. Selective ion-exchange of ammonia-nitrogen using the natural zeolite, clinoptilolite, in the sodium form, which is not very sensitive to temperature fluctuations, and which is a locally occurring mineral, should be suitable for ammonia-nitrogen removal from secondary sewage effluent. Knowledge that is lacking in South Africa is the performance of the local clinoptilolites for the removal of ammonia-nitrogen from secondary effluent. This technology could be an effective low-cost technology for the final polishing of secondary sewage effluent to reduce the ammonia-nitrogen concentration to acceptable levels.

Cost: R317 000
Term: 2006 - 2010

Programme 2: Application of appropriate technologies and tools

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

The aim of this study was to highlight the status quo of waste stabilisation ponds in South Africa, using the Eastern Cape and Free State as case studies. The information obtained was used to create a simpler and more user-friendly guide to operations and maintenance of waste stabilisation ponds. In addition, a key gap highlighted was the poor management of the plants which resulted in the compilation of a management guide for waste stabilisation systems. The study also led to the production of a waste stabilisation pond assessment tool which resides on the electronic Water Quality Management System (eWQMS). The tool will be useful for water service authorities (WSAs) in terms of identifying key areas of risks for waste stabilisation ponds so that they can plan and implement remedial measures accordingly.

Cost: R700 000
Term: 2006 - 2010

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

Stormwater ingress into sewer networks is a worldwide problem, but is particularly bad in South Africa. The Msunduzi Municipality is acutely affected, with peak sewer flows tripling or even quadrupling during times of heavy rain, and with average daily flows doubling and remaining elevated for a substantial period after rain. This study, therefore, used Msunduzi Municipality as a case study to evaluate the extent of the problem, the inventions required, the bylaws applicable, the inspection programmes that can be managed by municipalities without significant cost and the enforcement methods applied. The study showed

clearly that rainfall events which lead to sewers overflowing can be linked to illegal connections, and that sewers and wastewater treatment plants are severely impacted during rainfall events even if only 10% of the houses have illegal connections. It is important to note that people connected illegally to sewers in order to prevent their properties from being flooded; thus there was a need for municipalities to evaluate stormwater management options, especially in previously disadvantaged areas. Finally, the study demonstrated that a simple inspection programme could be created and successfully implemented by training and using local unemployed people. Public awareness and community education campaigns can serve to reduce the stormwater load at source, and provide an alternative to upgrading infrastructure which is capital intensive and time consuming. The study provided information on stormwater ingress in a pamphlet and distributed it to a sample of residents – this was found to increase awareness of stormwater ingress by up to 20% in the targeted areas relative to nearby areas which were not targeted. This was significant given the limited duration and scope of the intervention. For an awareness and education campaign to be really effective, however, it would need to be part of a co-ordinated city wide campaign followed up by extensive inspections and backed up by the political will to deal with transgressors.

Cost: R334 250
Term: 2007 - 2011

Development of a South African guide for the design and operation of waterborne sewerage systems
University of Pretoria
No. 1744

A number of sanitation options are available. The choice of the optimal/best option is inter-related to appropriate technologies, environmental impact and the health hazards to users, but is also strongly influenced by the operational and management inputs that are required for a sustainable service. Different standards for the various sanitation options are available, but no collated and comprehensive documentation is available in South Africa to educate the end user and to highlight the technologies in such a way that managers can select the optimal technology for a specific application. This is the first such consolidated and comprehensive guide in South Africa on the subject of water sanitation. The guidelines will also be a great educational tool which can be distributed throughout the country cost effectively (as a DVD), and which would open managers' and decision makers' eyes to the alternative options available.

Cost: R585 000
Term: 2007 - 2011

Sewer master planning tools and guidelines
Stellenbosch University; GLS Consulting Engineers
No. 1828

The aim of the project was to present a simplified approach to sewer system planning with accompanying tools that could be used directly as a low-technology (non-computer based) method for sewer system planning, and to better understand the planning process. A key problem identified in small local authorities was that staff members at ground level, responsible for service delivery, were often limited in terms of basic knowledge regarding the sewer system, its operation and planning. The understanding of sewer planning as a simple tool was developed through a series of workshops, an extensive knowledge review and feedback from the reference group. The knowledge review covered sewer system planning, local practice, key issues pertaining to small local authorities, design philosophies, the dynamic planning process, sewer flow and flow components, as well as an extensive review of completed South African sewer system (master) plans. The knowledge review set the scene for development of low-technology tools that could aid staff in small local authorities while the workshops allowed for the tools to be developed and adjusted during the process. Three outputs were produced from the study:

- A technical report explaining the process of development of the tools and the key components which are important for sewer planning
- A poster incorporating a simplified sewer planning process tool and sewer infrastructure estimates
- A low-technology toolkit comprising six stand-alone booklets termed 'tools'

Cost: R600 000
Term: 2008 - 2011

Programme 4: Wastewater sludge and faecal sludge management

Influence of sludge conditioners on the soil-conditioning properties of sewage sludge
University of Pretoria
No. 1540

This project studied the effect that organic and inorganic conditioning agents used in sludge treatment could have on the soil conditioning properties of sewage sludge. Overall, it was found that the polyelectrolytes investigated do not adversely affect the soil conditioning properties of sewage sludge. With the exception of ferric chloride, polyelectrolyte sludge conditioners were superior to inorganic sludge conditioners to dewater sludge. Water uptake was similar for both conditioned and unconditioned polyelectrolyte treated sludge, and higher than for sludge treated

with inorganic salts. Unconditioned and conditioned sludge displayed a similar hardness and BOD/COD ratios. Mineralisation of polyelectrolyte-treated sludge was not inhibited by high dosages of polyelectrolyte, while polyelectrolytes actually contribute towards slightly higher nutrient concentrations in the soil. It was recommended that the current practice of applying organic sludge conditioners to sewage sludge should be maintained

Cost: R101 000
Term: 2004 - 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 Lephalale region of the Waterberg contains the third largest coal reserves in South Africa and can become a new powerhouse for coal-fuelled electricity production in the country. Due to the planned expansion of the mining enterprises in the area and the accompanying developments, it is important to determine the extent of the impacts these developments will have in the area. This study looked specifically at the impacts these developments will have on the groundwater quality and quantity in the area. The project was conducted in several stages, beginning with two hydrocensus to locate as many boreholes in the area as possible. Water levels, borehole depths, location and EC and pH were measured and groundwater samples collected. Other data were gathered from Exxaro, Sasol and Eskom and compiled into a database used for contour maps, the determination of recharge, etc. Tests in the field determined the aquifer parameters of the different aquifers present in the study area. To account for influx of water to the study area, the recharge for the study area was calculated by means of the chloride mass balance method and the E.A.R.T.H. model. These calculations indicated a low recharge for the area. To determine the acid potential, acid-base accounting (ABA) was performed on the collected samples; the tests indicated that most of the samples collected would become acidic upon oxidation. To form a more complete conclusion of the potential impact of mining of the coal field samples were collected from the beneficiation plants at the Grootegeluk Mine. These samples were also analysed for acid potential, the results of which indicated that the samples will become acidic upon oxidation. Numerical modelling was used in order to determine the impact the mines would have on the groundwater and the flow directions of the groundwater. The dewatering models indicated that there very little water was available in the study area with small volumes predicted to flow into the mines. The decant models indicated that there was no possibility of the pits ever reaching decant levels with the highest recorded rise being seven metres, 50 years after mining had stopped. It was concluded that the most effective way to preserve the water quality and protect the groundwater quality from further deterioration was to keep all acid generating material dry as it would not be possible to flood this material once the mine closes, due to the small volumes of water in the area. The volumes of water that will enter the mines from groundwater and surface runoff will be small, hence it is recommended that the water be pumped out and used for run of mine operations such as dust suppression or washing of the ore. Steps should be taken to minimise the risk of encountering a fault during mining. If the mines encounter large faults and start to dewater the faults, many farmers with boreholes along the length of the fault might see significant decline in the water levels of their boreholes. It is recommended that preventative measures be taken rather than containment for the new mines planned for the area.

Cost: R700 000
Term: 2008 - 2010

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

Geochemical sampling and analyses for environmental risk assessments using the Wits Basin as a case study
Pulles, Howard & de Lange
No. 1624

Limited work has been done on the development of methodologies for sample sizing and quantifying uncertainties in geochemical sampling and analyses. This project addressed this deficiency in geochemical sampling and analyses and proposes two methodologies (i) for quantifying uncertainties in geochemical sampling and analysis as a function of sample size and analysis and (ii) for determining the optimum sample size to ensure data quality. The two methods were applied to acid-base accounting (ABA) data derived from geochemical assessment for environmental risk assessment of the West Wits and Vaal River tailings dams. The study was aimed at assessing and evaluating the potential of tailings dams in the two mining areas to impact on water quality and the implications of this in terms of mine closure and rehabilitation. Findings showed that the number of samples needed is influenced by the purpose of the study, size of the target area, nature and type of material, budget, tolerable error and the confidence level required, among other factors. Acceptable error has an inverse relationship with sample size, and confidence level and standard deviation have a positive

correlation with sample size; hence one can minimise error by increasing sample size. While a low value of acceptable error and high confidence are always desirable, a trade-off among these competing factors must be found. The findings also demonstrated that uncertainties in geochemical sampling and analysis are unavoidable. They arise from the fact that only a small portion of the population rather than a census is used to derive conclusions about certain characteristics of the target population. Effects such as poor sampling design, inadequate sample size, sample heterogeneity and other factors highly affect data quality and representivity hence measurement uncertainty. Among these factors, factors associated with sampling, and, mainly, heterogeneity, were found to be the strongest contributing factors toward overall uncertainty. This implies an increased proportion of expenditure should be channelled toward sampling to minimise uncertainty. Uncertainties can be reduced by adopting good sampling practices and increasing sample size.

Cost: R562 000
Term: 2005 - 2010

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

Fly ash has been investigated as a method to neutralise acid drainage from mines. The solids generated during the neutralisation process are generally rich in insoluble metals and metalloids (some of which are toxic or otherwise environmentally undesirable). The solids are being considered, inter alia, for backfilling of mines and use in soil remediation. This project thus established that the insoluble metals and metalloids, which form part of the solid neutralisation product, can be remobilised as a result of microbial activity which (eventually) develops in the solids during the process of maturation and when they are exposed to the environment.

Cost: R220 000
Term: 2006 - 2010

Refinement of the decision support system for metalliferous tailing disposal facilities
Golder Associates Africa
No. 1735

This project represents the second phase of a three-phase research programme to develop a comprehensive decision support system (DSS) for the sustainable design, operation and closure of mine residue disposal facilities. As part of the refinement of the DSS developed during the first phase, this project developed a performance demonstration protocol (i.e. a procedure or guidance that can be used to demonstrate the acceptability of a particular technique, technology or approach), assessed the alignment of the DSS to current legislation, undertook specialist studies of specific knowledge gaps and identified and assessed new and promising technologies and approaches. Four specialist studies related to water and geochemistry were conducted, namely depth of the oxidised zone, tailings water balances, pore-water quality evolution and protocols to handle uncertainty in model predictions. Surface stability specialist studies focused on erosion rate, effectiveness of cover technologies and the development of protocols to monitor and check surface stability during the post-closure phase.

Cost: R2 200 000
Term: 2007 - 2010

A systematic approach to sulphidic waste rock and tailings management to minimise AMD formation
University of Cape Town
No. 1831

One of the major environmental issues in the mining industry is that of acid rock drainage (ARD), caused by the disposal of sulphide-bearing wastes. Re-examination of the manner in which waste materials are disposed from the mineral processing and extraction stages of metal recovery is required to relieve the environmental burden created and reduce the time frame of risk. In this study, the approaches to the removal of risk through removal of sulphur species were considered through a review of key work and a set of case studies addressing specific mineral wastes. Aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides (especially pyrite) have been addressed, with the focus of reducing capacity to form ARD through removal of the sulphidic component of the waste. The understanding of the factors governing ARD generation from dump rock and tailings (similar to those governing mineral bioleaching) has been used to improve categorisation, separation and planned disposal of its components to mitigate ARD generation. While flotation and accelerated bioleaching have been used in the case studies to demonstrate sulphide removal by separation and reaction, a review of suitable unit operations is provided. Further, use of acid-base accounting and net acid generation methods as static chemical methods for evaluating ARD potential is supported by the development of a biokinetic test for assessing ARD potential under an environment more cognisant with the ARD-generating environment, as well as providing kinetic data over a shortened time frame to conventional kinetic tests. The biokinetic test also delivers solutions through which to

analyse metal deportment through ARD. A case study using flotation for the physical separation of sulphide from tailings allowed the demonstration of the concept of risk removal. In a second case study using reaction to remove the sulphide fraction, the relative impacts of removal of acid neutralising and acid forming capacity were apparent, with the rate of the former exceeding that of the latter and being largely complete within 50 days. A third, preliminary, case study on coal desulphurisation by flotation was unable to demonstrate significant separation of total sulphur from coal ultra-fines, both visual observation and net acid generation (NAG) prediction tests demonstrated a significant separation of sulphidic sulphur, with the majority of the acid-generating sulphidic sulphur reporting to the concentrate fraction, resulting in an acid-forming concentrate while the residual tailings showed an increased NAG pH and reduced acid-forming ability over the feed material. Physical separation of sulphidic materials from tailings has been demonstrated to provide the major tailings fraction as non-acid forming while the reactive gangue may be contained in a small fraction of the tailings for additional recovery of values, utilisation of the sulphide or contained disposal.

Cost: R598 320
Term: 2008 - 2010

Programme 4: Minimising waste production

The introduction of cleaner production technologies in the mining industry
Digby Wells & Associates
No. 1553

This project introduced cleaner production (CP) technologies to the mining industry by using a number of CP tools. A scoping study identified distinct differences in how big and small companies improve their practices and consider environmental impacts. Company policy and the practices of their competitors drive awareness within larger companies, while legislation drives awareness in smaller companies. The fact that several existing water-related threats by and to the mining industry can be alleviated by CP technologies presents opportunities to facilitate the introduction of CP approaches. Cleaner Production Forums were formed where coal and gold miners could share ideas, fight common battles and share success stories. Life cycle analysis studies were carried out to determine priority areas and acquaint industry with the technique. Throughout the project term a campaign was maintained to raise awareness of the benefits of and need for adopting CP approaches. A CP guide was developed to assist mining companies with implementing CP programmes.

Cost: R3 000 000
Term: 2004 - 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

This project was undertaken to reduce uncertainty regarding the applicability of different techniques that are available for the geochemical prediction of long-term water quality from mines and to address confusion about how the available tools should be applied in practice. Static tests (acid-base accounting and mineralogy), kinetic laboratory tests (humidity cell and column leach tests) and equilibrium and kinetic modelling techniques were evaluated at two underground collieries to establish what predictions could be made with each tool and what the limitations and uncertainties are with each. As far as possible, different specialists assessed the different tools in reasonable isolation from each other in order to determine what conclusions could be drawn without cross-referencing the results from other more sophisticated tools. A decision tree was developed to show how to apply the different tools. The use of a full suite of tools is capable of providing extensive information on potential future water quality impacts from mines.

Cost: R1 416 100
Term: 2001 - 2010

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

This project was undertaken to develop a procedure and methodology that mines, researchers and consultants can use to develop water balances for gold mine waste residue deposits. A wide range of measurements were made to characterise the water balance on two tailings dams and a gold waste rock dump. The water balance of tailings dams is complex since these facilities consist of variably unsaturated porous media with saturated and unsaturated zones. All of these components were studied and the report presents detailed recommendations on how water balance studies should be undertaken for cases where a screening-level water balance is required and for cases where a detailed and accurate water balance is required. For a detailed water balance, some form of numerical modelling will be required and the report provides guidance on what models could be used, what parameters need to be determined and how the required data should be collected.

Cost: R913 500
Term: 2003 - 2011

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

Available information (mainly) was used to predict how a number of management interventions may change the quantity and quality of water draining from Mpumalanga coal mines by 2080. The ACRU-Salinity model indicated that the increased recharge associated with mining can significantly increase the available water in the area. The Water Resource Planning Model indicated that mine water can contribute 65 to 100 Mℓ/d to meet growing future water demands of local municipalities. Water treatment was found to be the only management option that will be able to improve water quality within Witbank and Middelburg Dams to RWQO levels. Soil covers can significantly reduce recharge and thus the volume of water that needs treatment. The associated reduction in recharge, furthermore, delayed the onset of decant and the need for treatment. Relatively small sums of money have to be set aside now to cover the closure costs in 40 or 50 years' time.

Cost: R1 500 000
Term: 2005 - 2011

Programme 6: Reuse, recovery, beneficiation and treatment of industrial and mining effluents

Novel technology for the recovery of water and solid salts from hypersaline brines: Eutectic freeze crystallisation
University of Cape Town
No. 1727

Increasing use of water recycling has resulted in an increased generation of inorganic brines and concentrates. Eutectic freeze crystallization (EFC) offers a novel, sustainable method for treating brines and concentrates that were previously regarded as recalcitrant, due to their complex nature, and which were consequently discharged to evaporation ponds. With EFC, pure water and pure individual salts can be recovered, thereby making a significant leap towards achieving zero-effluent discharge. Eutectic freeze crystallization has been shown to be effective in separating a single salt and water, but has yet to be applied to complex hypersaline brines that are typical of reverse osmosis retentates in South Africa. Thus, the aim of this research was to investigate the applicability of EFC to the hypersaline brines and inorganic effluents produced by industries. The experimental work aimed at investigating the effect of complex aqueous chemistry and impurities on the EFC process. The presence of impurities, even in small concentrations, had a significant depressing impact on the eutectic temperature of the binary system. Maintaining a critical solid mass content, i.e. the amount of ice and salt crystals in the reactor, was found to be of significant importance as it directly affected the purity and yield of the crystalline products. Thermodynamic modelling of the effects of salts on eutectic temperatures was carried out and it was demonstrated that, at these relatively low concentrations, the ice always crystallizes first, followed by the higher hydrated salts. No significant shifts in salt freezing points were observed due to the relatively low concentration of salts in the retentate. Experimental studies were carried out on synthetic brines to establish the eutectic temperatures and compositions. A preliminary economic evaluation was conducted to provide an approximation of the expected operating and capital costs associated with using EFC. These were compared to triple-effect evaporative crystallization (EC) using two brines broadly representative of typical South African industrial brines, i.e. consisting of Na2SO4 and NaCl. A basis of 100 m3/day of brine was used. The operating cost savings of using EFC over EC were found to be 79% and 76% for Brine 1 and Brine 2 respectively. Future studies will focus on further refining the understanding of the scientific fundamentals together with investigating key operating parameters that will enable the process to be tested at pilot scale.

Cost: R793 305
Term: 2007 - 2010

Laboratory and pilot scale development of the Ambient Temperature Ferrite Process (ATFP)
Phatamanzi Water Treatment
No. 1891

This project was commissioned in response to an opportunity to implement the ambient temperature ferrite process (ATFP) as part of the CSIR ABC Desalination Process that was to be installed at the ERPM site in Germiston, Gauteng, treating 100 Mℓ/d of acid mine drainage (AMD). The laboratory results indicated a relationship between the operating pH, retention time, ferrite seed concentration and feed ferrous iron concentration in removing the ferrous iron from solution and forming ferrite intermediate on the ferrite seed present. The contact stabilisation reactor was fed Harmony Gold AMD, which contained Fe(II) concentrations of 280-890 mg Fe/ℓ. The contact stabilisation reactor was capable of removing all of the aqueous ferrous iron from the AMD if the system was operated at a pH of at least 9. For the systems, the feed ferrous iron was removed from concentrations as high as 890 mg Fe/ℓ, with seed concentrations of 3gFe/ℓ and retention times as low as 10 minutes, although 15 minutes was required for a system operating with a pH of 9. For solids removal, a clarifier operating with an up-flow velocity of 5 m/h was required,

resulting in a 14-times thickening of the ferrite solids (seed plus intermediate). However, when the ATFP pilot plant was operated under these conditions, the system failed within a few days, indicated by a build-up of brown-coloured material in the process. Numerous changes to the operating procedure were made, but it was shown that it was difficult to maintain high seed concentrations in the system using the existing infrastructure, since the freshly-produced ferrite seed had different settling properties to the mine ferrite. This led to a steady deterioration in the solids quality and ultimately process failure. Therefore, it was not possible to operate a successful ATFP treating AMD using lime. The process should first be proven at laboratory scale using AMD and lime before another pilot plant is built and operated.

Cost: R1 776 957
Term: 2009 - 2010

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 4: Technical sustainability of sanitation services

Sustainable options for community level management of grey-water in settlements without on-site water-borne sanitation
University of Cape Town (Department of Civil Engineering)
No. 1654

One of the main objectives of this study was to deliver low-cost, environmentally-friendly grey-water technologies, and to ensure that in so doing there was collaboration and genuine co-operation at all phases, including reflexive learning and modification of these options. The process and results were disappointing, attributed to the fact that the devices installed became dysfunctional in a matter of weeks, and because 'on the ground' social structures in both the primary research sites were weak. It appears that a PAR methodology is not going to deliver solutions without adequate commitment from the local authorities and also that intense attention and effort is needed for developing the capacity of the users of grey-water and sanitation technologies to manage both their use of those technologies and their relationships with local authority officials. Local authorities remain critical agents of local level social change, and should increasingly be positioned and resourced so that they can build their own capacity alongside that which inheres in well-functioning, truly representative local social structures such as street and block committees. At present it appears that neither the scope fo alternative service approaches nor the opportunities for community-based participation in technical options for grey-water management currently exist in informal settlements.

Cost: R750 000
Term: 2006 - 2010

Develop more robust and lighter VIP structures
University of Pretoria
No. 1781

In South Africa there are various systems available for the construction of the superstructure of toilets. These systems can be divided into two main groups, namely, the lightweight systems that can be moved (as a whole or dismantled) when the pit of a VIP is full and systems that cannot be moved, as such, but where the material may be re-useable in the construction of a new superstructure. The major problem with the provision of VIP superstructures is that there is no standard requirement and each supplier determines what the quality of the product is that they wish to deliver. It is recommended that a National Standard should be developed with minimum requirements that all VIP superstructures should adhere to. These requirements can include aspects such as minimum dimensions, load capacities, requirements for doors and fittings. Having minimum functional requirements for suppliers will prevent clients from opting for inferior products that may seem to be cheaper. During this project a moveable lightweight superstructure system made from high-strength fibre-reinforced concrete was developed. This system consists of a base slab, wall panels, a roof and a door and the system can be provided to communities in package form or can be manufactured by the communities themselves in controlled environments. A system that consists of bricks or blocks cannot compete with a pre-cast system as far as cost or quality is concerned.

Cost: R986 900
Term: 2007 - 2011

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

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

Critical assessment of raising basic level of water services
Nemai Consulting
No. 1892

The Government has indicated that its short-term goal is to meet the basic water and sanitation requirements of the nation, as well as to attain full water-supply coverage by 2008 and sanitation coverage by 2010. Government has also indicated that the long-term goal is to improve on the basic level of service, often termed 'climbing the ladder'. It is most obvious that climbing the ladder, which is possible, will nevertheless provide numerous challenges and require greater resources. Asking relevant questions and gaining an indication of specific challenges will assist the sector in starting a debate on how best to tackle the 'ladder-climbing' issue and to formulate new strategies and the necessary mind-shift. Essentially, moving to higher levels of service (i.e. above RDP levels) could have only limited health benefits but very significant economic benefits (jobs, income, etc.). The question is rather whether there should be a distinction between moving up the ladder in those areas where this can be afforded (through local finance) and those areas in which basic needs coverage has not yet been achieved and on which national finance should be concentrated. The question concerning what the priority should be ought to be posed. As the number of people without basic access to water declines, there are reduced demands in terms of attending to requirements of these groups and potentially greater benefits in refocusing attention increasingly on moving people up the ladder. The study will investigate where the break-point should be and whether the sector has already reached this stage. This desk-study, supported by analysis, will assist the sector in achieving preparedness for the future.

Estimated cost: R600 000
Expected term: 2009 - 2011

Programme 2: Institutional and management issues - Water services

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

Guidelines on determining the vulnerability and risks of water services infrastructure
Emanti Management
No. 1893

Any infringements to our water infrastructure could disrupt the direct functioning of key business and government activities, facilities, and systems, as well as have cascading effects throughout a nation's economy and society. Enhanced security features should drive all new designs and retrofits for water utility systems. Vulnerability and risk assessments can help guide and prioritise enhancements. There is a need for methodology and guidelines for application of risk management to strategic asset management (AM). Much has been done in the area of risk assessment for different sectors but no specific tools or guidelines have been developed or applied as an agreed national guideline for water utilities. The tools and guidelines may be used at a strategic level but may also be applied to specific individual assets to determine what measures may be taken to mitigate unacceptable risk. The tools and guidelines will enable design, operational and maintenance measures to

be reviewed in order to mitigate risk.

Estimated cost: R996 800
Expected term: 2009 - 2011

Development of protocols and guidelines for municipalities to undertake studies to determine the impact or influence of climate change on water service delivery
University of the Witwatersrand
No. 1953

The recent damages to water and municipal infrastructure due to weather-related/natural disasters raise many concerns for municipalities as to how to respond and plan for such occurrences brought about by climate change and its influences on nature. While the delivery of basic water services, (6 kℓ per household per month free), is driven by a national development goal, the responsibility of ensuring this right is ascribed to local government. For this, the local municipality needs to ensure that water supplies meet the consumption demand, present and future. Technical and financial planning is therefore required to ensure that an undisrupted service is provided. The impact of climate change needs to be included in this planning. All municipalities need to consider how climate change will affect their water services and to show how the departments most need to act or react. They must understand what climate change means for their work and future investments. In addition, a review of changes in weather and extreme weather events over the past few decades can help identify who and what is most vulnerable to some aspects of climate change. Various departments within the municipal government also must become aware of the need to consider climate change in their plans – for instance for water supply. Poor response to dealing with the outcomes of these climate changes will only escalate and increase the problems for municipalities. Municipal officials are unlikely to act if they have little idea of what climate change means for their city. To address this, the study will review and develop an understanding of the regional climate change knowledge and its relevance to municipalities in South Africa.

Estimated cost: R700 000
Expected term: 2009 - 2011

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

Social scarcity of water and water use
African Centre for Water Research
No. 1940

There are several ways of defining water scarcity. One view is that it is the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements, to the extent that the demand by all sectors, including the environment, cannot be satisfied fully. Water scarcity is a relative concept and can occur at any level of supply or demand. Scarcity may be a social construct (a product of affluence, expectations and customary behaviour) or the consequence of altered supply patterns stemming from climate change. Scarcity has various causes, most of which are capable of being remedied or alleviated. A society facing water scarcity usually has options. Water is essential for all socio-economic development and for maintaining healthy ecosystems. Water has traditionally been considered a physically scarce resource. Thus, growing scarcity and competition for water stand as a major threat to future advances in poverty alleviation, especially in rural areas. This study will explore the dimensions and relationship between social scarcity and water services or use. It will unpack the causes, understand how water can be used to break the cycle of poverty and establish how the recommendations from this study be incorporated into the macro-planning process.

Estimated cost: R500 000
Expected term: 2009 - 2011

Investigating the social vulnerability of people and their livelihoods and their response to water infrastructure
Umvoto Africa
No. 1888

Socio-economic vulnerability is seen as the integration across a range of stresses (not just biophysical, but also including exposure to uncertainties from interactions with markets, political and social exclusion and so on) and across the range of human capacities (i.e., not just food security, income or health). In relation to the livelihoods of the poor, one aspect of poverty is that poor people are often less able to cope with, adapt to or recover from these stresses. Even small variations in climatic conditions, market prices, etc., that less-poor people are able to cope with, can jeopardise the prospects of poor families lifting themselves out of their poverty and, in the worst cases, can even threaten their very existence. The result is often a risk-minimising approach to livelihoods, where the poor are more concerned with securing the minimum they need to survive than with taking advantage of development opportunities that could entail some risk. The study aims to establish the dynamic interaction between expectations, standards and actual service delivery. The central questions to be answered will be: How do people respond to different systems of water delivery, management and technologies? How is water used? What is the role of women?

Estimated cost: R500 000
Expected term: 2009 - 2011

Investigating operational and indigenous knowledge of water use and waste management, and establishing ways to integrate them into water service management
Nemai Consulting
No. 1941

Indigenous (or indigenized – practices and water use that have been introduced into the country and have been adopted and adapted by society) water management knowledge has played a significant part in the lives of many communities, to sustain their water needs against the harsh forces of nature, as well as the forces of segregation and apartheid. In the late 90's, the Department of Science and Technology initiated a number of projects aimed at capturing indigenous knowledge and practices in South Africa. One of the areas dealt with water management. The introduction of modern technology and systems has meant that this knowledge and its application have dwindled, and more crucial is that there is a lack of transfer of this knowledge to the new generation. Though Government has taken many measures to secure the provision of water to all persons in South Africa, many communities remain vulnerable due to a number of reasons. One of these crucial reasons is that of climate change and the challenges it will bring. Added to this, many of our initiatives in the water sector have actually marginalised or eroded this indigenous knowledge base to extinction. Thus, it becomes imperative and important to record these practices and establish how these practices could be beneficial to the management of water services in the future.

Estimated cost: R600 000
Expected term: 2009 - 2011

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

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 pre-treatment 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 nanotechnology 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

Assessment of the prevalence of organic compounds in raw and treated water for potable purposes, their fate in current treatment plants, and compilation of a guideline on best available technology for the removal thereof
University of Johannesburg
No. 1883

The number of organic chemicals discharged into the environment is escalating at a frightening pace. The United States EPA has drinking water regulations for more than 90 contaminants. The lack of knowledge about local natural organic matter (NOM) composition and interaction with the treatment steps hampers the understanding of removal mechanisms and the development of reliable qualitative and quantitative models. A large number of organic chemicals have not been adequately investigated with regard to the efficiency of their removal by local water treatment processes currently in use. Further, small and rural water treatment plants are often at a disadvantage regarding both their design and operation. Except for a few exploratory and regional studies on the occurrence of NOM, pesticides, algal toxins and endocrine-disrupting chemicals (EDCs), little has been done to determine the prevalence of organic contaminants in South African water sources being used for potable water supply – or the efficiency of SA plants in removing these contaminants. This project will investigate the prevalence of both natural and anthropogenic organic contaminant chemicals in SA water sources used for drinking water, determine the efficiencies of removal – especially by small treatment systems – and their effects in the distribution system, and suggest improvements to the treatment processes and operational procedures in order to safeguard the people against these contaminants.

Estimated cost: R1 800 000
Expected term: 2009 - 2012

Wastewater reclamation for potable reuse
Umgeni Water
No. 1894

Water is a scarce resource, especially in South Africa where runoff exceeds rainfall and is unevenly distributed. South Africa has been classified as water stressed and water should therefore be conserved. The pressure exerted on surface and groundwater supplies should be reduced or at best maintained, rather than increased as the country's human population and industrial development increase. Wastewater reuse offers such a possibility, and reclaiming

domestic wastewater from Darvill Wastewater Works for potable reuse using membrane bioreactor technology is therefore being investigated. This project is intended to pave the way for technology enabling South African water suppliers to produce consistent, acceptable drinking water quality through used-water reclamation. Initial feasibility work will be followed by a demonstration plant designed and operated over a long-term trial to establish operating guidelines that ensure reliable product water will be generated at all times.

Estimated cost: R650 000
Expected term: 2009 - 20112

The establishment and piloting of the Technical Assistance Centre for small water and wastewater treatment plants
Chris Swartz Water Utilisation Engineers
No. 1896

There currently exists a serious and acute need in South Africa to provide assistance to small water and wastewater treatment plants for proper and efficient operation and maintenance of these systems, to ensure compliance and sustainability in this important water sector. In order to address the serious challenges that are currently experienced with the compliance and sustainability of the small water and wastewater treatment systems in the country, it is proposed that a Technical Assistance Centre be established. This should be a collaborative effort between the DWA, WISA (implementing agent of DWA), the WRC, the DBSA and SALGA. Direct benefits of the Centre will be a significant improvement in compliance of treatment plants, improved leadership and facilitation of planning and development activities in the water sector, enhanced service delivery, positive economic impact through reduction in break-downs and downtime, and, overall, more sustainable development and improving quality of life in rural South Africa. This will be in line with DWAs strategy on Water for Growth and Development. The Eastern Cape and Western Cape have been chosen as the pilot provinces for the launch of this project.

Estimated cost: R275 000
Expected term: 2009 - 2010

Programme 2: Water treatment 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

Compilation of guidelines for the selection and use of home water treatment systems and devices
Tshwane University of Technology
No. 1884

At least 5.7 million people in South Africa still have no access to treated, potable water within reasonable distances from their dwellings and many thousands more take water from water sources and use it untreated because of problems experienced with adequate and reliable potable water supply. Surface waters have steadily become more polluted – especially with regard to microbiological quality, which exacerbates the situation of the immuno-compromised when drinking inadequately treated or poor-quality water. A number of home treatment systems and devices are being used internationally by small, rural communities without potable water services (decentralised systems). These units vary from the most simple – such as using material as filter – to the most sophisticated systems treating grey-water to potable standards. Although various systems and devices have been extensively reported on in the literature, and some exploratory work has been performed in South Africa, little is known locally about the existing options – and little has been done to assist local communities or their advisers in making informed choices on whether such a system or unit will be appropriate to their situation, or which unit should be selected. This project will meet the need to source and investigate appropriate units, to determine their efficiencies of contaminant removal under local conditions as well as their sustainability potential, and to provide guidance on the selection and use of these units under local conditions.

Estimated cost: R1 200 000
Expected term: 2009 - 2012

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 pastorus) 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

β-N-methylamino-L-alanine bioaccumulation and bio-magnification: Health risks and water treatment possibilities
Nelson Mandela Metropolitan University
No. 1885

β-N-methylamino-L-alanine (BMAA) is a neurotoxic, non-proteinogenic amino acid produced by the majority of cyanobacterial isolates. Free-living freshwater cyanobacteria from all five taxonomic sections were found to contain BMAA, in a study conducted by the team, which concluded that most if not all cyanobacteria produce BMAA. Cyanobacteria frequently found in drinking water sources have been found to produce BMAA. In addition to potential risk from free or cyanobacteria-associated BMAA, the potential for exposure to significant doses due to consumption of bioaccumulated BMAA from sources higher up the food chain is much greater. However, no information on bioaccumulation or bio-magnification in aquatic ecosystems exists. The scope of the study is to investigate the potential risk by evaluating bioaccumulation, bio-magnification and toxicological effects of these in aquatic ecosystems. The aim is to investigate the potential for health risk to consumers via indirect exposure to cyanobacterial BMAA and to evaluate treatment processes for BMAA removal from water.

Estimated cost: R1 800 000
Expected term: 2009 - 2011

Rapid enzymatic detection of organochlorine pesticides in water
Rhodes University
No. 1902

Endocrine-disrupting substances in the environment have become a concern over the past few years. The organochlorine pesticides (OCPs) (one of the groups of insecticides) are known to be EDCs and among the most persistent organic pollutants present in the environment, and tend to accumulate in organisms. A study done by the team has shown that the detection of various OCPs in isolation and in combination using a rapid alkaline phosphatase assay is indeed feasible in the South African context. The aim of this proposal is to optimise this alkaline phosphatase bioassay using the latest substrate technology for increased sensitivity, to determine the potential for interference by metals and organophosphate pesticides, and to investigate the feasibility of application into an affordable (cost-effective) biosensor system.

Estimated cost: R600 000
Expected term: 2009 - 2011

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.

Estimated cost: R400 000
Expected term: 2007 - 2009

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

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 AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

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 DWA 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 (DWA 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

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

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

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; eThekwini 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, eThekwini, 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; eThekwini 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 sewering 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 unserviced 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

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.

Cost: R1 510 900
Term: 2002 – 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

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

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 2: Regulatory, policy and financial 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 sustain-

able 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

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

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

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 assess¬ment 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 hazar¬dous 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

Development of a complete process integration framework for wastewater minimisation in multi-purpose 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

Technical guidelines for the implemen¬tation 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

Development of a zero-effluent mathematical model for wastewater minimization in a pharmaceutical facility
University of Pretoria
No. 1898

This new investigation is intended to be a spin-off project from WRC Project No. K5/1625, which was successfully completed in September 2007, whose aim was to develop a complete process integration framework for wastewater minimisation in multipurpose batch plants using a rigorous mathematical optimisation framework. During the course of project K5/1625 another opportunity, which is particular to industries that utilise water as a major ingredient in their final product, became apparent. The pharmaceuticals industry features very high in this category. Using careful analysis with proper understanding of these processes, a mathematical technique can be derived that could lead to almost zero-effluent operation. Preliminary results, using data from Johnson and Johnson (Pty.) Ltd., suggest that it is very possible to achieve this goal. This project aims to develop the model further and optimise it at a full-scale plant. In addition to the environmental benefit of water conservation, this research will result in significant savings in revenue. This is mainly due to the fact that the operations of interest generally produce wastewater containing product that can be recovered. Currently more than 500 t/a of product is dispensed with as effluent, which translates to more than R7 m. in lost revenue. This project thus aims to set up optimal water requirements and effluent generation in batch chemical plants, as well as designs to achieve the targets. Users of this product will also be able to assess the financial benefit of the application, without interfering with the existing plant operations.

It is anticipated that a novel mathematical technique for zero-effluent in multipurpose batch plants will be developed and that this tool can be used by the chemical industry, regulators and DWA in assessing and improving the efficiency and environmental performance of batch chemical plants. There is also a possibility for a patent to be applied for, as this is promising to be a revolutionary idea that might rekindle global interest in this area.

Estimated cost: R466 480
Expected term: 2009 - 2011

Programme 5: Improved ability to predict and quantify effects

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

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

Field-testing methods to determine the evaporation rates on brine solutions produced from mine water treatment
Golder Associates Africa (Pty.) Ltd.
No. 1895

Several coal mining groups in Mpumalanga have found that they will have excess water which needs to be treated, either currently or in the near future. Strict water quality targets must be met for either potable use or discharge to the environment. The most cost-effective technology currently available to achieve the targets is usually reverse osmosis, which produces a concentrated brine requiring an environmentally sound and stable disposal method. In Mpumalanga, evaporation ponds are the preferred brine disposal method. A good estimate of the evaporation rate is required to size a brine disposal pond. The salinity of the water results in a reduction in the evaporation rate. It is suggested that the evaporation rate for water at the disposal area is multiplied by a factor of 0.7 to determine the evaporation rate of brine. However, the evaporation rate varies from location to location and depends on the composition of the solution being evaporated. Very little literature is available on the evaporation rate of brine solutions, and this study will benefit the water engineering community of South Africa and result in more reliable information for use in the design of the brine disposal facilities by filling this knowledge gap.

Estimated cost: R452 100
Expected term: 2009 - 2010

Programme 6: Reuse, recovery, beneficiation and treatment of industrial and mining effluents

'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

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 BioSureTM 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

Nanotechnology in water treatment
University of the Western Cape
No. 1897

The National Nanotechnology Strategy has identified water treatment as a prime area of focus. Nanotechnology could lead to advanced water treatment technologies. Promising techniques include photo- and electrocatalytic materials, leading to the destruction of contaminants, and new nanostructured materials such as filtering membranes or adsorbents that could purify even the worst wastewater. This project aims to develop a suite of nanotechnology-based water treatment technologies through stages of fundamental research, process engineering and pilot plant evaluation. The investigations will include nanostructured ion-exchangers and adsorbents, development of in situ generated ozone to sterilise water, nanospray desalination and electrospun nanofibres for application as filters. Fundamental research will be conducted to understand the molecular mechanisms by which the technologies proceed and the processes will then be optimised for industrial application using first laboratory-scale rigs and then on-site pilot plants.

Estimated cost: R1 483 000
Expected term: 2009 - 2012

Pilot application of a dual stage membrane bioreactor for industrial effluent treatment
Alt Hydro cc
No. 1900

Over the past decade solutions are increasingly sought using membrane bioreactor technology. This is mainly due to recent refinements and lowering of costs associated with this technology. Significant improvement in process efficiency associated with the treatment of industrial effluent using a novel dual-stage side-stream membrane bioreactor has been previously reported. This dual-stage approach to wastewater treatment using this membrane bioreactor configuration greatly enhanced performance and increased the long-term adaptability and stability of the developed and retained microbial populations within the system by facilitating a continuous microbial ecology management strategy. Compared to conventional suspended culture wastewater treatment processes, this system facilitated a 75% improvement in acclimation efficiency of the resident microbial consortia, which translated directly to considerable improvements in the resultant effluent quality and consistent operation of the treatment process. However, variations in wastewater streams make it imperative to assess the performance of the system on-site and at the pilot-scale level, in order to accurately gauge the impact of real wastewater challenges on the robustness of

the process technology. This pilot project therefore aims to develop on-site wastewater treatment solutions for industries typically targeted by DWA as it increases its monitoring and legislative framework capacity. As legislative enforcement is addressed, increasingly, industrial offenders responsible for further burdening already overloaded municipal WWTP infrastructure are now being forced to seek on-site wastewater solutions prior to discharge. This technology aims to address these increasingly prevalent needs by providing a mobile, adaptable solution to specific industry needs.

Estimated cost: R950 000
Expected term: 2009 - 2011

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 DWA, 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

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
Expected term: 2008 - 2010

Survey of hand-washing hygiene behaviour
Sustento Development Services
No. 1886

Hand-washing is universally accepted and promoted for health interventions, but an assessment has not been completed in South Africa to benchmark or measure the impact of programmes designed to improve hand hygiene behaviour. The unique nature of the South African environment must be better understood in order to develop more appropriate and effective hand-washing messages and programmes. It is imperative to develop a methodology to measure the effectiveness of the efforts being made and to determine what activities are most successful in changing behaviour. Hand-washing must be indicated by a community's willingness to actually do it - even though they might seem to admit that they think it is important. These results will be used to guide the development of future hand hygiene and public health programmes to deliver improved performance more efficiently. The study will measure whether a hygiene education intervention is having effect on both the quality and the frequency of hand-washing behaviour and which hygiene and hand-washing promotion activities appear more effective at stimulating and sustaining behavioural change.

Estimated cost: R520 670
Expected term: 2009 - 2011

Programme 2: Peri-urban sanitation research

Establishment of sanitation technology demonstration centre
CSIR
No. 1890

Knowledge and dissemination of sanitation technologies have been found to not be effectively transferred through guidelines. In fact, guidelines and reports have more meaning for technical practitioners; however, the key decision makers rarely have a good understanding

of the reality of the technology and its benefits. In South East Asia, the concept of sanitation technology centres and sanitation marts have proved successful in promoting technology and its acceptability. A sanitation demonstration concept consists of a site where full-scale models of technology are available for viewing (a sort of a museum), which enables one to learn and understand, as well as appreciate, the function and benefits of the technologies available. In South Africa, there is a lack of such a facility or facilities which communities, councillors and emerging professionals can access to appreciate technologies. Thus there is a need for a sanitation technology demonstration centre which can house and accommodate all existing and new sanitation technology products in existence. This will assist and facilitate decision makers and communities to have direct access to view and learn about the technology options. The study will establish a sanitation technology centre, where to-scale models of different types of sanitation technologies will be constructed for training and display. The sanitation technology platform will form part of a wider housing-services technology demonstration centre.

Estimated cost: R596 600
Expected term: 2009 - 2011

Programme 3: Institutional and management aspects of sanitation service delivery

An approach to reduce risks and hazards from human waste generated by informal settlements
Cape Peninsula University of Technology
No. 1901

Human settlement strategies continue to seek alternative approaches to confronting the growth of informal settlements while rapid urbanisation of poverty poses serious challenges to municipalities. Housing delivery has failed to address downstream water pollution. This study will identify realistic opportunities for informal settlements' residents to contribute to on-site improvements of basic waste disposal systems, in partnership with municipalities. The capacity of informal residents to contribute to protecting their immediate environment will be explored.

Estimated cost: R587 800
Expected term: 2009 - 2011

Programme 4: Technical sustainability of sanitation services

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

Piloting and testing the pour flush latrine technology for its applicability in South Africa
Partners in Development
No. 1887

Recent research studies concluded by the WRC have raised many concerns about the long-term sustainability of dry sanitation technologies. The studies have found that the technology has led to unintended consequences due to misuse by users, as well as the lack of understanding of the science of dry sanitation systems. A combination of these factors and the stringent design requirements are proving it difficult to access pits for pit emptying. This is further compounded by user behaviour which is resulting in the intrusion of solid waste, plastics and other undesirables into the pits, resulting in difficulties around pit emptying and the rapid filling of pits. This coupled with the fact that there is no easy mechanical or physical modus operandi for servicing full pits. All of these issues are raising many new challenges which jeopardise the sustainability and the target set by government for coverage of sanitation. Amongst the suite of technologies, pour-flush latrines, which are used widely as a basic sanitation norm in South East Asian countries, have the potential to resolve many of these issues. However, very little promotion and application has been done in South Africa. This research study aims to create an understanding of the technical, social and environmental challenges associated with its application.

Estimated cost: R1 000 000
Expected term: 2009 - 2011

NEW PROJECTS

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost recovery in water services

Strengthening the sustainability and effectiveness of Free Basic Water
Counterpoint Development
No. 1989

There is growing recognition across South Africa of the pivotal importance of sustainability in water services provision: sustainable funding and revenue to support ongoing service delivery, sustainable water resources management to meet current and future demand, and sound operation and maintenance of all associated infrastructure to sustain continuous provision of potable water to citizens and key sectors of the economy. But does provision of Free Basic Water support or undermine sustainable provision of water services? The need to provide support to households living in poverty to enable them to access at least basic water services affordably is not in question. But how sustainable is the provision of Free Basic Water, as currently implemented, if it sends out mixed messages about the real value of water in a context of growing scarcity, and if it is contributing to operating shortfalls in municipal revenue arising from unbilled water? What are the trade-offs in the current approach? Are there more effective ways of achieving the desired outcome of ensuring that even the poorest citizens can afford at least basic services? There is growing evidence that the administrative and financial requirements for providing Free Basic Water and Sanitation sustainably to those who need it have been underestimated. Free Basic Water is at risk of becoming increasingly anti-poor, because many municipalities lack the capacity to implement it effectively or sustainably, are not able to manage their available funds optimally, and are funding service provision through under-spending on operation and maintenance. Inevitably these weaknesses compromise the quality of service provision, and it is the most impoverished households who are impacted most. In a context of chronic poverty, limited administrative capacity in many municipalities, and growing water scarcity, is the provision of Free Basic Water the most effective and sustainable way of giving force to the Constitutional right of access to adequate water? This study aims to review international good practice around financing water services and designing water tariffs for sustainable water servicing and to review approaches and funding mechanisms adopted by relevant middle-income developing countries with substantial poor populations to providing affordable water services to needy and vulnerable citizens.

Estimated cost: R1 400 000
Expected term: 2010 - 2012

Programme 2: Institutional and management issues - Water services

The provision of FBW to backyard dwellers and/or more than one household per stand
Nemai Consulting
No. 1987

Backyard dwelling, prevalent since the 1950s, is not a new phenomenon, nor is it a phenomenon which is likely to dissipate. With the provision of RDP housing and an influx of rural people to urban areas to find employment, there has been an increase in backyard dwellers. It is more prevalent in larger cities where there are more opportunities for work. The WRC commissioned a study in 2008 entitled 'The impact of large consumer unit size on water and sanitation services in lower income urban areas in South Africa'. This study illustrated the access to and affordability of water and sanitation services of backyard dwellers in lower income formal urban areas. It found that affordability was an issue for large consumer dwellings. The study suggested that a policy statement was necessary to alleviate these challenges. This research project aims to answer the questions raised in the 2008 study and to address the gaps identified. The 'Provision of FBW to backyard dwellers and/or more than one household per stand' research study would thus build on the existing research in terms of conducting a policy analysis and determining the legislative implications around not providing water to backyard dwellers/more than one household per stand, suggesting the relevant policy and strategic revision and developing a user-friendly guideline for the provision of water to backyard dwellers/more than one household per stand for municipalities. This would clearly address both policy issues and technical options for water provision as recommended in the 2008 WRC report.

Estimated cost: R601 800
Expected term: 2010 - 2012

Programme 3: Innovative management arrangements - Rural water supply

Bridging the policy divide: Women in rural villages and the Water for Growth and Development Framework
Mvula Trust
No. 1988

While national policy has increasingly clear intentions for pro-poor policies and integrated and sustainable rural development, these intentions do not readily translate to improved living conditions on the ground. A range of explanations for this mismatch between intention and impact are possible, but detailed, on-the-ground research

that reaches from community to local government and to national decision making can hope to unpack these dynamics. Water provision is a core to pro-poor development. In the 2009 ANC manifesto, a new focus on rural development is put forward, including a much stronger link between land and agrarian reform programmes and water resource allocation and ensuring that the best quality water resources reach all our people, especially the poor. The Water for Growth and Development Framework clearly recognises the leading role that rural women play in the management of water, often in difficult conditions: Women should be thought of as strategic users of water. They manage the use of water for preparing food, for drinking, bathing and washing, for irrigating home gardens and watering livestock. Women know the location, reliability and quality of local water resources. They collect water, store it, and control its use and sanitation. They recycle water, using grey-water for washing and irrigation. Their participation in all development programmes should be given priority. This research will explore the multiple water use strategies of rural women in two different rural villages. The research will test the adequacy of current policies and practices against the reality and aspirations of women and their families in two villages: The research will take an explicit gender-oriented, pro-poor, bottom-up approach to policy formulation, within a framework of evidence-based policy and will produce qualitative knowledge and understanding of poverty and household dynamics, as well as the dynamics of the local government setting that determines whether and how water-related resources needed by women in rural villages are available or could be made available to them.

Estimated cost: R596 000
Expected term: 2010 - 2012

Innovative water and sanitation management arrangements at family and neighbourhood level
Sarah Slabbert Associates
No. 1990

Outcomes sought in public communication campaigns are, typically, awareness, attitude change, or behavioural change. Although large amounts of money are spent on public communication campaigns, 'many mass media campaigns proceed in the absence of a research foundation'. There is often no pre-campaign research that investigates the issues and solutions that already exist in target populations. Nor is evidence sought of how many members of the target public read the publications or listened to the radio messages, understood them, believed them, or changed their attitude or behaviour as a result of them. This will only become known through evaluation research. This research project will apply the methodologies of qualitative ethnographic research with the objective to shed new light on the user culture of water and sanitation management at family and neighbourhood level in rural South Africa. This information will assist government municipalities and other organisations to make strategic and informed decisions on sanitation delivery.

Estimated cost: R412 000
Expected term: 2010 - 2012

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Development of a costing model to determine the cost-efficiency and energy-efficiency of water treatment technologies and supply options
Chris Swartz Water Utilisation Engineers
No. 1992

While considerable information is available on technical aspects (design; operation; maintenance) of water treatment technologies, there is still a serious lack of information on costs of water treatment systems and technologies, in particular life-cycle costs, which are used in the comparison and selection of these technologies. This includes both capital costs and operating costs (operation; maintenance; management). In this regard, the escalating cost of energy is a major factor necessitating increasing attention. Water service authorities (WSAs), water services providers (WSPs) and consultants alike all have scant comparative costing information for water treatment system options on which to base their decisions for a new water treatment scheme(s). This results in incomplete planning and inadequate budgeting for these systems. This project will undertake a detailed analysis of available information and provide guidelines to assess under which circumstances decentralised, small water treatment systems are economically preferable to larger, centralised treatment schemes with their associated distribution systems. The guidelines will further encompass costing of different energy sources for potable water production. The guidelines will include a listing and description of all the different energy sources (existing; new; emerging) that can be used for driving water treatment technologies and treatment systems to produce drinking water, both on small-scale and large-scale. A user-friendly costing model for establishing and predicting the cost-efficiency of a range of small-scale water treatment technologies that are normally used in water supply schemes, thereby allowing economic comparison between different water treatment options being considered for a water supply scheme(s), will be developed.

Estimated cost: R763 000
Expected term: 2010 - 2012

An independent investigation into the purification capacity of small-scale water purification units manufactured and supplied in South Africa
University of Johannesburg
No. 1994

Recent outbreaks of cholera and other waterborne diseases in southern Africa have resulted in a public perception that tap water is not safe for drinking purposes. As a result, the use of small scale water purification systems in the domestic and occupational setting is increasing rapidly. Most of these units are sold over the counter and consumers buy the products in good faith on the basis of claims of their efficiency made during marketing and advertising campaigns, and with the expectation that the units will remove 90-100% of all harmful microorganisms. Very few independent studies have been published on the capacity of these units to remove microorganisms and the majority are only tested for a single organism or compound and/or a single product. Only two studies have been published where the units were tested for more than one compound simultaneously. The overall objective of the study is to assess small scale water purification units manufactured and sold in South Africa for their capacity to provide safe drinking water for domestic, public and occupational use and to provide guidelines to enable consumers to make informed decisions when purchasing these units.

Estimated cost: R809 000
Expected term: 2010 - 2012

Programme 3: Drinking water quality

Nanotechnology solutions for drinking water
Rhodes University
No. 1991

The South African Nanotechnology Strategy amongst its objectives states the need to: a) support long-term nano-science research that will lead to the fundamental understanding of the design, synthesis, characterisation, modelling and fabrication of nano-materials and (b) support the creation of new and novel devices for application in various areas. The Strategy also lists six focus areas which include: Water, Health as well as Advanced Material and Manufacturing. Harnessing nanotechnology ushers in opportunities that can find application in many areas including initiatives that can ensure the supply of clean drinking water. The availability of clean drinking water means that there is a positive impact on the less advantaged communities and a reduction in health-related costs. This project will develop nanotechnology solutions for drinking water. The first phase of the project will involve fabrication of electrospun nano-fibre membranes which are functionalised with a variety of moieties to enable them to serve as solid phase sample clean-up devices for complex water samples. The second phase will involve fabrication and functionalisation of electrospun nanofibre membranes for the uptake of endocrine disruptors from water samples. The third phase will involve immobilisation of enzymes/enzyme substrates on electrospun nano-fibres for point-of-use devices by encapsulation or surface attachment and optimising hydrolytic characteristics for selected endocrine disruptors. The fourth phase will involve functionalisation of electrospun nano-fibres with imidazoles and silver to impact antimicrobial activity. The project will conclude by fabricating point-of-use devices that incorporate the developed technologies.

Estimated cost: R1 800 000
Expected term: 2010 - 2012

Programme 4: Water distribution and distribution systems

Integration of water safety plan requirements into the existing WRC water supply system assessment tool
eManti Management
No. 1993

Previous WRC projects have resulted in a generic Water Safety Plan and the creation of the electronic water quality management system (eWQMS), an award-winning online tool to enable water service authorities (WSAs) to better manage their service provision and water supplies. This project will integrate the WSP with the existing eWQMS, providing an updated tool available to all WSAs in South Africa. As such, all WSAs have access to the eWQMS and tools that reside on the eWQMS. By incorporating this tool onto the eWQMS (via both a downloadable file and web enablement of the application), the developed project products would be easily available to a wide audience. In addition, the various DWA/IMESA/SALGA eWQMS teams regularly engage with WSAs and attend both National and Provincial Water Sector Forums. During these meetings, tools available for WSAs to use are demonstrated and discussed. In this way, the water sector is easily made aware of new developments and tools available to improve current practices.

Estimated cost: R190 000
Expected term: 2010 - 2012

Practical application of residential water demand and wastewater flow end-use model in South Africa
University of Stellenbosch
No. 1995

Modelling water demand on small spatial scales (e.g. individual water use events at single homes) and short time scales (as brief as one second) has various advantages above the more conventional approaches based on modelling demand at lower resolutions. There is growing

interest both internationally and locally in end-use modelling of water demand. One of the first advances was the residential end-use model (REUM) that enables the analyst to estimate the indoor- and outdoor water demand, hot water demand, wastewater flow, and concentration of total dissolved solids in the wastewater flow for an individual residential property and a given set of input parameters. This combination of components makes REUM unique. An added advantage of end-use modelling is the power provided in describing the interface between water demand and wastewater generation. End-use models have been found to accurately estimate water demand of typical suburban homes internationally. There are no local studies based on measured water use at a suitably high resolution. In addition, none of the studies reported locally or internationally have correlated end-use estimates for water demand and wastewater flow to measured results of both these parameters. This is simply because, to date, no data have been recorded at the required resolution in any African country and made available for testing the application of end-use models. This study aims to set up two such pilot application sites. Addressing this research would be the first pilot project of its kind in Africa and one of only a few in the world. It would most certainly provide for unique, high-quality research outputs during the project and for many years to come.

Estimated cost: R659 500
Expected term: 2010 - 2012

Assessment of non-revenue water in South Africa
WRP Consulting Engineers
No. 1996

In 2004 and 2005, WRP was commissioned by the WRC to undertake an assessment of the levels of non-revenue water (NRW) throughout South Africa. In the course of this work, over 100 water audits were undertaken for selected water supply areas. In some cases, the areas investigated were complete municipalities and in other cases the areas were split into smaller components for which appropriate data could be established. From the initial 100 areas investigated, it was only possible to derive a realistic water balance for approximately 60 of the areas which represented approximately 70% of South Africa's municipal water demand. The figures received were extrapolated to provide an estimate of non-revenue water for the whole country and as such represented the first such estimate based on realistic data. Although there were some gaps in the data obtained from the various municipalities, the final data sets and extrapolated estimates of the non-revenue water for SA remain the best estimates currently available and to date no one has provided a more reliable estimate. In view of the fact that the issue of non-revenue water has become the highest priority issue within the Department of Water Affairs, it is essential that the benchmarking process is not stopped and it should become an annual assessment. It is only in this manner that the results and data can be improved and the key problem areas identified. The project will complete an update of the 2005 water audits and to set up a system that can be updated on an annual basis and to extrapolate the available information to provide an indication of non-revenue water for the whole of South Africa.

Estimated cost: R994 500
Expected term: 2010 - 2012

Compendium of case studies relating to water loss and water demand interventions at the municipal level in South Africa
Resolve Consulting
No. 1997

Within this context water demand management and water loss management (WDM/WLM) have already emerged as the most desirable alternative to the augmentation of water. Indeed many studies prove that investment in demand interventions represents only a fraction of the cost of investment in infrastructure to augment supply. There have been a number of different, highly successful and even partially successful WDM/WLM initiatives in the urban water sector over the past decade. However, there is a need to disseminate this knowledge gained through the implementation of these initiatives by demonstrating the successes and shortcomings of these initiatives as case studies. Although there is, in some cases, literature on these success stories, they have not been captured, documented and disseminated as case studies in a single, easily-readable publication with the focus of the documentation of comparative WDM/WLM interventions. This study will compile a Compendium of approximately 50 case studies relating to water loss and water demand interventions that have been implemented throughout South Africa at the municipal level.

Estimated cost: R600 000
Expected term: 2010 - 2012

Apparent losses in selected areas in South Africa
University of Cape Town
No. 1998

Water is an essential but limited natural resource which is indispensable for life and economic development. Water for human, commercial and industrial consumption is abstracted from natural water bodies, purified and distributed through water supply systems to users. There is renewed international awareness that water distribution systems world-wide are aging and deteriorating, while the demands on these systems, and thus on our natural water resources, are ever increasing. Water losses from

water distribution systems are reaching alarming levels in many towns and cities throughout the world. 'Real losses' consist of physical leaks from the distribution system up to consumer connections. 'Apparent losses', on the other hand, consist of water that is delivered to users, but look like losses to the water service authority. Apparent losses consist of two main components, namely, water meter under-registration and unauthorised consumption (theft and illegal use). New municipal water meters are sized to be accurate at the normal flow rates estimated for different consumers. While the metering error at these flow rates will typically be small (less than 2%), the meter accuracy can be substantially lower at low flow rates. In addition meter accuracy reduces with time, and thus the under-registration error increases if flow meters are not replaced at regular intervals. Under-registration of consumption is worst at very low consumption rates, for example when slowly filling a toilet cistern. On-site leakage is a particular problem, since a small leak or dripping tap on a property will produce a constant, low flow rate that is likely to be under-registered by the flow meter (or may not even be picked up at all). Since the leak flow is constant, significant volumes of water can be lost by the municipality in this way. A recent WRC research project showed that significant on-site losses may be occurring in different areas in South Africa. For instance, of 182 randomly selected properties in suburbs in Johannesburg, 64% had measurable on-site leakage. The average on-site water losses were found to be in the order of 25% of total consumption. The purpose of this study will thus be to estimate the extent of apparent losses in selected suburbs in South Africa to provide insight into the extent of this problem.

Estimated cost: R400 000
Expected term: 2010 - 2012

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER MANAGEMENT AND SANITATION

Programme 1: Emerging technologies and solutions

Biotech in sanitation: biopolymer production with Natronococcus occultus, a haloalkaliphile using municipal wastewater and other waste resources
University of Cape Town
No. 2000

Natronococcus occultus is a haloalkaliphile isolated from East African soda lakes, which are characterised by low Ca and Mg levels, with high Na, Cl and CO3 concentrations and a pH of 10-11. Natronococcus occultus, produces a glutamic acid-rich polymer, poly-glutamic acid (PGA). This polymer has a wide range of uses including hydrogels, flocculants and soil conditioners and may be used for medical applications. Preliminary work in CeBER (UCT) laboratories has shown more consistent growth in the high salt environment under non-sterile conditions. This project aims to study this organism using wastewater as a feed substrate to produce a biopolymer or environmentally friendly flocculants. It can also be cross-linked and blended with the treated sludge for a high-value soil conditioner. This project investigates the potential of municipal wastewater treatment plants to produce materials required by the plant for operation, from its own waste resources.

Estimated cost: R356 000
Expected term: 2010 - 2012

Co-digestion of sewage sludge and industrial concentrates
University of KwaZulu-Natal
No. 2001

The WRC has supported several laboratory-scale and feasibility projects on co-digestion of industrial effluent as a treatment strategy for toxic industrial wastes. eThekwini municipality has agreed to pilot full-scale anaerobic co-digesters at Amanzimtoti WWTW. The digesters are expected to be refurbished in 2010. As a support to this initiative, this project will look at using WEST software to assist in building and transferring knowledge on operation and training needs. The investigation will be undertaken in six phases that will overlap with one another. The project will look to develop an in-line model of the laboratory-scale AD which will be followed by the development of an unsteady state model for the anaerobic digesters at Amanzimtoti WWTW. This will be used to predict performance of the full-scale digester. The WEST model will also be developed to analyze tests undertaken with selected industrial effluents in order to determine the parameters necessary for describing the kinetic effects of co-digestion of different feeding rates of the effluent. The model will be assessed for its ability to predict and test the performance of several industrial concentrates at once. The project will also investigate scenarios to maximise methane production or toxic effluent treatment and to demonstrate recovery from process upsets. Finally, the West model will be used to train the operational staff on how to react to different hypothetical upset conditions. If during the period of the project, upset conditions occur, data will be recorded so that a portfolio of case studies can be developed and procedures will be developed to determine the root cause of the upsets. Overall, this project will assist in developing a model to assist in the process control and training of support staff for the implementation of co-digestion at a full-scale AD.

Estimated cost: R1 050 000
Expected term: 2010 - 2012

Urban effluent treatment in a rhizofiltration system
Durban University of Technology/University of Stellenbosch/University of Cape Town
No. 2004

Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see highly variable flow rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material are selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

Estimated cost: R2 400 000
Expected term: 2010 - 2012

The optimisation of waste stabilisation ponds by combining duckweed-based and algal-based systems, together with rock filters
ARTechnologies
No. 2005

Waste stabilisation pond technology is the most cost-effective wastewater treatment technology for the removal of pathogenic micro-organisms. The treatment is achieved through natural disinfection mechanisms. It is particularly well suited for tropical and subtropical countries because the intensity of the sunlight and temperature are key factors for the efficiency of the removal processes. Poor performance of WSP in developing countries can be attributed to both poor process design and poor physical design. This project investigates the combination of rock filters, duckweed and algal ponds for improved performance of current systems. There is a worldwide trend to include a rock filtration system, often with aeration, as a polishing step to remove the suspended algal cells. Duckweed-based WSP systems have a distinctive floating mat of duckweed covering the surface of the pond; it has been shown that these systems are able to remove COD and nutrients effectively. Since they inhibit algal growth, the effluent is free from suspended material and therefore has a lower COD as compared with algae-based WSP systems. The disadvantage is that production of oxygen is limited to the surface layer associated with the mat of duckweed, and the water column remains essentially anaerobic. This project proposes to study the following treatment train: anaerobic or facultative ponds (for COD removal), followed by a duckweed system, combined with an algal-based system, together with an aerated rock filtration step before discharge of the effluent. The advantages of the algal system will mitigate the disadvantages of the duckweed system and vice versa. At present not all of the process design criteria have been developed for duckweed systems, and a detailed study on the kinetics and hydrodynamics of a duckweed system would greatly contribute to the knowledge base in this regard. The combination of the two systems is a novel idea, and information gained on the system design and operation will provide design and operating guidelines to use for new designs and upgrading of existing ponds.

Estimated cost: R1 000 000
Expected term: 2010 - 2012

The development of nanocomposite polysulphone membrane with reduced fouling properties for use in wastewater treatment
University of the Western Cape
No. 2006

Polysulphone (PSF) membranes are the most common membranes used in ultrafiltration of wastewater due to their mechanical robustness and structural- and chemical stability. Unfortunately PSF is a hydrophobic material, making its surface prone to fouling due to adsorptive mechanisms. Fouling can either be caused by cake formation on the surface of the membrane, or by adsorption of the foulants both on the surface and in the membrane pores. Cake fouling is generally reversible and can be removed by

backwashing or water flushing. Foulant adsorption however is irreversible and can only be remedied by very harsh chemical cleaning. Many studies have been conducted to increase the hydrophilic properties of the polysulphone membrane surface. These studies can be divided into three categories: 1) blending PSF with hydrophilic nanoparticles such as SiO2, ZrO2 and TiO2; 2) grafting with hydrophilic polymers, monomers or functional groups; and 3) coating with hydrophilic polymers. Despite these efforts to minimise fouling of PSF membranes during wastewater treatment, there are still many unanswered questions regarding the mechanisms involved. This study will attempt to develop a novel PSF nanocomposite membrane with minimised fouling properties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 2: Application of appropriate technologies and tools

Ultra-sensitive electrochemical nanobiosensors array devices for real-time determination of estrogenic endocrine disruptors in municipal wastewater (ENDOTEK)
University of the Western Cape
No. 1999

There is a current concern in South Africa that water resources are heavily contaminated with pollutants generally classified as endocrine disruptors or endocrine disrupting chemicals (EDCs). This study will focus on endocrine disruptors that are natural and synthetic estrogenic hormones such as estriol, 17-estradiol and 17-ethinylestradiol and estrone. Estrogenic hormones are the most endocrine-disrupting chemicals because the disrupting potency can be several thousand times higher than other chemicals such as nonylphenol. This implies that natural and synthetic estrogens can be biologically reactive even at low nanogram per litre levels. Consequently, the detection of these trace contaminants in municipal water resources and their elimination are very important areas of current research interest. The level of contamination of municipal wastewater in South Africa by individual synthetic and natural estrogens is not fully known and there is no available technology for their real-time determination. The main methods for the determination of estrogenic EDCs have been through vitellogen (a biomarker for EDCs) enzyme-linked immunosorbent assay (ELISA) on fish samples or by chromatographic (HPLC) analysis of wastewater. They are very technical methods requiring extensive sample pre-treatment and high-level qualified personnel. Thus the development of rapid, simple and low-cost procedures for detection of estrogenic activity in wastewater samples is of utmost importance. The proposed research is on the development of a nanostructured electrochemical DNA aptamer array biosensor for detecting and quantifying estrogenic endocrine disruptors in wastewater samples down to the femto- or atto-molar range. The idea is to determine individual estrogen compounds simultaneously in one measurement using multichannel microchip array signal transduction approach.

Estimated cost: R1 665 000
Expected term: 2010 - 2012

Microbial database-tool for evaluating the BNR processes in KZN
Durban University of Technology
No. 2003

Biological nutrient removal treatment processes are highly organised systems that depend on a synergy between microbial populations and plant configuration and operating parameters. These microbial populations comprise primarily of functional groups of organisms such as ordinary heterotrophs that facilitate COD removal and denitrification, nitrifiers that facilitate nitrification, phosphate-accumulating organisms that are responsible for biological phosphate removal and filamentous bacteria that are responsible for the formation of the core of the floc in activated sludge processes. There is a fine balance between these different groups that has to be maintained in order for optimal functioning of these processes. Selection of these populations is generally based on influent characteristics, operating parameters and process configuration and therefore the microbial population dynamics in full scale treatment processes are closely linked to the former operational conditions. In South Africa, previous studies on these correlations were conducted a long time ago (Ekama et al., 1999), focusing primarily on engineering paradigms. The microbial population investigations were based on conventional microbiological techniques. With the advent of novel molecular techniques, there has been a paradigm shift in microbial population dynamic studies allowing a high degree of accuracy. An IWA specialist group on activated sludge separation problems stated the general situation in conventional and BNR plants in South Africa (Pitman, 2006), but most of the referenced publications were over two decades old. Therefore there is need for more updated knowledge in population dynamics. The proposed research will focus on using these novel molecular techniques to accurately profile functional groups of microorganisms and correlate to plant operating parameters and influent characteristics with the aim of understanding microbial contributions. It is hoped that this will aid in optimising plant performance and prevent problems such as bulking and foaming. The approach will be unique in South Africa and findings will be relevant to the South African wastewater treatment systems

Estimated cost: R900 000
Expected term: 2010 - 2012

Evaluation of the DEWATS process for decentralised wastewater treatment
University of KwaZulu-Natal
No. 2002

Several WRC projects have looked at the anaerobic baffle reactor (ABR) as a decentralised technology option for wastewater treatment. The DEWATS system aims to provide a treatment train consisting of the ABR connected to a wetland or membranes to study final effluent quality. The aim is to reuse the effluent for agricultural trials and thus link the technology to agriculture and food security. This projected will be piloted in KwaMashu, KZN and aims to: (1) understand the capabilities of the DEWATS system for municipal waterborne sanitation, (2) re-assess the provision of sanitation to poor households and its opportunities, (3) gain experience in using different wastewater streams in agriculture, and (4) gain knowledge in disinfecting treated wastewater using gravity membranes at a larger scale. The data from the performance of the ABR will be compared to that of the earlier laboratory and pilot-scale systems and the previously developed model will be assessed and improved where necessary. The performance of the anaerobic filter compartments will be assessed in a similar way to the ABR compartments. While failure is not expected to occur, the performance under different loading rates will be assessed and a model of this part of the system will be developed. Effluent from different stages of the ABR through the process will be supplied for specific agricultural trials to assess suitability for agriculture. The suitability of the soil at the Permaculture Centre will be assessed for different qualities of irrigation water and a selection of appropriate crops made. Water and nutrient balances will be undertaken across different agricultural plots and the two planted gravel filters to assess the impact of using treated effluent. The removal of pathogens at different points through the system will be assessed and quantitative microbial risk assessments are to be undertaken for agricultural workers and for the use of different crops irrigated in different ways.

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 3: Stormwater and sewerage systems

Investigation into pumps and pressurised flow in separate sewer systems
University of Stellenbosch
No. 2007

In a former WRC study a first-order national audit of sewerage reticulation issues was presented which highlighted amongst others various urgent future research aspects pertaining to sewer infrastructure. The proposal sets out to address a number of pertinent issues with regard to pumps, pump stations, rising mains, and other elements in the sewer system where pressurised flow occurs in separate sewer systems by means of applied research. It is hoped that the research will provide solutions to reducing the high energy input for pump stations. Energy consumption at pumping installations is an ever-increasing concern. From a strategic point of view sewer pump stations form only another component of the entire sewer system. Rising mains are another, and are often separately assessed. However, these two components are integrated hydraulically and should be optimised in combination, not separately. It is hoped this study will link theory to practice when it comes to pumping sewerage. Hydraulics and theory have their place, but a lot of experience has over the years been gained based on practical considerations, particularly as it pertains to local conditions. For example, work on the design and construction of sand/silt/rag traps as well as pump stations by members of the project team has underlined the urgent need to handle insoluble matter of all sorts arriving at sewer pump stations with the flow. This study intends to capture as much of the local knowledge in this field, test and verify it, and present a solution in the form of a tool and guide for use by both academics (e.g. published research to disseminate knowledge among peers; lecture notes) and those in the engineering fraternity (e.g. acting as a design guideline).

Estimated cost: R1 000 000
Expected term: 2010 - 2012

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 3: Minimising impact of waste on the water environment

Evaluating approaches to and benefits of minimising the formation of acid mine drainage through management of the disposal of sulphidic waste rock and tailings
University of Cape Town
No. 2015

One of the major environmental issues in the mining industry is that of acid rock drainage (ARD), caused by the disposal of voluminous sulphide-bearing wastes. The legacy of the ongoing generation of ARD from the disposal of low grade dump rock, of tailings and from the mine site itself, may continue for decades following active metal extraction. 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 ARD remediation, and the re-examination of the manner in which waste materials are disposed from the mineral processing and extraction stages of metal recovery in order to relieve the environmental burden created and reduce the time frame of risk. Particularly, the delay in the time of ARD formation is no longer acceptable and the need to remove the risk completely accepted. In this project, previous work in WRC Project K5/1831/3 will be extended to address aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides (especially pyrite), specifically with the focus of reducing capacity to form ARD and thereby the ongoing risk associated with the disposal of sulphidic mineral ore wastes, through removal of the sulphidic component of the waste. In this project, we seek to use the understanding of the factors governing ARD generation from dump rock and tailings (similar to those governing mineral bioleaching) with the view to the improvement in planned disposal of its components to mitigate ARD generation. Having identified in our previous project the components responsible for ARD generation and characteristics of the waste for disposal, in order to ensure minimisation and control of this generation, this project will focus on the methodologies used to minimise and control ARD formation and will provide an approach to evaluate the relative cost of ARD prevention based on treatments prior to disposal and ARD treatment following its generation.

Estimated cost: R1 435 250
Expected term: 2010 - 2012

Programme 4: Minimising waste production

Application of emulsion liquid membranes in the recovery of platinum group metals from precious metal refinery wastewaters and mining effluents
Rhodes University
No. 2011

Growing attention has been paid to the environmental implications of liquid effluents from mines and metal refineries. At the same time, water demand of the mining/metal refinery operations and values of precious metals have been increasing while the known reserves have decreased. This led to intense research into the recovery of precious metals from wastewaters. Methods studied include solvent extraction, biosorption, precipitation, ion exchange, electrochemical techniques, cementation, and membrane-based separations. Applicability of a particular method will depend on the speciation and the concentration of the metal in question, as well as on the chemical composition of the effluent in question. These factors can limit the efficacy of individual processes. Solvent extraction with emulsion liquid membranes (ELMs) reduces energy and financial costs, the kinetics of extraction is generally faster, and the extraction yields are higher in comparison with diluent-extractant mixtures. The disadvantages of ELMs include the instability of emulsion globules against shear fluid stress, and the resulting decreases in the rates of mass transfer. These drawbacks can be eliminated by increasing the stability of the ELM through the application of non-Newtonian ELMs, and the application of the Taylor-vortex column instead of the continuously stirred tank. After the design of an efficient extraction system at laboratory scale, the scale-up can be achieved by a simple constancy of the Taylor number, thus reducing the process development costs. The application of this process to precious and platinum group metals (PGMs) has not been investigated. The aim of this project is to fill this knowledge gap, and to examine the chemical changes and toxicological implications of the proposed process.

Estimated cost: R337 450
Expected term: 2010 - 2012

Preparation of magnetic nano composite beads and their application to remediation of mine wastewaters
University of the Witwatersrand
No. 2014

The potential of magnetic nano-composite beads to remediate water environments such as those from mine wastewaters and acid mine drainage water will be known. Molecularly imprinted polymer (MIP) beads have been used extensively for selective extraction of pollutants from various environmental compartments as part of environmental monitoring. Very little work has been focused on using the same materials for environmental remediation. This project will therefore give valuable information in this direction using magnetic nano-composite beads as potential novel materials for remediation of pollutants such as chromium (VI) and uranium (VI) in mine wastewater and acid mine drainage water under laboratory-controlled experiments. The possibility of incorporation of magnetic properties into MIP beads is a new and novel idea that makes it easier to separate them from the wastewater.

Estimated cost: R378 500
Expected term: 2010 - 2012

Programme 5: Improved ability to predict and quantify effects

Development of an analytical sensor for the identification, quantification and detection of heavy metal pollution associated with precious metal refinery wastewater
CSIR
No. 2013

The main aim of this project is the development of an electrochemical sensor for the detection of Pb, Zn, As, Cd,

Ni, Al, Pt and Pd in precious metal mining wastewaters. The data will be used to determine the effect and extent of the pollution on the aquatic environment. The development of the electrochemical sensor will involve the incorporation and optimisation of chemical materials (e.g. ion exchange material) for low-level detection of these metal ions in precious metal mining wastewaters. The secondary objective is the determination, collection and optimisation of the chemical precipitation parameters for the precipitation and speciation of Pb, Zn, As, Cd, Ni, Pt and Pd metals from precious metal mining wastewaters under different chemical conditions. It is envisaged that the research undertaken in this project will contribute to the further development of South Africa's capacity in trace metal pollution assessment. The development of electrochemical sensors will ensure that South Africa is a key player in the development and application of this technology.

Estimated cost: R716 000
Expected term: 2010 - 2012

Programme 6: Beneficiation & treatment of industrial and mining effluents

A tunable immobilised lignocellulosic enzyme (TILE) system for treatment of industrial wastewaters
Cape Peninsula University of Technology
No. 2009

This project will look at biosolubilising lignocellulosics, using a 'Tunable Immobilised Lignocellulosic Enzyme (TILE)' system. This involves rationally selected key enzymes, focusing on integration of their synergistic action to depolymerise lignocellulosic residues. Isolated enzymes are preferred to whole cell organisms because they have greater specificity, are easier to handle and store, and the enzyme concentration used in the process is not dependent on microbial growth. The primary objective is to liberate carbon in a form suitable for uptake as nutrient by biomass, thus removing the carbon and generating clean reclaimable water. This proposal addresses three major global problems: 1) the increasing scarcity of clean water, leading to the need for effective treatment of industrial effluents and reuse of water, 2) agri-industrial effluents which are produced in significant volumes but are problematic to treat cost-effectively, with few successful processes available, and 3) agri-industrial wastes which contain lignocellulosics presenting particular challenges. This work aims to develop a continuous process using immobilised enzymes in a membrane bioreactor incorporating a selected group of enzymes which are immobilised together to effect depolymerisation of the lignocellulosic content of the waste and will include in- situ generation of peroxide and hence prevention of inhibitor build-up.

Estimated cost: R2 200 000
Expected term: 2010 - 2012

Recovery and beneficiation of nutrients, water and energy from brewery effluent by means of algal assimilation, hydroponics and aquaculture
Rhodes University (Ichthyology)
No. 2008

Effluent disposal is an increasingly costly liability for industry and ultimately for the environment. The current proposal addresses the treatment and recycling of brewery effluent at the iBhayi brewery for a pilot study. The project is an integrated, multidisciplinary approach to generate the knowledge required for treating brewery effluent using (1) anaerobic digestion, (2) an algal ponding system, and (3) hydroponic vegetable production to sequester the remaining nutrients from the effluent. Beneficiation will include the use of (1) recycled heat energy from the anaerobic digester and brewery to heat the algal pond, (2) growing vegetables hydroponically on the effluent nutrients, (3) harvesting algal biomass, (4) aquaculture of edible fish and high-value aquarium fish in the recycled water, and (5) fish feed containing the algal biomass and other brewery by-products such as yeast and spent grains and finally (6) the excess recovered water will be available for use in the brewery or in other applications. The unique aspect of the proposed project is the sequencing and integration of the proposed effluent treatment and beneficiation technologies which will result in a novel approach to the way industrial effluent is processed, and the constituents made available for reuse and beneficiation. The 'proof-of-concept' phase of this R&D programme was successfully completed in 2008. The challenge now is to understand the dynamics of the parameters determining the rate processes (i.e. the biochemical and chemical processes and their reaction rates) and mass dynamics in the respective systems and develop economically viable specifications.

Estimated cost: R1 798 000
Expected term: 2010 - 2012

Development of hybrid membrane-chromatography system for simultaneous recovery of valuable products and water purification for recycle in the olive Industry, with a view towards commercial application thereof
University of Cape Town
No. 2010

In South Africa, the olive oil industry uses up to 20m3 of potable water per ton of olives processed. A previous WRC project (K8/814) investigated a hybrid membrane-based system for simultaneous recovery of valuable products and wastewater purification to the extent that it may be recycled back into the olive production process. This process has been successfully demonstrated at laboratory

scale (WRC Report No. K8/814). The wastewater has been fractionated through successive membrane separations to produce 3 separate streams: 1) a concentrated effluent containing high Mw polyphenols that can be discharged as per normal or composted, 2) a low Mw phenolic fraction containing the antioxidant extract which is rich in hydroxytyrosol,and 3) purified water containing salts and some organic acids, which can be recycled as make-up water for the fermentation and brining process. The large quantities of salt (NaCl) used are thus also recycled. Subsequent research has shown that it is possible to use only NF and chromatographic adsorption for the process if there is adequate pretreatment (i.e. particle filtration to remove suspended solids): in this case the high Mw polyphenols are rejected by the NF (Mw cut-off 270 Da), while the permeate is passed through the chromatography column to extract hydroxytyrosol, and can then be sent directly for recycle. The advantage of this approach is the recovery of a valuable product helps to offset the operational cost of wastewater treatment, and this is achieved in one operation. This project proposes to research and develop a scaled-up system though the construction and commissioning of a dedicated containerised wastewater treatment plant and research facility on-site at the Buffet Olives farm. It is intended that the plant will be a stand-alone skid mounted end-of-pipe system, which could then serve as a demonstration model for commercialisation and roll-out to other farms.

Estimated cost: R892 000
Expected term: 2010 - 2012

Extended investigations into recovery of water and salts from multi-component hypersaline brines using eutectic freeze crystallisation
University of Cape Town (Precipitation & Crystallisation)
No. 2012

South African water users are facing challenges in terms of the declining availability of sufficient quantities of water and the deterioration of the quality of the available water. In addition, with the increasing use of water treatment, the result has been an increased generation of inorganic brines and concentrates. Treating these brines, either for the recovery of the salt, or for the reduction of waste streams via a concentration process, is energy intensive and thus costly. The standard design approach for inland desalination plants is one of bulk softening and subsequent concentration of mono-valent salts. This results in mixed brines and sludges of low (or even negative) value, often containing hazardous substances. As a result, brine and sludge disposal occur mainly through forced evaporation and crystallisation of mixed (and often hazardous) salts. The extremely large energy requirements to evaporate the water can be prohibitive and the salt product is still a waste that must be disposed of. Eutectic freeze crystallisation (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. A modelling and experimental programme focussing on the use of EFC has already been undertaken (WRC Project K5/1727, which has shown proof-of-concept for EFC as a feasible treatment for hypersaline brines. However, as for any novel technology, there are still many aspects that need to be investigated and these are the focus of this proposal

Estimated cost: R1 571 490
Expected term: 2010 - 2012

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 2: Peri-urban sanitation research

Evaluation of the Mobisan technology as a sanitation option for informal settlements: Assessing performance, operational requirements and community perspectives
Cape Peninsula University of Technology
No. 2017

The provision of water supply and sanitation services has significant potential to alleviate poverty through job creation, use of local resources, improvement of nutrition and health and provision of long-term livelihood for many households. However, it has been found that technical innovations often lack sustainability due to a lack of attention or provision of operational requirements as well as community involvement. Several technologies has been developed and implemented countrywide; amongst these the MobiSan dry sanitation system has been brought in recently as an alternative sanitation technology option for informal settlements in order to improve the sanitation delivery. The MobiSan technology is a dry sanitation and urine diversion stand-alone, portable and self-contained system which does not affect groundwater. It stores urine and faeces separately, with urine being diverted away into a container tank while faeces fall into a ventilated chamber containing sawdust. As with many other sanitation technologies, previous research shows that the main problem with sanitation technologies lies in the lack of efficient Operation and Maintenance (O&M). The aim is, in the context of the MobiSan pilot of the recently-developed O&M guidelines, to understand the operational problems, assess performance in order to ensure its sustainability and to understand the perspectives of end-users of the new technology. The research will investigate the current approaches to the implementation of a new sanitation technology and evaluate the performance and O&M requirements of the MobiSan technology, as well as related community perspectives, sustainability and development opportuni-

ties through the application of recently-developed O&M Guidelines. The research study will assist municipalities with a comprehensive overview of the new sanitation technology provided in the market; it will further provide an understanding of the operational and O&M requirements, and community perceptions of the technology.

Estimated cost: R716 750
Expected term: 2010 - 2012

Programme 4: Technical sustainability of sanitation services

Evaluation of the bucket eradication programme
Hlathi Development Services
No. 2016

The bucket backlog was estimated at 252 254 in 2005. A special fund of R1.2 bn. was allocated to the programme over a three-year period and a further R400 m. was allocated in the 2007/2008 financial year. Between 2005 and March 2008 a total of 229 171 buckets were eradicated and a backlog of 23 083 buckets were due to be eliminated before December 2008. Most municipalities have used waterborne sanitation systems to replace buckets in urban formal settlements as recommended by the Strategic Framework for Water Services (SFWS). This has presented a challenge for municipalities servicing areas without bulk sewers and adequate wastewater treatment capacity and in some cases the available water supply could not support the new waterborne sanitation services. Case studies of two bucket eradication sanitation projects highlighted several problems such as the difficulties experienced by municipalities in replacing buckets with full waterborne sanitation systems in poorly-planned townships in Free State Province, and the problem of high costs of such projects. Therefore it would be of interest to identify successful approaches followed by other municipalities to address these problems. It would be very important to document lessons learned from the bucket eradication programmes, so that these lessons could be used to inform the planning of future programmes of upgrading of sanitation services for households that are still using buckets and other forms of sanitation facilities that are below the basic sanitation service level. It would be important to compare approaches followed by the different role-players that were leading the implementation of the bucket eradication programme. This study proposes to evaluate the integration of sanitation policy principles in the implementation of the bucket eradication programme.

Estimated cost: R920 000
Expected term: 2010 - 2012

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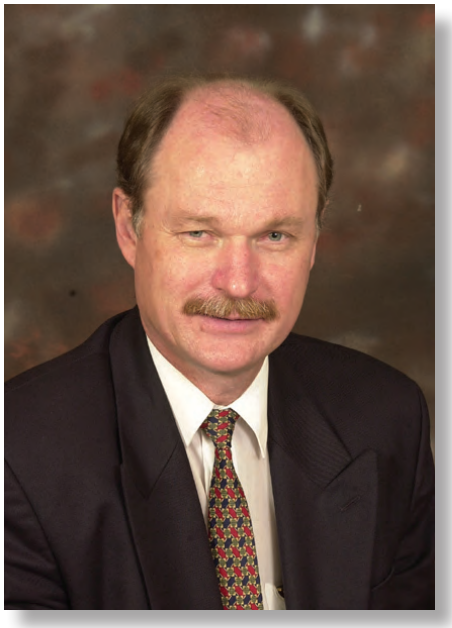

KSA 4: Water Utilisation in Agriculture

Dr Gerhard Backeberg:
Director

SCOPE

Utilisation and development of water resources in agriculture must be analysed in relation to the needs and requirements of people. People using water in agriculture comprise a diverse group of subsistence, emerging and commercial farmers within the following inter-related sub-sectors of agriculture namely:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

As in previous years, the scope in terms of people and subsectors is comprehensive and inclusive and will therefore be retained.

Water users in all the above-mentioned subsectors as well as organisations such as WUAs, cooperatives, agri-businesses and government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life problems experienced primarily by water users and related organisations, for irrigated and rain-fed crop production, fuel-wood and timber production as well as live¬stock and fish production. The problems which may be experienced in practice for any aspect of water use on the farm, irrigation scheme or river catchment vary from non-existence of knowledge, doubt regarding the applicability of existing knowledge, deviation of empirical observations from some relevant theoretical optimum, to an unclear outcome of possible alternative decisions and actions.

Research as a dynamic problem-solving and creative process must provide information, technologies and models, which can be applied by present and future generations of water users. The overall objectives are to utilise scarce water resources efficiently, beneficially and sustainably to increase household food security and farming profitability, and thereby increase economic and social welfare, i.e. efficient growth and equitable distribution of wealth on a farming, local community and regional level. These objectives must be achieved through the creation of knowledge by means of research and dissemination of knowledge, technology transfer, training and extension. Traditionally contributions are made by scientists in applied disciplines or focus areas of soils, crops, engineering, climatology, economics and sociology. Increasingly, however, the complexity of the information needs of water users requires a multidisciplinary or interdisciplinary research effort. In all instances the priorities are enhancement of management abilities in order to improve the efficiency of water utilisation for food, fibre, forage and fuel production.

OBJECTIVES

The **primary objective** is to increase household food security and to improve the livelihoods of people on 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

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 two 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 fuel-wood and timber production. This thrust includes one 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 two 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 to abstract 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 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 two programmes:

- Sustainable water resource use on irrigation schemes and within river catchments
- Impact assessment and environmental management of agricultural production

RESEARCH PORTFOLIO FOR 2010/11

In this KSA a holistic systems 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 and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to the DWAF strategy Water for Growth and Development (Version 7), the National Agricultural Research and Development Strategy, the Green Paper on National Strategic Planning 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 and fisheries 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

Over the past eight 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 toward 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 next 2 years, emphasis will be placed on quantification of water use and the nutrient content of economically important food crops in diets of the rural poor; determination of rain-fed and irrigated crop water use with satellite imagery; determination of tree water use for re-establishment of woodlands and agro-forestry systems; revision and refinement of guidelines on groundwater quality for domestic use and livestock watering; empowerment of women through water use security and skills development for improved livelihoods and reduced poverty in rural areas; assessment of the potential of small and large storage dams for inland freshwater fisheries to produce fish for food security in rural areas; promotion of the efficient conservation of water resources and water inputs within food-value chains for emerging farmers as part of land and water allocation reform projects; developing technical and financial standards for drainage of irrigated land; determination of the magnitude of pollution by agricultural chemicals and the potential risks for the environment; developing guidelines for rainwater harvesting and livestock production on natural grasslands for generation of biogas as renewable energy.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to committed funding of R24 279 587, including R2 600 000 for new projects.

CORE STRATEGY

Strategic context

The Green Paper on National Strategic Planning (2009) seeks to answer, amongst others, how to reduce poverty and what capacity is needed to ensure availability of water, energy and food in the future. The intention is to articulate a vision and strategy for the next 15 years, to which all organisations of government are aligned. In this regard the South Africa Vision 2025 of the Medium Term Strategic Framework projects a society in which, *inter alia*:

- People are united in diversity while appreciating the common interest that bind them together
- Conditions have been created for full participation of women
- Effective programmes exist to reduce poverty and protect the most vulnerable in society
- Beneficial and sustainable use is made of human resources, natural resources and modern technology
- Common interests are promoted by investment and competitive returns for the private sector

People-centred research and development for poverty reduction, productive use of natural resources and technology with competitive growth in agriculture have been key elements of the core strategy of the KSA as presented in previous years and again elaborated below.

Furthermore, the strategic context for research on water utilisation in agriculture was given renewed impetus by a 2008 report of the National Agricultural Marketing Council (NAMC), which serves the strategic positioning of South African agriculture. It was reported that food production had not kept pace with consumer demand, mainly driven by population growth and increasing per capita income, leading to food price increases. Several factors had contributed to the poor performance, including adverse climatic conditions, lack of availability and quality of water, low profitability with lack of investment because of high input costs and insufficient progress to increase productivity. The report highlighted the importance of making available adequate water and fertiliser production inputs and to improve agricultural support through research in order to increase food production.

The water resource base is therefore 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- and groundwater-dependent use. Approxi¬mately 12% and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grass¬lands, woodlands and forests respectively. Rainwater runoff and deep percolation become available as surface- and ground¬water of which approximately 62% is used for irrigation. It is abundantly clear that the biggest share of water is used for both extensive and intensive production in agriculture.

The significance of agriculture and the impact of research in the development process encompass the following:

- Everybody in society consumes food. Technological progress in agriculture therefore has widely distributed benefits.
- Agriculture is the key to poverty reduction in rural areas. Water resource use and production should be analysed as a value-adding process (from farmer to consumer) and recognise the business and employment opportunities which are created.
- Research increases the productivity of natural and human resources. This improves the competitive advantage of agriculture in a global economy.

In South Africa, at most 35% of the economically active population are directly or indirectly dependent on agriculture, although this percentage is declining each year. 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. Estimates also show that 48.5% of the population are living below the poverty line of which 70% are in rural areas. According to the HSRC (2009) about 4.5 million Blacks (or 9% of the population) in South Africa participate in agriculture in some form, mainly livestock production. Many of these are involved in low-input, low-output farming activity that provides supplementary food for households. Recent data from various surveys indicates that 52% of households experience hunger and with a monthly income poverty line of R1 200, 59% of households are food insecure.

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. Until 2006 agriculture was also a net exporter of food, contributing 10% of total exports of which 50% are processed products. During 2007 imports exceeded exports, mainly due to import of processed food products. Since 2008 the trade balance is again positive.

The above-mentioned current reality of agriculture in South Africa is also clearly stated by the Department of Water Affairs and Forestry (DWAF) in the strategy on *Water for Growth and Development in South Africa* (2008) (Version 7). Effective change in water use behaviour to promote water savings for growth could be achieved through incentives to improve irrigation efficiency and conservation practices. These include water measuring and user charges as tools to manage demand, upgrading irrigation technology and trading of water use entitlements. Revitalisation of irrigation schemes in the former homelands is required for household and community level irrigation. Furthermore it is important to provide water for food production in home gardens in rural villages or towns and peri-urban areas. This can be done through development of small-scale infrastructure for different forms of rainwater harvesting and storage which promotes rural development.

Critical issues in the forthcoming years and the next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing consumer income levels. Expansion of agricultural production on land suitable for cultivation will be increasingly 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 relative 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 ero¬sion, 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 with research and development must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background it is important to emphasise that the strategic focus of water research in this KSA, which was also found to be relevant by the *July 2006 External Institutional Review*, 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)
- Increasing the household food security and profit ability of farming and thereby the livelihoods of people dependent on agriculture (i.e. improving the knowledge of manage¬ment processes by people who are using water)
- 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)

In drawing up plans to implement these strategies, cognizance has to be taken of the national needs, technological trends and stakeholder expectations.

Needs analysis

Previously identified needs, re-affirmed by recent reports, reviews and policies, 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) and is currently being revised. 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 one of four 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 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. agri-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 2007 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.

At a conference on Nutrition and Food for Special Dietary Uses at the beginning of November 2008 in Cape Town, the Minister of Health stated that 'food insecurity and high rates of malnutrition, coupled with high food prices, remain the biggest threat to nutrition in Africa'. More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices.

Specific recommendations by DWAF (2008) to promote water for growth and development of agriculture are measure¬ment of water, correct scheduling and implementation of appropriate technologies to enhance efficiency and to reduce the amount of water used for irrigation; re-establishment of high value crops under irrigation in areas where production can be supported on a sustainable basis; revitalisation of irrigation schemes and exploring, developing and using groundwater for small-scale irrigation on household and community food plots; and investment in small projects for rainwater harvesting and conservation in rural areas.

During 2009 the Minister of Water Affairs raised three key issues which are directly relevant to the KSA: First, the need for incentives, technologies, guidelines and training for rainwater harvesting; second, the need for awareness, knowledge, education, compliance and enforcement to prevent water pollution; third, the need to disaggregate models and enable intervention at a local level to improve agricultural productivity with climate change under conditions of water stress.

In the 2009 Budget Vote, the Minister of Agriculture, Forestry and Fisheries emphasised the Comprehensive Rural Development Programme (CRDP). This will enable people in rural areas to meaningfully participate in the economy through the productive use of natural resources at their disposal and thereby effectively reduce poverty. Specific mention was made of the need and commitment to train extension officers. Regarding forestry the Million Trees Programme and Livelihoods Programme encourages the planting of trees and harvesting of firewood, building material, medical plants and edible fruit to address the basic needs of the rural poor. It was also stated that the declining fish stocks must be managed by development and sustainable use of natural resources.

The consultation with stakeholders during 2009 highlighted the following priorities which are relevant to the KSA: Water security; poverty alleviation; trade-offs between

food and bio-fuel production; efficiency of water use and improved measuring tools; the water footprint of agriculture; water shortages and drought; and the impact of climate change.

These relevant needs and priorities as expressed by government, public organisations and stakeholder representatives at national, regional and international levels are all receiving attention in the research and development strategy of the KSA. As in previous years they will guide the selection of topics for expansion of projects in the research portfolio and can be summarised under the following key activities:

- Increasing the productivity of rainwater and irrigation water for crop and livestock production
- Uplifting rural economies through commercial food production
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving nutrition and health
- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

Key stakeholders

This KSA clearly supports South African government strategies and initiatives where water conservation and in particularly water utilisation for agriculture is of concern. Government departments, especially the Department of Water Affairs (DWA) and the Department of Agriculture, Forestry and Fisheries (DAFF) are important stakeholders. These links have also been formalised by the support of selected projects of mutual interest through leveraged funding. 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. In all cases co-operation is achieved by invitations to review research proposals and to serve on the reference group of relevant research projects.

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 45 000 commercial farmers, 250 000 emergent farmers and 4.5 million subsistence farmers.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies has been designed by formalising stakeholder relationships. It is gradually being implemented to reach farmers and their representatives on 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 players

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 DAFF mainly through its Directorate: Water Use and Irrigation Development and DWA through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC are firstly, inter alia, an initiative by the DAFF to give policy direction to development through integrated water manage¬ment for agricultural use and implementation of the irrigation strategy. Secondly, the water conservation and demand management strategy in agriculture, the water allocation reform strategy and the broad-based black economic empowerment guidelines for water use that DWA is implementing.

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 eight 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 establish¬ment 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. Research is done under four themes of water availability and access; productive water use; water quality, health and environment; and water governance.

The CGIAR Challenge Program on Water and Food (CPWF) is an international, multi-organisational research initiative. The partnerships seek meaningful impacts for people who use innovations developed by scientific research. Its goal is to increase the productivity of water used for agriculture, leaving more water for other users and the environment. In the Limpopo basin, the development challenge is to improve rural livelihoods through better management of rainwater, including management of small dams.

Research providers

The main suppliers of research projects are universities and colleges (currently Universities of KwaZulu-Natal, Pretoria, Free State, Stellenbosch, Rhodes, Fort Hare, Cape Town 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

- AgriSA organised a Water Conference with the theme: Water Utilisation and Food Security - Policy and Practice, 11 August 2010, Kempton Park, at which the KSA Director was invited to give a presentation on the 'Strategic direction for research on water utilisation in agriculture'.
- The KSA manages the Network on Irrigation Research and Extension for Smallholder Agriculture (NIRESA), established to facilitate interaction between researchers at universities and science councils on the one side and extension officers in provincial departments on the other. Particular attention is given to available knowledge and practical requirements on smallholder irrigation farming and schemes which must receive priority attention. NIRESA held their annual workshop from 26 to 28 October 2010 in the Western Cape, which included a field visit to irrigation schemes on the 27 October 2010.

Leadership positions

- Treasurer and members of the Executive Committee of the South African National Committee on Irrigation and Drainage (SANCID). The KSA Director was invited to give a presentation at the biennial SANCID Symposium, Upington, 16-18 November 2010, on 'Innovations for effective agricultural water management and efficient food production'.

Strategic positioning

- Discussions were held with the following officials in the Department of Agriculture, Forestry and Fisheries (DAFF) for leverage of research funding:
  - The existing Collaboration Agreement with funding from the Directorate: Water Use and Irrigation Development expired in March 2011. Research projects of mutual interest to DAFF and WRC were agreed to and a list of projects with requested funding was completed and will be submitted with a request to extend the Collaboration Agreement with 5 years and a total annual budget for leverage funding of R3 million.
  - A new Service Level Agreement is being negotiated with the Directorate: Agricultural Engineering Services.
  - A new Service Level Agreement is also being negotiated with the Directorate: Animal and Aqua Production Systems.
- The Deputy Director-General of the Department of Agriculture, Forestry and Fisheries (DAFF), requested the KSA 4 Director to give a presentation to the CEO Steering Committee on the findings of WRC project (K5/1773/4) on a 'Quantitative investigation into the link between irrigation water quality and food safety' during a meeting held on 26 July 2010.
- On request of the Acting DG of DWA and the CEO of the WRC, a presentation was given by the KSA 4 Director to DWA Top Management on 'The value of water for economic development', on 6 September 2010, followed by an interactive discussion on the issues raised during the presentation.
- Following the meeting between staff of DWA and WRC held on 2 September 2010, regarding oversight of the R&D strategy and business plan for 2010/11 to 2012/13, a discussion was organised with the Acting DDG to explain how the WRC-funded Water Administration System (WAS) can support DWA to implement water loss control and achieve significant water savings in irrigated agriculture.
- Progress is being made with the research impact study on WRC-funded irrigation scheduling tools and models being undertaken by the University of Pretoria, Department of Agricultural Economics, Extension and Rural Development. The purpose is to determine whether research-based knowledge for irrigation scheduling was used for decisions and actions.
- Frost and Sullivan International have been commissioned to develop a database of all water-related research projects in agriculture which have been undertaken in South Africa during 2010. A questionnaire has been sent to all research organisations (universities, science councils, grower associations and provincial government departments) to gather information on the project title, project aims and objectives, and total project funding. It will also be determined in what area (rain-fed and irrigated cropping, agro-forestry, livestock watering and aquaculture/inland fisheries) research is being undertaken in comparison with the thrusts and programmes of the KSA: Water Utilisation in Agriculture of the WRC.

African leadership

- Member of Advisory Board, International Centre for Water Economics and Governance in Africa (IWEGA).
- Chairman, Southern African Regional Irrigation Association (SARIA).
- From 14 to 16 September 2010 IWEGA presented a course on 'Water Economics and Governance in South

Africa: Basic Issues and Operational Tools' to staff of DWA at the Roodeplaat Training Centre. The KSA 4 Director presented a case study on 'Development and financing of irrigation schemes' and the available WRC guidelines on the revitalisation of smallholder irrigation schemes were explained.

- A research manager attended a regional stakeholder consultation forum in Zambia organised by IWMI, 10 to 11 August 2010, with participants from different countries in the SADC region, and chaired one of the discussion groups. The purpose of the meeting was to discuss the research programme of IWMI, which is currently conducting a restructuring process.
- The Partnership for Agricultural Water in Africa (AgWA) is a voluntary partnership comprising various African public and private organisations and international bodies that have a common interest and desire to support agricultural water management (AWM) and development in Africa. During the second-half of 2010, extensive consultations took place in East/Southern and West/Central regions of Sub-Saharan Africa to develop propositions on the governance and implementation architecture of AgWA. A research manager participated in the discussions at the final meeting of this series of consultative meetings, held in Johannesburg from 17-18 January 2011, in his capacity as Chairman of SARIA.
- A research manager organised and chaired the annual workshop and steering committee meeting of the Southern African Regional Irrigation Association (SARIA), held from 15-17 February 2011 at Maguga Lodge, Swaziland. The KSA 4 Director presented a paper at the workshop entitled 'Towards productive water use and household food security in South Africa', based on various completed WRC research projects including the comprehensive resource material on 'Agricultural Water Use in Homestead Gardening Systems'.

International player

- Chairman, ICID Task Force on Financing Water for Agriculture (TF: FIN).
- Vice-Chairman, ICID African Regional Working Group (Af: RWG).
- A paper was prepared and a presentation was made on 'Crop production and water use for bio-fuels in South Africa' at the *3rd International Seminar on Crop Science for Food Security, Bio-energy and Sustainability*, 1 to 3 June 2010, Szeged, Hungary, held by the Cereal Research Non-Profit Ltd., Hungary and International Foundation for Sustainable Development in Africa and Asia (IFSDAA), Göttingen, Germany.
- KSA members participated in the Pre-Council meetings of Workbodies and the *6th Asian Regional Conference of the International Commission on Irrigation and Drainage (ICID)*, held in Yogyakarta, Indonesia, 11 to 15 October 2010. A Workshop on 12 October was organised by the KSA 4 Director in his capacity as Chairman of the ICID Task Force on Financing Water for Agriculture. The topic of the Workshop was 'Country policies and strategies on financing and implementation of current water use charging systems in irrigation'. A paper was presented at a workshop on 13 October on 'Water saving practices in agriculture' of the Working Group on Water and Crops. A paper was also presented on 'Towards productive water use and household food security in South Africa' during the *6th Asian Regional Conference*.
- Representatives from international and national research organisations and various SADC countries (i.e. Malawi, Zambia, Tanzania, Zimbabwe, Botswana), and the Department of Science and Technology attended the International Institute for Applied Systems Analysis (IIASA) regional workshop for Southern Africa in Cape Town on 27 and 28 January, 2011. A research manager presented a paper on the Water Research Commission's research and development strategy on 'Water utilisation in agriculture' during the workshop, and was also one of the panel members in a session on 'Climate adaptation: Food and water in changing urban and rural landscapes'.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

During 2010/11 135 students received training as part of KSA 4 projects, of which 78 (58%) were from previously disadvantaged (PD) backgrounds.

TABLE 1
Capacity building through student involvement in KSA 4 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Agricultural Research Council	3	5
Aquagreen Consulting	1	4
Asset Research	0	5
CPH Water	0	1
CSIR	9	14
Institute of Natural Resources	2	2
Rhodes University	4	6
Sigma Beta	4	8
Tshwane University of Technology	8	8
University of Cape Town	0	6
University of Fort Hare	5	5
University of the Free State	5	9
University of KwaZulu-Natal	15	24
University of Pretoria	12	19
University of Stellenbosch	10	19
TOTAL	**78**	**135**

Capacity building interventions

Meetings were held with various faculties of agriculture in South Africa in 2010/11 with the intention of improving communication, strengthening the working relationship between universities and the WRC and discussing the way forward in the context of the WRC research and development strategy. Particular attention was given to identifying priority areas for research and co-operation for post-graduate training and building careers for scientists in water related research.

Meetings were held with:

- Dean of the Faculty of Agriculture of the University of Fort Hare, 28 July 2010
- Deputy Vice Chancellor for the College of Agriculture, Engineering and Science of the University of KwaZulu-Natal, 3 August 2010
- Dean of the Faculty of Natural and Agricultural Sciences of the University of Pretoria, 31 March 2011
- Director for Research of the School of Agricultural and Environmental Sciences at the University of Limpopo, 11 April 2011
- Dean of the Faculty of Agricultural Sciences at the University of Stellenbosch, 13 April 2011

Knowledge dissemination

- On 8 September the Aquaculture Association of South Africa (AASA) organised an Aquaculture Workshop at the Willows Country Lodge in Pretoria, at which the KSA 4 Director was invited to give a presentation on 'Research initiatives of the Water Research Commission on Aquaculture and Freshwater Inland Fisheries'. This opportunity was used to invite the representatives at the workshop to use the AASA as a channel to communicate research priorities to the WRC.
- During the *3rd African Association of Agricultural Economists and the 48th Agricultural Economics Association*

of South Africa Conference, held in Cape Town from 19 to 23 September 2010, the KSA 4 Director organised a mini-symposium on 23 September with the topic 'Opportunities for more productive water use and household food security in South Africa'.
- The South African Institute of Agricultural Engineers invited the KSA 4 Director to give a presentation on 'Institutional reform and modernisation of irrigation systems in South Africa' during a Continuous Professional Development (CPD) Event held from 28 to 30 September 2010 at the Pumulani Lodge near Pretoria.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- Presentation on 'Innovations for effective agricultural water management and efficient food production' during the *SANCID 2010 Symposium*, Upington, 16 November 2010.
- Paper and presentation on 'Towards productive water use and household food security in South Africa' during the *6th Asian Regional Conference of ICID* held in Yogyakarta, Indonesia, on 14 October 2010.
- A paper was presented at the *2nd International Seminar of the International Foundation for Sustainable Development in Africa and Asia*, July 2009, held in Göttingen, Germany. All peer-reviewed papers have now been published in a book. The reference is as follows: Backeberg GR (2010). Improving Rural Livelihoods with Rainwater Harvesting and Conservation on Communal Croplands in South Africa: Opportunities and Obstacles. In: Behl RK, Merbach W, Meliczek H and Kaetsch C (Editors) *Crop Science and Land Use for Food and Bioenergy*. Agribios International, Jodhpur, India.
- Following a workshop held in January 2009 as part of the WRC-initiated solicited research project (No. 1771) on 'Water use of drought tolerant food crops', an issue with selected peer-reviewed papers was published by the *South African Journal of Plant and Soil*. The Foreword to this issue was written by the KSA 4 Director, entitled: 'Underutilised indigenous and traditional crops: why is research on water use important for South Africa?' *(S. Afr. J. Plant & Soil,* 27(4), 291-292).
- The summary and conclusion of the paper presented at the *ICID 6th Asian Regional Conference* in Yogyakarta, Indonesia, entitled 'Towards productive water use and household food security in South Africa' was published as a popular article in two technical magazines: *SABI Magazine* (Volume 3, Issue 2, December 2010/January 2011, 33-34) and *The Water Wheel* (Volume 10 No 1, January/February 2011, 32-33).

IMPLEMENTATION PLAN

Research portfolio for 2010/11

As in previous years, the **primary objective** is 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** 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

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	**Scope:** 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	**Scope:** 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	**Scope:** 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	**Scope:** 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	**Scope:** 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 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.

RESEARCH PROJECTS FOR 2010/11

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

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

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of 'measure; assess; improve; evaluate'. It promotes an investigative approach to improving efficiency, rather than relying only on water accounting. The main output of the project was the compilation of guidelines for improved irrigation water management from dam wall release to root zone application. The guidelines are aimed at assisting both water users and authorities to achieve a better understanding of how irrigation water management can be improved, thereby building human capacity, allowing targeted investments to be made with fewer social and environmental costs. Using lessons learnt during the WRC project, best practices and technologies were introduced and illustrated.

Cost: R5 742 128 (incl. leverage)
Term: 2004 - 2010

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

This project was undertaken to provide guidance regarding the conditions under which grey-water use should be allowed or propagated and to provide guidance to users about its sustainable use in small-scale agriculture and gardens. Two main products were produced: a user-friendly Guidance Document and a supporting Technical Background Document which captures the technical information on which the Guidance Document is based and describes the extensive process that was followed to devel-

op the Guidance Document. The Guidance Document is aimed at municipalities, NGOs and informed members of the public who wish to implement grey-water irrigation. The focus of the Guidance Document is to minimise the risks of:

- Illness in handlers of grey-water and grey-water irrigated produce, or consumers of grey-water irrigated produce
- Reduction in growth or yield of plants/crops irrigated with grey-water
- Environmental degradation, especially reduction in the ability of soil irrigated with grey-water to support plant growth

Cost: R1 670 000
Term: 2005 - 2010

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

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; University of Pretoria; Zakhe Agricultural Training Institute
No. 1477

The project was conducted in the form of two case studies based in Zanyokwe Irrigation Scheme (ZIS) which uses sprinkler irrigation and Tugela Ferry Irrigation Scheme (TFIS) which uses a short-furrow irrigation system. The main objective was to carry out research in Zanyokwe and Tugela Ferry irrigation schemes with a view to developing and implementing technologies and knowledge useful for farmers in order to improve their livelihoods and those of surrounding communities. Participatory research methodologies were employed where the smallholder farmers and other stakeholders were involved in project activities. Important agronomic and socio-economic (including organisational and institutional arrangements) constraints to crop production on the two schemes were identified and action was taken together with the farmers to address the problem. The need for training of extension staff in irrigation management in order to better support farmers was highlighted. The project had a positive impact on the irrigating and non-irrigating communities of Zanyokwe and Tugela Ferry. The participatory implementation of interventions to address identified constraints, socio-economic factors and water and crop management factors, was to a large extent successful. The findings of the action research agronomic studies clearly indicated that it is possible to significantly improve yields to near-potential levels by simply improving the crop husbandry practices. It is, therefore, recommended that smallholder irrigation scheme revitalisation programmes should place capacity building in basic crop and irrigation management practices, and strengthening institutional/organizational arrangements, prominently in their revitalisation agendas in any efforts to improve on the performance of these schemes in South Africa.

Cost: R4 500 000
Term: 2004 - 2010

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Definition of process zones and connectivity in catchment-scale NPS processes
University of KwaZulu-Natal; ARC; University of Pretoria; Sigma Beta
No. 1808

This project made use of sediment fingerprinting, geophysical and soil pedological surveys and stable isotopes to study the processes through which water, sediment and nutrients are delivered in a research catchment, with the aim of improving our understanding and ability to predict and model agricultural non-point source pollution. The processes studied include land-based connectivity and stream reach barriers and controls. It was found that the earlier construction of a drainage ditch through the upstream-most wetland has significantly altered the geomorphic and hydrologic connectivity of the catchment. Sediment source was furthermore found to vary as a function of runoff magnitude. The dominant mechanism for nutrient transport in the landscape appears to be in the subsurface, through lateral discharge in the intermediate layer between the sandy soil and bedrock. This relatively short-term study has thus significantly improved our understanding of the processes and controls affecting the transport of nutrients and sediments.

Cost: R722 540
Term: 2008 - 2011

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

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 hectarage, 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

Water use of cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production
University of KwaZulu-Natal (School of Bioresources Engineering and Environmental Hydrology)
No. 1874

In South Africa, the establishment of an economically viable biofuels industry is increasingly becoming a possibility due to technological advances; global commitment to limit greenhouse gases and to reduce global warming; the need to diversify energy supply; and the need to accelerate rural economic growth by the agricultural sector. With diminishing fossil fuel resources and increasing oil prices, attention is being focused on producing alternatives to fossil fuel, with emphasis on the production of biofuels. The Biofuels Industrial Strategy of South Africa specifies the use of certain crops as feedstocks for bio-diesel and bio-ethanol production. The consideration of a range of crops and cropping systems as feedstocks is necessary, especially those which may produce food and fodder as well as fuel. Furthermore, the evolution of 'second generation' biofuel technologies which allow for the conversion of cellulose (biomass) for biofuel production must also be investigated in terms of water use and potential impacts on the country's food production. Studies on the water use impacts of the biofuels industry on South Africa's limited water resources are urgently required for both local and national water resource planning. A scoping study on the water use of crops/trees for biofuel production (WRC Project No. 1772) provides preliminary results on the water use and growing conditions of limited biofuel crops based on broad climatic parameters and crop bio-physical requirements. The report of this follow-on project will document the water use and optimal growing conditions for a comprehensive range of potential crops/trees. It will include detailed mapping of suitable production areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R5 000 000
Expected term: 2009 - 2015

Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture

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

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

An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing
University of Pretoria (Department of Microbiology and Plant Pathology)
No. 1875

With decreasing water resource availability for agricultural purposes and increasing water pollution, contamination of food products may increase health risks. Poor health due to water and food contamination has negative impacts on the productivity of human resources in all sectors of the economy. This emphasises the importance of minimising food safety risks. Due to under-nutrition, consumption of fresh and raw fruit and vegetables is encouraged as a source of essential micro-nutrients. If the water and produce are not safe, or if there is a lack of effective food safety management, this benefit may be eliminated and the health of all people, but in particular the vulnerable poor people, will weaken. In addition, earning of foreign exchange is a key contribution of agriculture to the economy. Microbial contamination of food products for local and export markets will have negative impacts on trade relationships. Losing market access due to perceived high risks of contaminated produce could have severe constraining implications for future economic development. For food safety management, European and American models are currently applied. These are not necessarily appropriate for South Africa and consequently the risk may not be correctly assessed. In addition, CODEX standards are presently adopted and officials are not able to benchmark these with locally verified data. Therefore, this research project on microbial contamination of fruit and vegetables will enable the drafting of relevant national microbial standards which comply with international requirements. The knowledge obtained through the project will also contribute to effective management of water resources and food products to improve food safety. Better understanding of the nature and extent of the problem of microbial contamination of food, in the context of South Africa as a developing country, will support accurate health risk assessment and subsequent community health management.

Estimated cost: R4 419 200
Expected term: 2009 - 2015

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

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

Water use and economic value of the biomass of indigenous trees under natural and plantation conditions

CSIR Natural Resources and the Environment
No. 1876

Specific findings, recommendations and gaps in knowledge regarding the water use efficiency (WUE) and economic potential of indigenous tree systems were identified in a previous WRC project (K5/1462) which was finalised in March 2008. These included the need for improved understanding of the WUE of a wider selection of indigenous tree species growing under a range of bio-climatic

conditions in South Africa. This information is needed to explore the possibility of expanding and growing the local forestry industry using indigenous tree species. Potential benefits of this expansion include the expected lower water use rates of indigenous species, and the high economic value of biomass products. Furthermore, it is important to place the water use of exotic commercial plantations in perspective, through comparisons with indigenous tree-production systems. There is also a need to establish a baseline water use by indigenous trees under natural conditions to facilitate the evaluation of likely water resource changes associated with a change in land use. Improved knowledge in these aspects will contribute to improving or enhancing rural livelihoods through the use of indigenous tree-production systems. In addition, possibilities exist to provide alternative wood-production systems to replace alien invasive plants, as the process of alien plant eradication continues. Ultimately, the research output should enable formulation of recommendations regarding the use of indigenous natural and plantation tree systems, with emphasis on WUE, site-species matching and economic viability to support sustainable rural development.

Estimated cost: R4 999 100
Expected term: 2009 - 2015

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

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

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. 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

Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province
Tshwane University of Technology; ARC (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

Empowerment of women in rural areas through water use security and agricultural skills training for gender equity and poverty reduction
University of KwaZulu-Natal (School of Environment Sciences)
No. 1878

The joint document published in 2008 by the Department of Agriculture and Land Affairs, the Land and Agrarian Report Project (LARP), among other things, prioritises the revival of agricultural production by 10 to 15% in former homelands where valuable fertile land lies fallow. This plan is complemented by the objectives of the Department of Water Affairs, which seeks to, among others, ensure reliable and equitable supply of water for sustainable economic and social development including the eradication of poverty. A key feature for sustainable rural productivity will clearly be to develop capacity of the principal users of the land who are women. It has been reported that women constitute 70% of the agricultural labour force and are the main food producers for rural households in South Africa. However, there is sufficient evidence to suggest that poor rural women are considerably more disadvantaged because of gender bias in land allocation, access to credit, marketing channels and agricultural services in general. Women living in traditional rural areas form part of the most economically and socially disempowered groups in South Africa. This project focuses on the skills and training needed by rural women in order to sufficiently equip them to address the challenges of food insecurity and poverty. Although reports on agricultural training and skills development are widely available and have been well documented, very few, if any, are specifically tailored to meet the skills and training requirements of women in rural areas, within cultural and traditional realities. The report will identify skills required by women in agriculture (farming and non-farming activities within the food-value chain). The report will furthermore highlight the incentives of secure water and land entitlements which enable women to increase food security and reduce poverty at the household level.

Estimated cost: R3 000 000
Expected term: 2009 - 2014

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 - 2010

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 DWA 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

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 DWA and the 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
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

Analysis of food-value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy
University of KwaZulu-Natal (Institute of Natural Resources)
No. 1879

The inclusion of subsistence and emerging farmers in the mainstream of the economy is a nationally identified priority. Structural and cyclical obstacles must be overcome to accomplish this. These are mainly the dualistic nature of the agricultural economy and the recent occurrence of food shortages with high input costs. Although expectations are high for subsistence farmers to enter the market, experience shows that technical and business skills are required to obtain access to assets in agriculture by entering food-value chains. With high poverty levels and increasing unemployment, there is also a need to ensure growth with equity and therefore impacting on a wider group of people to promote rural economic development. Achieving this is a real possibility, since on the demand side there are different value chains, with consumers demanding food in different marketing outlets. On the supply side there are a large number of rural inhabitants, which includes groups who can be broadly categorised as subsistence, emerging and commercial farmers, who can potentially respond and enter any one or a combination of these value chains. The productive use of water in the value chain for both rain-fed and irrigated food production is of particular importance. The project will investigate factors such as needs and aspirations, technical capabilities, risks of crop production, food price expectations, water use security and incentives to increase water productivity which influence the decision of what value chain to enter and the degree of success obtained. The report will highlight innovative ways to promote integration of subsistence, emerging and commercial farming in food-value chains for crop and animal products with use of rain- and irrigation water.

Estimated cost: R2 999 989
Expected term: 2009 - 2014

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

Methodology to monitor the status of water logging and salt-affected soils on selected irrigation schemes in South Africa
ARC (Institute for Soil, Climate and Water)
No. 1880

Major capital investments have been made in irrigated areas of South Africa. Declining productivity due to salinisation will have an impact on individual farms and the sustainability of food production is potentially threatened. Therefore, it is important to monitor degradation and plan rehabilitation at scheme level. Since the late 1980s no national effort has been made to quantify the extent of water logging and salt accumulation across irrigation schemes. Indications are that water quality is declining and these problems are actually escalating. In order to identify soils for drainage and reclamation, the extent of water logging and salt accumulation has to be determined. National monitoring of water logging and salt accumulation is a high priority but currently no verified methodology is available to undertake this task. Data of soil conditions for different irrigation schemes is located at different organisations and the ARC-ISCW needs to be supported to act as custodian of baseline soils data. The GIS database and mapping is a new tool that is available for national application with the Agricultural Information System (AGIS). The general aim of this project is to develop and test a methodological approach for identification, classification and monitoring the extent and degree of water logging and salt accumulation at scheme, farm and field level. Guidelines will be produced for application at national scale which will ensure sustainable utilisation of soil and water for irrigation.

Estimated cost: R3 693 800
Expected term: 2009 – 2014

Programme 2: Impact assessment and environmental management of agricultural production

Modelling non-point source (NPS) pollution in \ agriculture from field to catchment scale
Aurecon SA (Pty.) Ltd.
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 eThekwini 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

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

Impact of wastewater irrigation by wineries on soils, crop growth and product quality
ARC (Infruitec, Nietvoorbij)
No. 1881

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation of agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well known and

their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

Estimated cost: R3 500 000
Expected term: 2009 - 2014

Adaptive interventions in agriculture to reduce vulnerability of different farming systems to climate change in South Africa
University of Cape Town (Climate Systems Analysis Group)
No. 1882

South Africa has a high risk agro-hydrological environment which is likely to be exacerbated under conditions of climate change. It is widely recognised that ongoing changes in climatic conditions will generally have an adverse effect on, amongst others, agricultural production, biodiversity and water resources. Agriculture is a key sector in the economy with regard to rural livelihoods and food security and it is therefore vital to proactively access potential impacts of climate change on this sector. The National Disaster Management Framework of South Africa, a legal instrument specified by the Disaster Management Act, No 57 of 2002 recognises a diversity of risks and disasters that occur in Southern Africa, and gives priority to developmental measures that reduce vulnerability of disaster-prone areas, communities and households. In addition, the National Climate Change Response Strategy for South Africa, compiled in 2004, aims to address issues identified as priorities for dealing with climate change in each sector in the country. These documents informed the recently completed Climate Change Sector Plan for Agriculture compiled by the Department of Agriculture. The plan seeks to address institutional arrangements, vulnerability assessments, adaptation and mitigation as well as response and recovery of the agricultural sector as a result of climate change. Research related to vulnerability and adaptation is identified in the plan as a priority. There is a lack of integrated knowledge regarding the vulnerability of agriculture in terms of climate change and water availability. The project aims to investigate the impact of projected climate change on agriculture; assess the vulnerability of crops, rangelands and farming households and enterprises; identify and suggest appropriate adaptive techniques and practices in selected catchments and farming areas. The report will provide an assessment of the vulnerability of different farming systems to climate change. It will evaluate alternative adaptation practices and techniques (indigenous and science-based knowledge) and if necessary develop and test innovative, appropriate and sustainable interventions, including internal management measures and external policy measures.

Estimated cost: R4 000 000
Expected term: 2009 - 2014

NEW 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

Baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security
University of Pretoria (Department of Human Nutrition)
No. 1954

One of the main food security challenges facing South Africa is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices. It is important to know what food crops are currently available but also what alternative food crops can be considered that will address the nutritional imbalances. In order to improve nourishment of people, supplements are required over the short-term; fortification over the medium-term; and better nutrition behaviour over the long-term. Information is available on what people should be eating but not what people are actually eating. There is a need to understand the linkages between diet, nutrient intake, foods, crop and animal products, processed and unprocessed food products. In addition, very little local knowledge is available on nutritional water productivity (i.e. nutrition per volume water expressed as nutritional units (kJ of energy; grams of protein; RE for vitamin A; mg of Fe or Zn) per m^3). Both water and fertiliser management will determine the productivity of water and quality of crop food products. The contradiction between rural poverty, food insecurity, inadequate nutrition and underutilisation of natural resources raises a number of funda-

mental research questions. Clearly, there is an important need to understand the aspirations of people to bridge the gap between, for example, usual and adequate nutrition, food intake and food demand. This scoping study seeks to understand the gaps in knowledge before formulating more focused research project(s).

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

THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

Programme 1: Sustainable water-based agricultural activities in rural communities

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods
Rhodes University (Department of Ichthyology and Fisheries Science)
No. 1957

In South Africa the potential of inland fisheries, which exists in the form of hundreds of water impoundments or storage dams throughout the country, is largely underdeveloped and underutilised. With exception of traditional practices in e.g. specific regions of KwaZulu-Natal and Limpopo Province, there is no culture of fish consumption in rural areas, despite the fact that fish is one of the best sources of protein. Due to the decline of production of marine fish stocks (which has been caused by overfishing) and a higher demand for fish, the price of fish is increasing. With increase in demand, the development and use of water resources in storage dams for inland fisheries have the potential to contribute to uplifting rural economic activity. There is a need for government interventions to formulate policies and strategies that support inland fisheries. These inland fisheries encompass community-managed subsistence fishery, commercial fishery and recreational fishery. The links between hatcheries, aquaculture and inland fisheries, such as culture-based fisheries, and the stocking of small farm dams and large storage dams, also needs to be explored. Inland fisheries can thereby create a fairly large support base for job creation, skills development and poverty reduction at a local level. Sustainable use of water resources with inland fisheries requires appropriate institutional arrangements, organisational structures and governance systems, for the application of technologies, management of water resources and service delivery to be successful. In this baseline and scoping study the current situation regarding water use for inland fisheries will be documented. Contributions will be made to formulate strategies for future development. The gaps in knowledge and priorities for further research will be identified.

Estimated cost: R2 000 000
Expected term: 2010 - 2014

Programme 2: Integrated water management for profitable farming systems

Investigation of water conservation in food value chains by beneficiaries of water allocation reform and land reform programmes in South Africa
CSIR (Water Resources Governance System)
No. 1958

The Water Allocation Reform Strategy of the Department of Water Affairs and Forestry (2008) states that by 2014, 30% of allocable water should be to the benefit of Black people. By 2024 the target is 60%, of which half should be under control of black women. Indications are, however, that so far very few water use entitlements have been awarded and/or taken up by individuals or groups of black emerging farmers. Evidence is also increasing that most water allocation reform and land reform projects are not leading to sustainable development. For establishment of commercially-oriented black farmers, the support services need to be substantially improved. These include access to finance and markets, better local organisation, improved management training and provision of extension services. Food value chain analysis is an appropriate basis for determining the requirements for integrating subsistence, emerging and commercial farming enterprises. There are different approaches for this analysis and in practice value chains vary in complexity. Food value chains essentially are the different stages for the production, marketing and distribution of goods and services. Important participants are value chain players (e.g. farmers, processers, retailers); influencers (e.g. regulators of food safety and trade); and supporters (e.g. providers of information and training). Within the embeddedness of a particular set of societal norms, the structure, conduct and performance of value chains can be analysed in combination with institutional arrangements, governance systems and resource allocation. In the South African context of water allocation reform, this approach should be applied and tested. The research input will show how black emerging and white commercial farmers can be integrated and productivity of water use can be increased through value adding in the food chain. Recommendations will be made to give support and direction to successful implementation of the Water Allocation Reform Strategy and enable meeting of the set targets.

Estimated cost: R3 000 000
Expected term: 2010 - 2014

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments

Development of technical and financial norms and standards for drainage of irrigated lands
ARC (Institute of Agricultural Engineering)
No. 2026

The extent and severity of drainage problems on irrigation schemes in South Africa is clear from the fact that an estimated 242 000 ha is affected by rising water tables and salinisation. These problems appear to be expanding and indications are also that costs of drainage have increased quite significantly. Apart from isolated projects which were undertaken for specific reasons, no comprehensive research on drainage has been done in South Africa over the past 25 years. Existing norms and standards have been adjusted over the years by means of ad hoc studies. There is evidently a need to revise and publish up-to-date norms and standards. New ways of managing drainage should be introduced instead of having only a narrow focus on the presently-known solutions. Irrigation, surface run-off and sub-surface drainage are all related and need to be managed as a whole. It is essential to distinguish between requirements and standards for design, installation, operation and maintenance of drainage. The internationally available research results and modelling approaches will be assessed and evaluated for applicability in South Africa. The demand for design and installation of drainage in the field by far exceeds the available capacity. Timing is critical because only a very small group of experts is still active in the field and there is an urgent need to train new practitioners. This report will form the basis for training at tertiary level and for providing guidance to practitioners. The research output will form the basis of informing public policy formulation and strategies for implementing drainage systems on irrigation schemes.

Estimated cost: R4 000 000
Expected term: 2010 - 2015

Programme 2: Impact assessment and environmental management of agricultural production

Improving the livestock carrying capacity with rainwater harvesting and conservation on grasslands for extensive and/or intensive livestock production and biogas generation from manure in rural areas of South Africa
University of KwaZulu-Natal (Department of Grassland Science)
No. 1955

The majority of households in communal areas are dependent on resources from the local woodlands, grasslands and livestock production. Livestock are a potential asset to rural households because of the opportunities presented for participation in the rural economy. It has been shown that households are eager to keep livestock for the multiple benefits they provide, rather than for exclusively social status. One potential benefit is livestock as a source of manure for biogas production. Biogas technology, in its simplest form, involves the use of digesters that are vessels in which animal waste and other biodegradables are broken down (digested) by bacteria in the absence of oxygen. In particular livestock manure must be collected, transported and stored for the biogas digester. Therefore it is important to consider how livestock will be managed with reference to rotational grazing on the commons, keeping livestock in a kraal overnight near the village and utilising manure from the kraal for biogas digesters at household or village scale. These household or village scale biogas digesters require access to water, therefore rainwater harvesting tanks will need to be constructed. Biogas generation as an energy source for cooking, heating, cooling and lighting can play an important role in improving the quality of life for rural households. It is a single intervention that directly addresses energy insecurity, and indirectly through liquid fertiliser also food security, at the household garden level and thereby reduces vulnerability of the poor. By linking biogas generation to manure management and rainwater harvesting, this research report will make an innovative contribution and fill a major knowledge gap.

Estimated cost: R5 000 000
Expected term: 2010 - 2015

Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health
CSIR (Natural Resources and the Environment)
No. 1956

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these

studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825
Expected term: 2010 - 2015

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THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION
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THRUST 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE
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THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE
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KSA 5: Water-Centred Knowledge

Dr Heidi Snyman:
Director

SCOPE

KSA 5 addresses the management of water-centred knowledge (created via the support of the WRC as well as other sources) and leads the effective dissemination thereof.

The scope of this KSA includes:

- Supporting knowledge creation by providing appropriate research management tools and logistic support
- Sharing and disseminating water-centred knowledge internally and externally
- Enhancing the credibility and relevance of the WRC through strategic positioning and strengthening stakeholder relations
- Providing strategic research advice

THRUSTS

The overall scope is further expanded in a number of thrusts which form the general framework of this KSA:

THRUST 1: SUPPORT KNOWLEDGE CREATION – RESEARCH MANAGEMENT AND LOGISTIC SUPPORT

Aim: To coordinate the research funding cycle and provide effective tools, systems and procedures to support knowledge creation in the WRC and provide a better internal and external interface with the research community.

This KSA provides support to the 'engine room' of the WRC, i.e. the four key strategic areas mandated to coordinate and fund water research. It supports the management of research projects, enhances innovation and provides the tools and processes for protecting technological developments. It also links the financial processes with the technical fund management processes. This includes:

- Research management
  - Coordinate the annual funding cycle
  - Providing the logistics required for the flow of research related information into and out of the WRC
  - Increasing the user-friendliness of the WRC Fund Management System (FMS) for both external and internal users
  - Advancing the linkage between financial and technical management of research projects
  - Providing support to the research KSAs 1-4 with regard to proposal cycle and project management on FMS
  - Provide legal advice for contract management
  - Advance research management by developing interactive discussion forums
- Intellectual property management
  - Manage technology transfer and commercialisation
  - Manage the WRC patent portfolio and contracts related to licensing and commercialisation, benefit sharing and technology transfer
  - Provide support to strengthen the ability of academic institutions to manage their intellectual property
- Printing and distribution
  - Manage the quality-control process of WRC technical and technology transfer final reports
  - Manage the process of layout and printing of the WRC reports and other publications
  - Manage the effective distribution of research reports
  - Manage effective report distribution facilities (manual and electronic)

THRUST 2: KNOWLEDGE SHARING AND DISSEMINATION (INTERNAL AND EXTERNAL)

Aim: To effectively share and disseminate relevant knowledge in the water sector and within the WRC and to develop knowledge-sharing mechanisms/instruments to support the objectives of the WRC.

This KSA leads the participation of the WRC in knowledge-sharing and knowledge-dissemination activities (e.g. workshops, exhibitions) organised by the WRC, as well as by other organisations within the sector – locally, in the rest of Africa and globally. It strengthens the WRC's ability to exchange information and data on developments around water management issues. It also oversees the flow of water-centred knowledge to and from the WRC by improving access to external information and water-centred knowledge, and acting as a resource centre to meet the information requirements of the WRC and the water sector in general. This includes:

- Knowledge packaging
  - Develop and maintain innovative ways to share and disseminate WRC products, e.g. brochures, project briefing notes, Knowledge Review, media briefings
  - Support KSAs 1-4 with the production of Technology Transfer documents
- Promote the public understanding of science
  - Produce and publish *The Water Wheel*
  - Produce and publish special publications such as books and learning material
  - Support water-related youth and learner awareness programmes
- Ensure that scientific knowledge is globally recognised and exchanged
  - Manage the production and publication of *Water SA*
- Knowledge sharing (External)
  - Prepare media briefings, media conferences and press-club networking events in order to create and sustain an awareness and appreciation among the media of the WRC's position of leadership within the water sector (the media should automatically recognise the WRC as the main source of information on any water-related issue)
  - Develop and maintain the Electronic Water Knowledge Hub for easy access to all WRC publications and resources
  - Develop mechanisms for effective knowledge sharing and information transfer
  - Developing and implementing technology-transfer instruments
  - Exhibit at high-profile, water-centred conferences nationally and, if necessary, internationally
- Knowledge sharing (Internal)
  - Manage the WRC internal library
  - Organise knowledge-sharing events such as internal open days, guest lectures and regular research manager's meetings
- Enhance the effectiveness of knowledge dissemination
  - Create and apply new knowledge dissemination mechanisms
  - Maintain an effective interface between service providers and the WRC, and between users of WRC knowledge products and the WRC

THRUST 3: STRATEGIC POSITIONING AND STAKEHOLDER RELATIONS

Aim: To enhance the credibility and relevance of the WRC locally and globally.

This KSA supports the WRC in developing and maintaining strong stakeholder relationships to enhance the credibility and relevance of the WRC. This KSA supports the organisation in formalising relationships and maintaining relationships that are not KSA-specific. This includes:

- Establish working relationships with industry, decision makers and key stakeholders
  - Strengthen relationships through formal memoranda of understanding
  - Provide knowledge in a format that is fit-for-use
  - Deliver multimedia presentations to inform various target groups about the WRC and its accomplishments
- Establish and strengthen the relationship with a number of Parliamentary portfolio committees
  - Establish and maintain relationships with the planning commission and the Parliamentary portfolio committees of various departments including Water and Environmental Affairs, Health, Science and Technology, Agriculture, Cooperative Governance and Traditional Affairs, Human Settlements
  - Provide interactive information sessions to the portfolio committees and respond to their knowledge requirements
- Support national, African and global initiatives
  - Support national initiatives of key importance to the water and other related sectors where the WRC plays a significant role
  - Support other KSA initiatives through providing support related to exhibitions, media briefings, events management, etc.
  - Support African initiatives for building water science and technology in the continent (example: NEPAD's initiative to establish a network of centres of excellence in Water Science and Technology in five regions in Africa)
  - Establish and maintain bilateral relationships
  - Support global initiatives and partnerships through, for example:
- Linking to international associations such as the International Water Association, World Water Forum, etc.

- Linking with the global research community through *Water SA*
- Prepare positioning material such as the WRC Annual Report, strategic messages, Ministerial and policy briefs
- Support the research community
  - Develop and implement mechanisms to recognise the research community
  - Improve the relationship and interaction with the research community (beyond the project)
- Promote the WRC at carefully selected opportunities
  - Contribute and/or advertise in selected media or periodicals (e.g. National Agricultural Directory, Local Government Handbook, WISA Directory) to coincide with events of special significance for water, e.g. Water Week, a water conservation campaign, etc.
  - Engage with the youth through science festivals, games and competitions to serve the dual purpose of positioning the WRC and stimulating interest in water-centred science, engineering and technology

THRUST 4: RESEARCH ADVICE

Aim: To provide strategic research advice related to the water sector, capacity, knowledge flow and ultimate impact.

The WRC is mandated to lead and co-ordinate water research in South Africa. It is also tasked to promote effective knowledge transfer and enhance knowledge and capacity in the sector. It is therefore important that the WRC understands all the elements driving the water knowledge cycle in South Africa.

This KSA focuses on researching various elements, drivers and trends affecting the dynamics of the water-centred knowledge cycle, from issues related to research capacity and overall funding of research by the sector to the effectiveness of research and its impact on policy and technology used by the sector. In the long-term this functional area may also provide the advice regarding sector needs and global trends, i.e., foresight and scenario studies.

Examples of research/studies to be carried out under the leadership of this functional area are:

- Assessment of the scope and extent of water research done in South Africa (funding, content, value as a role player and extent of global cooperation)
- Analysis of research capacity, demographics, current and future needs
- Impact of research, including methodology for impact assessments
- Long-term scenario building
- Assessing knowledge uptake and dissemination and establishing new effective mechanisms

CORE STRATEGY

Strategic context

The strategic context of the **Water-Centred Knowledge** Key Strategic Area (KSA 5) should be seen in the context of the WRC strategy as documented in the Strategic Plan 20010/11 – 2012/13. The WRC research portfolio addresses the full water cycle through the four research key strategic areas and links this to the knowledge cycle with the support from KSA 5.

Considering the sector trends both nationally and internationally, the role of KSA 5 is becoming increasingly strategic.

Sector threats

The South African water sector faces serious challenges that threaten its sustainability. The dominant risks, threats and challenges to the country being able to sustainably supply water to meet growth and development needs into the future include water availability, climate change, infrastructure, human resources, compliance and enforcement, raw water quality, financial support and water pricing (Water for Growth and Development Framework, Version 7). Threats in terms of a knowledgeable, productive water sector include the:

- Human resource capacity in the public sector – often qualified but less experienced people need to acquire a level of competence in a short period of time without the luxury of continuous mentorship
- Functioning and pursuing targets in a resource constraint environment
- Working in a complex and multidisciplinary sector and often across institutions and across disciplines
- Limited research capacity in certain of the water-related research areas and reduced ability to deliver – this will cause a medium- to long-term shortage of knowledge in these areas with knock-on effects on the quality of decisions made
- Shortage of South African students studying towards a higher degree in water knowledge – a balance is required between the need to continue research (creating knowledge) to ensure a sustainable water sector and the need to build capacity to export to other African states
- The lack of knowledge uptake in the sector

Relevance and impact

The perceived relevance of the WRC in the short term is to a degree dependent on the absorptive capacity for the knowledge in the sector. The WRC, through this KSA, needs to place more emphasis on understanding and enabling

knowledge uptake rather than focusing purely on knowledge dissemination.

Van Ryneveld and Sproule (2007) defined knowledge uptake as 'the active acquisition of disseminated information, the comprehension of the information and the ability of practitioners to apply the information in the field'.

While the WRC continues to generate water-related knowledge-based products which contribute to addressing the knowledge gaps in the water sector, it also seeks to better understand the mechanisms of knowledge uptake.

The role of KSA 5 is therefore becoming increasingly important for the continued relevance of the WRC and for the sustainability of the sector. The emphasis will now also move to understanding, developing and applying methodology to ensure that the water-related knowledge generated by the WRC is absorbed and applied to solve the water challenges that South Africa experiences. KSA 5 therefore aims to lead the knowledge dissemination programmes with an understanding of what the knowledge uptake drivers are. It also strives to influence the research KSAs to encourage knowledge sharing early in the research projects.

This KSA will also continue to support the organisation with knowledge creation and sharing through:

- Supporting research management and providing logistic support
- Developing effective internal and external knowledge sharing and dissemination mechanisms/instruments
- Enhancing the credibility and relevance of the WRC locally, in the rest of the African continent and globally

Key stakeholders

Internal stakeholders - Research managers and staff of the WRC

The needs of these stakeholders have been identified as having an effective management system for research funds, easy access to resources, an electronic document management system, and a dynamic interface with the local and global water sector.

External stakeholders

The KSA loosely defines its external stakeholders as knowledge creators and knowledge users (with an understanding that the same individual could dynamically move between being a knowledge user and a knowledge creator). Knowledge creators are typically researchers, students and consultants while knowledge users include the same group as well as govern¬ment, educators, service providers, decision-makers, policy-makers, farmers, the media and community-based organisations in the water sector. This wide group of stakeholders requires the knowledge provided to be relevant and accessible to them.

Other stakeholders

This group includes local knowledge partners such as DWA, WIN-SA, WISA and SAICE. These organisations require water-centred knowledge, and the WRC can improve its knowledge dissemination by creating appropriate links with them, thus making water-related documents, data and knowledge more accessible to internal and external users. This group also includes continental and global stakeholders that work in collaboration with the WRC and in some cases formal agreements exist. Examples include:

- Water Research Foundation (WRF)
- IRD, CIRAD and CNRS (France)
- Department of Science and Technology (DST) bilateral co-operation programmes
- NEPAD Office of Science and Technology

Public

South Africa cannot progress to sustainable water resource management without the co-operation of the public, and the latter cannot co-operate unless they have sufficient knowledge and are able to contribute meaningfully. For this reason, the WRC contributes to enhancing the public understanding of science and contributes to youth education.

STRATEGIC INITIATIVES

National initiatives

- *WISA 2010*: KSA 5 participated in the biennial conference and exhibition of the Water Institute of Southern Africa themed: '2010 – A time to reflect'. The WRC exhibition stand which combined the traditional report distribution with electronic searchers for material was well received. Training and demonstration of the WRC's fund management system was also available at the exhibition stand.
- NRF Akili Complexity and Integration Programme: The WRC supports the NRF Akili Complexity and Integration Programme within the Human and Social Dynamics in Development Grand Challenge initiative to strengthen knowledge flow in the sector. This conceptual model suggests that through time research can build towards and include transdisciplinary research. Research that takes account of various research outcomes, including complexity and integration, acknowledges complex adaptive social-ecological systems, and therefore traverses scale and sector and will contribute to research

outcomes that have a greater chance of meeting societal needs.
- IWA SA/WISA strategic relationship: The Executive Committee of IWA SA and WISA met on 22 June 2010 to discuss the future of the strategic relationship between WISA and the IWA SA. It was decided in the interest of the South African water sector that IWA-SA and WISA explore ways of incorporating the IWA Executive Committee as part of WISA governance, structure and activities. This approach will facilitate a global conduit for WISA and its numbers, whilst improving coordination of IWA-SA activities for the benefit of all South African members of IWA and WISA.
- Supporting KSA2 in the Adopt-a-River programme.
- The WRC supports the development of the Research Information Management System (RIMS) developed by the DST which has the potential to deliver auditable information on publications and intellectual property emanating from WRC-funded research from publicly-funded research institutions (Universities and Science Councils). The WRC is currently working with the DST and the development team to ensure that the WRC is a potential output user.
- Supporting the DWA in the development of the National Water Resource Strategy: The WRC is assisting the DWA in the development of the 2nd edition of the National Water Resource Strategy (NWRS-2), in particular the sections that deal with 'Monitoring and Information' as well as 'Knowledge Research'.
- Water research landscape of South Africa: DWA is currently reviewing all water-related Acts including the Water Research Act (Act No. 34 of 1971) as well as undertaking an institutional re-alignment to rationalise the number of entities reporting to the Minister of Water and Environmental Affairs. A high-level delegation from the Department visited the WRC on 3 March 2011 to inform the WRC of progress to date and to plan for a broader workshop held in association with the Department of Science and Technology. Three WRC directors as well as a research manager (KSA 1) participated in a workshop entitled: 'Re-defining water research landscape of South Africa' held at the CSIR Convention Centre on 10 March 2011.

Strategic positioning

Meeting with the Parliamentary portfolio committees related to water

It is of strategic importance to form a dynamic relationship with the Parliamentary portfolio committees related to water. This KSA therefore supported the WRC with specifically targeted interactions to strengthen the strategic relationship. Some interactions for 2010/11 included:

- The WRC CEO, a director and knowledge dissemination officer attended the Budget Vote Speech by the Minister of Water and Environmental Affairs on 15 April 2010.
- A WRC research manager and knowledge dissemination officer attended the Budget Vote Speech by the Minister of Science and Technology on 22 April 2010.
- Two WRC research managers briefed the members of the Portfolio Committee on Water and Environmental Affairs on acid mine drainage in South Africa, together with the Department of Water Affairs, and the Federation for a Sustainable Environment. A briefing session was held on 21 July 2010 in the offices of the Department of Water Affairs in Cape Town.
- On 21 June 2010 the WRC knowledge dissemination officer met with the content advisor for the Portfolio Committee on Rural Development and Land Reform and discussed collaboration between the WRC and the committee.
- A WRC researcher briefed the members of Portfolio Committee on Water and Environmental Affairs on eutrophication linked to the *Harties Metsi a me* Remediation Project, together with the Department of Water Affairs.
- Members of the WRC were invited to Parliament on 15 February 2011 to brief the Portfolio Committee on Water and Environmental Affairs about the WRC's involvement in solving the country's water-related problems and also to state the challenges the Commission faces.
- Members of the made inputs to the Green Paper on Climate Change in Parliament, Cape Town, on 3 March 2011.
- A WRC research manager and the CEO were invited by the National Planning Commission (NPC) to a meeting held on 15 March 2011 at the Union Buildings in Pretoria, on 'How to transition to a low carbon, climate resilient economy'. The session forms part of a series of working sessions which the NPC will use to crystallise ideas and make recommendations for inclusion as proposals in the National Development Plan.

Links with knowledge-dissemination organisations and knowledge sharing

- Bilateral agreement with Eskom: Recognising the strategic link between sustainable water management and energy generation, the WRC and Eskom have agreed to enter into a strategic research partnership through a Memorandum of Agreement and the formation of a Joint Research Committee. Through this partnership, Eskom and the WRC will jointly fund and undertake research on topics of mutual and strategic interest, covering climate change, water resource availability and accessibility, water quality, operation and maintenance, water conservation and water demand management, technology development and appropriate technology, excess water and acid mine drainage, residue management (ash, brine

and sludge management), ecosystems and remediation and groundwater impact as well as vulnerability and remediation.
- Bilateral agreement with SASOL: The WRC and Sasol are in advanced stages of negotiating an agreement to establish a strategic partnership to encourage cooperation and partnership in research and development for mutual benefit in line with the respective party's mandates. Ten WRC staff members visited the Sasol Research Laboratories in Secunda on 4 February 2011. The purpose of the visit was to familiarise WRC technical staff with the Sasol research laboratories and pilot plants and identify opportunities for collaborative research projects. It was agreed that the Sasol and WRC will not wait for the signing of the Memorandum of Agreement (although this should be given priority) to start collaborating on projects. In the interim, the parties will identify possible collaborative projects and Sasol agreed that they would consider making the research facilities available to researchers on a case by case bases.

Stakeholder survey and communication strategy

During the year under review the WRC developed a communication strategy that includes specific strategic objectives for enhancing uptake of knowledge created via WRC-funded projects, and which included a plan of action for the next three years. The communication strategy was informed by a detailed stakeholder survey as well as other strategic feedback and information (e.g. the WRC scenario studies). The survey was facilitated by an external party and included 462 individuals from central and local government, water institutions, industry, the farming community, the research community, NGOs and the media. The objective of the survey was to determine how effectively the WRC fulfils its role and achieves its vision and mission. It explored the nature and strength of relationship of stakeholders with the WRC and obtained perceptions about the WRC's image, structure, people, processes and output, as well as reasons for these perceptions. The survey found an overwhelming positive response to the WRC with direct correlation between familiarity (exposure) of each stakeholder grouping with the WRC and its perceptions about the WRC. Stakeholders indicated that the WRC:

- "Is a necessary organisation to ensure SA has enough quality water now and in future"
- "Makes a difference to the quality of life or ordinary South Africans"
- "Is globally recognised as a leader in water research"

40th Birthday celebration publication

The text for the celebratory book *Celebrating 40 years of Research Excellence in the Water Sector* was completed. The book focuses on the impact of the WRC over the last 40 years, in particular the nexus between water and society, health, economy and the environment. It also focuses on highlights such as the impact of the WRC research on membrane technology, climate change, weather modification and capacity building.

African leadership

- Establishing the NEPAD Network of Centres of Excellence in Water Science and Technology:
  - *Southern African Network*: The WRC continues to support the NEPAD programme on the African Network of Centres of Excellence in Water Science and Technology. A WRC Director assisted in two workshops of the founding members of the Southern Africa Network of Centres of Excellence in Water Science and Technology aimed at developing the business plan for the region. The WRC has been tasked to assist the NEPAD Office of Science and Technology (OST) to expand the Southern African Network to include more Southern African countries as the South African involvement is currently disproportionally high.
  - *West African Network*: A member of the IRD and a WRC director visited the National Water Resources Institute in Kaduna and the University of Benin, Benin City, Nigeria, from 30 May to 5 June 2010 to evaluate these institutions for their suitability for inclusion into the West African network. Both institutions qualified which means that there is sufficient critical mass to establish the West African regional network. The Université Cheikh Anta Diop's Department of 'Qualité et Usages de l'Eau' was formally designated as the NEPAD Agency's Coordinating Hub on Water Science for West Africa, thus formally establishing the West African Network of Centres of Excellence in Water Science and Technology.
- Assisting KSA 1 with UNEP – Sudan initiative: The WRC entered into an agreement with United Nations Environmental Programme (UNEP), Sudan, to host a delegation from Darfur for a period of two weeks, 16 – 31 May 2010. The technical delegation of water professionals engaged in a technical tour around South Africa aimed as sharing South African research knowledge on water issues which are similar to Darfur conditions. The tour also aimed at fostering working relationships with Darfur within the context of NEPAD and for the purpose of sharing capacity in water research in the continent. KSA 5 also assisted KSA 1 in hosting a parliamentary delegation from Sudan during the period 31 October 2010 - 7 November 2010. This delegation consisted of senior decision-makers in the Sudanese government and associated organisations, including Federal Ministers and Directors-General mainly from the Darfur states.
- European Union Water Initiative (EUWI) Africa Working Group: The KSA 5 director was invited to participate in and deliver a presentation at the European Union Water

Initiative Africa Working Group Meeting held in Cape Town on 26 July 2010. The EUWI form strategic partnerships in specific regions to draw together government, civil society, private sector and other stakeholders.

- Supporting the United Cities and Local Governments of Africa (UCLGA): 'Local initiatives in promotion of the attainment of water and sanitation millennium development goals' is a project of the United Cities and Local Governments of Africa (UCLGA) in partnership with ICLEI – Local Governments for Sustainability Africa Secretariat supported by the European Union. Focal Point (in-country) representatives in 15 African countries have been identified by national associations of local government to participate in this a flagship project of the UCLGA. The WRC hosted the delegation participating in UCLGA Focal Point Network Working session (15-19 August 2010) on 17 August 2010 as part of their technical programme. Representatives from national associations of local government in Benin, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Malawi, Mali, Namibia, South Africa, Uganda, Zambia and Zimbabwe, attended the information session on the WRC.
- Supporting the 3rd Africa Water Week, Addis Ababa: The WRC (KSA 5 Director) assisted in the development of the technical programme for a session entitled 'Institution building and capacity development for implementing the 'African Water Vision 2025: Science institutions and capacity building for managing Africa's water resources' at the 3rd Africa Water Week held in Addis Ababa from 21-26 November 2010. The KSA 5 director presented a paper on: 'Establishing and sustaining the NEPAD Network of Centres of Excellence for Water Science and Technologies in Africa' and represented the WRC at this event.

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. Specific initiatives undertaken during the year under review included:

- World Water Week in Stockholm: A WRC Director attended the *2010 World Water Week* in Stockholm, Sweden, 5-11 September 2010 and delivered an oral presentation entitled: 'Minimising land use based water pollution through sustainable wastewater sludge management practices – South African Case Study' within Workshop 6: 'Minimising land use based pollution'.
- *IWA World Conference and Exhibition* in Montreal, Canada: The KSA 5 Director gave an oral presentation entitled: 'Commercialisation of a product for water supply in small communities – Africa' in the workshop programme entitled: 'Accelerating innovation in the water sector: Social entrepreneurs driving innovation' at the *IWA World Conference and Exhibition* held in Montreal, Canada, 19-24 September 2010. The KSA 5 director also chaired the Specialist Group on Sludge Management Meeting on 21 September 2010.
- Hosting of a Chinese delegation: A Chinese delegation visited the WRC on 16 September 2010. The main objective was to establish partnerships with water colleagues in South Africa in order to understand the region's water research and development better; to learn more about the advanced construction of water infrastructure in South Africa and to promote communication and cooperation between South Africa and China on water resources.
- UN *World Water Day 2011* and *National Water Week* 20-25 March 2011: The WRC supported the UN *World Water Day* on 22 March 2011 by exhibiting at the event held at the International Convention Centre, Cape Town. The event was a joint collaboration of UN-Water, the African Minister's Council on Water (AMCOW), the United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB) and the United Nations Human Settlements Programme (UN-HABIT). *World Water Day* is held annually to highlight the importance of freshwater and the sustainable management of freshwater resources.
- KSA 3, KSA 5 and KSA 2 worked together in planning the parallel sessions for the *National Water Week* held on 20 March under the themes 'Fixing the leaks in urban areas –The South African experience' and 'Ecosystems as a natural capital and water infrastructure for developing countries'.

Improved commercialisation of intellectual property

New patent applications

The following two new patent applications were filed. Neither of these has been granted and both are still being prosecuted.

- **Remote data collector:** In particular, this invention aims to address the requirement to install a remote data logger in a location where data is to be collected, logged and intermittently retrieved. The invention includes a data recorder and a monitoring system. A South African patent application for this invention was filed on 22 July 2010.
- **Membrane bioreactor:** This invention relates to an immersed membrane bioreactor, and to a method for treating water. Existing membrane bioreactors have the disadvantage that they are damaged when dried, due to a change in the polymers from which they are manufactured. The membranes are also subject to damage when not handled carefully, i.e. by scouring or scratching. Existing membranes also require periodical chemi-

cal cleaning. This invention aims to address some of these shortcomings. A South African patent application for this invention was filed on 25 June 2010.

Alignment with the IPR Act

The Intellectual Property Rights from Publicly Financed Research and Development Act (No. 51 of 2008) (IPR Act) was passed to meet the growing need to effectively protect and commercialise intellectual property (IP) emanating from publicly-funded research. The WRC implemented interim guiding principles with regard to the WRC's position on intellectual property management in the period leading up to 2 August 2010, when the IPR Regulations became effective. The Regulations clearly articulate the processes which publicly-financed institutions should adhere to when dealing with the protection, management and commercialisation of intellectual property generated by such institutions. In particular, the regulations clearly emphasise the need to obtain statutory protection and ownership of intellectual property by publicly-financed institutions. In this regard, a WRC Intellectual Property Management Policy was developed, which was approved by the Board.

GROWING THE KNOWLEDGE BASE

Capacity-building initiatives

Strategic meetings with capacity building organisations

As the main funder of water research in the country, the WRC's relationship with the water research community is crucial for its effective operation. During 2010/11 the WRC put emphasis on meeting with as many universities as possible, to discuss their challenges and their current and future contributions to water research. The WRC representatives visited research organisations in the country and had informal discussions with the research directors/deputy vice-chancellors for research and senior researchers. Meetings were held with:

- Tshwane University of Technology (14 July 2010)
- Cape Peninsula University of Technology (21 July 2010)
- University of the Western Cape (21 July 2010)
- University of Stellenbosch (22 July 2010)
- University of Cape Town (22 July 2010)
- University of KwaZulu-Natal (23 August 2010)
- Durban University of Technology (23 August 2010)
- Mangosuthu University of Technology (25 August 2010)
- University of Zululand (25 August 2010)
- University of Pretoria (20 October 2010)
- Rhodes University (21 October 2010)
- University of Fort Hare (22 October 2010)
- North-West University (25 October 2010)

Student database

The FMS module for capturing student demographics was used for the year under review. Student name, gender, race, qualification, institution and country of origin were entered directly by the project leader or by the WRC coordinator in cases where the project leader submitted a report outside the FMS system. Of the 520 students supported by WRC-funded projects in 2010/11, 311 or 60% were from disadvantaged backgrounds. Of these historically disadvantaged students, the majority, 261, were Black, and 50 were Indian or Coloured. About 2% of the total number of students originated from countries outside the African continent. Of the total number of students 58% were males and 42% were females. The bulk of the students were working towards Masters or PhD degrees.

Regional WRC 101 courses

The WRC developed an informative one-day course/workshop for aspiring and new project leaders to understand the WRC research cycle, the research priorities of the WRC and the fund allocation for each of the priorities, and the process of preparing a comprehensive proposal. Tips were provided to improve the chances of proposal success, to manage the technical, administrative and financial aspects of a WRC project, understand the contractual and financial audit requirements and about the resources available to enhance the success of the project. Three regional courses were held in the year under review: Gauteng (3 May 2010), Western Cape (14 June 2010) and KwaZulu-Natal (21 June 2010).

Knowledge dissemination

Knowledge sharing events

- Weather Modification Workshop – supporting KSA 1: KSA 5 supported KSA 1 with all the logistical arrangements for the workshop entitled 'Possible resumption of weather modification research and implementation in SA' held on the 3 May 2010, Pretoria. Approximately 20 delegates attended.
- Celebration of International *Year of Biodiversity*: KSA 2 and KSA 5 jointly organised the seminar at Tswaing Crater on 17 September 2010 in celebration of the *International Year of Biodiversity*, which was co-hosted by the WRC, South African National Biodiversity Institute (SANBI), Ditsong Museums and the Departments of Water and Environmental Affairs.
- Media breakfasts: The WRC hosts workshops for the media specifically to inform and improve their knowledge on selected topics. The aim is to improve the quality of journalism related to water issues and to make the media aware of the WRC knowledge resources. KSA 5 and KSA 3, in association with the DWA, hosted

a Media Breakfast on 7 October 2010 under the theme 'Drinking water quality' held at Willow Park, Kempton Park. A media article entitled 'incentives for clean water supply, SA are the first country to have incentive-based regulation for municipal water treatment, to encourage accountability and transparency' emanated from this event.
- The WRC held a media breakfast on 22 March 2011 at the WRC offices in an effort to educate the media on groundwater and the latest water availability studies.
- Internal Open Day: WRC staff members visited the waste treatment works and laboratories of the East Rand Water Care Company (ERWAT) on 7 July 2010. Prior to the visit; the WRC staff were given a presentation by the KSA5 Director on how wastewater treatment plants operate. ERWAT is a commercial wastewater management company which provides bulk wastewater conveyance and wastewater treatment services for 2000 industries and more than 3.5 million people who have access to sanitation services. The WRC staff also visited the laboratories, which provide the water industry with a wide variety of services in the fields of chemical and microbiological analysis, as well as expert advice on water-related problems.

Exhibitions

Exhibitions in which the WRC participated included:

- The Budget Vote, 15 April 2010, Cape Town
- *WISA 2010*, 18-22 April 2010, Durban
- Western Cape Provincial Government *Drought Indaba*, 24-25 May 2010, George
- *South African Women in Engineering*, 22 July 2010, Cape Town
- *AGRI SA Water Conference*, 11 August 2010, Kempton Park
- *International Society of Limnology (SIL) Conference*, 15-20 August 2010, Cape Town
- *WASTECON Conference 2010*, 4-8 October 2010, Kempton Park
- *Water and Poverty Alleviation - A Dialogue for Action*, 11-13 October 2010, Durban
- *IMESA Conference*, 27-29 October 2010, East London
- *Local Climate Solutions for Africa 2011, ICLEI Congress,* 27 February - 3 March 2011, Cape Town
- *UN World Water Day 2011*, 20-22 March 2011, Cape Town

Enhancing access to WRC publications

- The KSA continues to advertise and disseminate WRC publications at exhibitions, through press releases, the 'New from the WRC' feature in *The Water Wheel* and through publishing 'briefs'. The WRC is also continuing with the update and development of a series of brochures advertising relevant research reports related to specific topics. The following brochures were developed/updated and published during the 2010/11 financial year: sanitation, water and health, groundwater and climate change.
- The latest research reports are now advertised in the WISA and WIN-SA newsletters.
- The redesign of *The Water Wheel* magazine was completed with the first 'new-look' issue published in May 2010. This issue was very well received by readers.
- The WRC developed an advertorial titled 'Liquid Gold' which was published in the March issue of *Sawubona* magazine, with the aim of targeting key international and local water sector travellers, and to coincide with *World Water Day* and South Africa's *National Water Week*.
- All research reports (> 1500) in the WRC Electronic knowledge hub have been tagged with unique categories and keywords, allowing users of the website to search either through a search function or to obtain lists of research reports on specific subject matter.
- Seven thousand (7 000) copies of the DVD entitled *Water is Life, a South African Journey,* developed by KSA 1, were included in the January/February 2011 edition of *The Water Wheel*.
- An A3 size brochure of the research portfolio of each of the KSAs, showing new, ongoing and finalised projects as well as recently published reports, was developed and submitted to the Chairperson of the Parliamentary Portfolio Committee on Water and Environment. The same documents were distributed internally.

Briefs

This knowledge tool attempts to communicate, in a clear and brief format, the outcome of various research studies to the water sector, with special emphasis on non-technical professionals, policy and decision makers. Another 31 briefs were produced during the year under review (the number in brackets refers to the report number):

Technical briefs:

- Water use of indigenous tree species (1567/1/08)
- Assessing the impact of research into rainwater harvesting (TT 444/08)
- The basement aquifers of Southern Africa (TT 428/09)
- Incorporating community-based procurement in the operation and maintenance of basic services (1714/1/09)
- Technology in strategic asset management: Existing and future needs (1785/1/09)
- Refining tools for evaporation monitoring (1567/1/08)
- Acceptance of membrane technology among rural consumers (1529/1/09)
- Water quality and cage aquaculture (1461/1/08)
- WR 2005 study (TT380-382/08)
- Impact of introducing zero-phosphate detergents (TT446/10)

- Water use of biofuel crops (1772/1/09)
- Licensing of streamflow reduction activities (1428/1/09)
- Conceptualising groundwater flow and storage within the TMG Aquifer (1419/1/09)
- Standards for municipal invoices (1664/1/09)
- Eutrophication research impact study (TT 461/10)
- Reticulated sewerage infrastructure (1671/1/08)
- Guidelines and training aids for small water treatment plants (1559/1/09)
- EDCs in drinking water – protecting human health (1749/1/09)
- Evaluating passive mine-water treatment (16231/1/10)

Policy briefs:

- Assessing the impact of research into rainwater harvesting (TT 444/08)
- Technology in strategic asset management: Existing and future needs (1785/1/09)
- Eutrophication research impact study (TT 461/10)
- Standards for municipal invoices (1664/1/09)
- Exploring the economic value of water in the Greater Letaba River catchment (989/1/08)
- SHAPE model for sustainable service delivery (1664/1/09)
- EDCs in drinking water – protecting human health (Report No: 1749/1/09)
- Wetland management in South Africa (KV 253/10)

Special policy briefs (not printed):

- Meeting the ecological Reserve in rivers of the Lowveld (K5/1711)
- Fish rehabilitation at Rondegat River (K8/922)
- Research on wetland management in SA (KV 235/10)

Ministerial brief:

- DDT for malaria control: Environmental and human health risk (1674/1/09)

Effective interaction with the media

- The WRC, in partnership with KZN Department of Agriculture, Environment and Rural Development, launched a campaign on 21 October 2010, on *Ukhozi* radio station, to inform communities about the existence of the WRC resource pack on 'Agricultural Homestead Gardening Systems'.

Examples of exposure in the print media included:

- An article entitled 'Water Research Commission calls for simplified municipal accounts' published in the May 2010 issue of the *SA Local Government Briefing* magazine, owned by the SA Local Government Research Centre.
- An article which appeared on 22 May 2010 in the *Business Times* entitled 'SA running on empty' quoted a WRC research manager on the issue of mine water drainage.
- An article on a WRC study on DDT entitled 'The devil you know, the devil you don't' was published in the CSIR quarterly publication *Science Scope* Vol. 3, November issue.
- Two WRC articles appeared in the Engineering News of 6 August 2010 – 'Water Administration System improves agricultural productivity' and 'Water saving may result in agricultural productivity'.
- In the *Sowetan* of 22 July 2010 a WRC article entitled 'Moving towards a moveable toilet structure' was published.
- The WRC was quoted in a *Business Report* article entitled 'State to act on phosphate detergents' published on 29 October 2010.
- *The Star* newspaper published an article entitled 'Eskom to probe climate change with the WRC' on 10 November 2010.
- The WRC and Eskom signing ceremony was publicised on various SABC and Primedia radio stations, e.g. *Radio Pretoria* and *Classic FM*, and also on the *e-News* television channel on 9 November 2010.
- *Business Day* published an article entitled 'Eskom explores water-power symbiosis' on 16 November 2010.
- The article entitled "Government strengthens Eskom's balance" was published by *Legalbrief* on 17 November 2010.
- The Minister of Water Affairs, Buyelwa Sonjica, quoted the Water Research Commission in the article 'Climate Change boosts invasive alien threat' when she responded to an interview by the *Sunday Times* on 8 October 2010.
- Two WRC research managers' comments were included in an article published by the *Sunday Times*, 28 November 2010, entitled 'Study outlines costly effect of decreased water quality'.
- The WRC project 'A quantitative investigation into the link between irrigation water quality and food safety' was quoted in the *Sunday Times*, 19 December 2010.
- A WRC research manager was involved in a television shoot for the SABC2 children's educational programme *Rivoningo Water Week*, flighted on 18 January 2011.
- The *Sunday Times* article entitled 'Acid water threat mounts', published on 22 January 2011, reported comments from WRC research managers.
- An article entitled 'New technology freezes acid mine water' which quoted a KSA 3 project was published in the *Business Day* on 1 February 2011.

Several WRC staff members also appeared in the media, for example:

- A WRC research manager was interviewed about the Wastewater Treatment Conference held in East London, on *Igagasi 99.5 FM*, on 24 November 2010.

- A WRC research manager together with the WISA CEO and DWA Regulations Director took part in a debate on the issue of wastewater treatment plants in South Africa on *SAfm's* 'After-8-Debate'.
- The KSA2 Director was interviewed on *SAfm's* 'Green Environment programme' about the Ramsar event held at Emperors Palace from November 30 to 3 December 2010.
- A WRC research manager was interviewed on the SABC radio stations *Lesedi FM* (Sotho), *Radio 2000* and *SAfm* about the WRC press release 'Risk factors associated with floods, the WRC warns', 26-27 January 2011.
- A WRC research manager was interviewed by *AgriTV* on 18 February 2011, in connection with the 'Wetlands Seminar' organised by the Agricultural Research Council's Institute for Soil, Climate and Water, together with the International Mire Conservation Group. The interview was flighted on 29 February 2011 on *SABC 2*.

Strategic press releases

The following press releases were made available on the website during the 2010/11 financial year:

- Groundwater use potential for South Africa (22 March 2011)
- What happens when a pit is full? (11 March 2011)
- SA's practical achievement for irrigation water savings receives international recognition (26 January 2011)
- Risk factors associated with floods, the WRC warns (25 January 2011)
- Moving towards the improvement of small wastewater treatment works (23 November 2010)
- Measures to control alien fishes in the Cape Floristic Region (16 November 2010)
- ESKOM and WRC enter into a strategic research partnership (3 November 2010)
- Urgent measures are needed to increase food security in rural households (27 October 2010)
- Good science supporting safe drinking water in South Africa (19 October 2010)
- Groundwater brings hope for SA's driest regions (23 September 2010)
- Our biodiversity is our heritage (17 September 2010)
- Thumbs up for *Water SA* (15 August 2010)
- Moving towards a moveable toilet structure (13 July 2010)
- University degree not enough to make sense of your municipal account (10 May 2010)
- Warning against DDT spraying (29 April 2010)
- Dual grey- and drinking water reticulation systems could save SA's high quality water (16 April 2010)

TABLE 1
WRC reports distributed to stakeholders in 2010/11

FWR	166
Institutes	4312
Municipalities	52
Private	9652
Schools	41
State Library	90
University/University of Technology	3798
WRC	273
WRC Board	6
TOTAL	**18390**

TABLE 2
Most popular reports distributed during 2010/11

Report no	Title	KSA	Total
TT 334/09	WET- Origins	2	359
TT 335/09	WET- Management Review	2	351
TT 336/09	WET- RehabPlan	2	345
TT 337/09	WET- Prioritise	2	318
TT 338/09	WET- Legal	2	370
TT 339/09	WET- EcoServices	2	368
TT 340/09	WET- Health	2	349
TT 341/09	WET- RehabMethods	2	349
TT 342/09	WET- RehabEvaluate	2	349
TT 343/09	WET- OutcomesEvaluate	2	349

CONTACT PERSONS

THRUST 1: SUPPORT KNOWLEDGE CREATION – RESEARCH MANAGEMENT AND LOGISTIC SUPPORT

FMS
Pieter Smit
E-mail: pieters@wrc.org.za
REPORTS
Patrick Kgoale
Hendrick Manaiwa
E-mail: orders@wrc.org.za
REPORT QUALITY CONTROL
Reg Sutton
E-mail: regs@wrc.org.za
IP MANAGEMENT
Lawrence Baloyi
E-mail: lawrenceb@wrc.org.za

THRUST 2: KNOWLEDGE SHARING AND DISSEMINATION (INTERNAL AND EXTERNAL)

KNOWLEDGE DISSEMINATION
Hlengiwe Cele
E-mail: hlengiwec@wrc.org.za
LAYOUT AND DESIGN
Drinie van Rensburg
E-mail: driniev@wrc.org.za
WATER SA
Tamsyn Sherwill
E-mail: watersa@wrc.org.za
THE WATER WHEEL
Lani van Vuuren
E-mail: laniv@wrc.org.za
SUBSCRIPTIONS
Mmatsie Masekwa
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Tel: +27 12 330 9009

THRUST 3: STRATEGIC POSITIONING AND STAKEHOLDER RELATIONS

PR EVENTS
Zagry Scholtz (PR events coordinator)
E-mail: zagrys@wrc.org.za

THRUST 4: RESEARCH ADVICE

Dr Heidi Snyman
E-mail: heidis@wrc.org.za

CATALOGUE OF AVAILABLE TT REPORTS

A gap analysis of water testing laboratories in South Africa

Faye Balfour, Hanlie Badenhorst and Debbie Trollip

There are a limited number of laboratories that undertake water quality testing in South Africa. More significantly, many of these laboratories have capacity limitations. These laboratories are a critical link in the value chain that ensures safe drinking water for consumers and unpolluted water in our water resources. Until recently there has been little focus on the quality control of the laboratories utilized in the testing of water. This has resulted in municipalities and the Department of Water Affairs (DWA) using both centres of excellence and those with little evidence of being able to produce reliable results. However, the most startling issue is that although the problem was acknowledged within the sector, it could not be quantified. How many laboratories are there? Where are they? What quality control measures do they have in place? Do they have suitably qualified staff? This WRC project has begun the process of quantifying these gaps in the sector. This project developed a database of existing laboratories that undertake water quality testing and, through a survey, obtained information on their capability and credibility. Nearly 200 laboratories were identified and 50% of these completed the survey.

TT 488/11
ISBN: 9781431201051
Overseas Price: $30.00

Cleaner Production: A Guidance Document for the Mining Industry in South Africa Sustainable Use of Greywater – Guidance Report

Susan Barclay, Graham Trusler, Harro von Blottnitz, Christopher Andrew Buckley, Bas Kothuis & Claire Janisch

This project introduced Cleaner Production (CP) technologies to the mining industry by using a number of CP tools. A scoping study identified distinct differences in how big and small companies improve their practices and consider environmental impacts. Company policy and the practices of their competitors drive awareness within larger companies, while legislation drives awareness in smaller companies. The fact that several existing water-related threats by and to the mining industry can be alleviated by CP technologies, presents opportunities to facilitate the introduction of CP approaches. Cleaner Production Forums were formed where coal and gold miners could share ideas, fight common battles and share success stories. Life Cycle Analysis studies were carried out to determine priority areas and acquaint industry with the technique. Throughout the project term a campaign was maintained to raise awareness of the benefits and need for adopting CP approaches. A CP guide was developed to assist mining companies with implementing CP programmes.

TT 485/11
ISBN: 978431200979
Overseas Price: $35.00

Nicola Rodda, Kirsty Carden and Neil Armitage

This project was undertaken to provide guidance regarding the conditions under which greywater use should be allowed or propagated and to provide guidance to users about its sustainable use in small-scale agriculture and gardens. Two main products were produced, viz a user friendly Guidance Document and a supporting Technical Background Document which captures the technical information on which the Guidance Document is based and describes the extensive process that was followed to develop the Guidance Document. The Guidance Document is aimed at Municipalities, NGOs and informed members of the public who wish to implement greywater irrigation. The focus of the Guidance Document is to minimise the risks of:

- illness in handlers of greywater and greywater-irrigated produce, or consumers of greywater-irrigated produce.
- reduction in growth or yield of plants/crops irrigated with greywater.
- environmental degradation, especially reduction in the ability of soil irrigated with greywater to support plant growth.

TT 469/11
ISBN: 9781431200917
Overseas Price: 30.00

Agricultural water use in homestead gardening systems

Christiaan Matthys Stimie, Marna de Lange, Charles Terrence Crosby and Erna Kruger

The overall objective of this project was to improve food security through homestead gardening, by developing and evaluating the appropriateness and acceptability of training material for agricultural water use, training of household members in selected areas. Particular attention was given to the development of the 800 page resource

material for facilitators and food gardeners on "Agricultural use in Agricultural water use in homestead gardening systems

TT 431/10
ISBN: 9781770059184
Overseas Price: $60.00

Christiaan Matthys Stimie, Marna de Lange, Charles Terrence Crosby and Erna Kruger

The overall objective of this project was to improve food security through homestead gardening, by developing and evaluating the appropriateness and acceptability of training material for agricultural water use, training the trainers and training of household members in selected areas. Particular attention was given to the development of the 800 page resource material for facilitators and food gardeners on "Agricultural Water Use in Homestead Gardening Systems". The development of the resource material followed a participatory approach and was field tested and refined with the assistance of food secure and insecure households in rural villages. The resource material succeeded in drawing widely from local and international materials and experience. Its usefulness in practice has been substantiated by facilitators who were not part of its development. It is anticipated that a variety of stakeholders will draw on this resource material to develop course material for their own purposes. A significant demand for the material exists from universities and agricultural colleges that are aware of the material. Best management practices for smallholder farming on two irrigation schemes.

TT 430/09
ISBN: 9781770059177
Overseas Price: 40.00

Manual for rural freshwater aquaculture

Qurban Rouhani, Niall, Nicholas James and John Case

In 2004, the Rural Fisheries Programme of the Department of Ichthyology and Fisheries Science, Rhodes University completed a project on behalf of the Water Research Commission (WRC) to assess the contributions of rural aquaculture to livelihoods. It became apparent that although the current contributions were low, the potential was significant. To exploit this potential, Project K5/1580//4 was targeted solicited by the WRC in 2005 and is co-funded by the Department of Agriculture, Forestry and Fisheries (DAFF). This project was formulated to address a number of issues, such as developing provincial aquaculture strategic plans, revitalizing state hatcheries, training of extension officers and the development of a manual to complement the training. An inclusive process to develop an aquaculture training manual for extension officers was followed. The provincial Departments of Agriculture made inputs on the content and structure of the manual and drafts were then sent to DAFF and other stakeholders for review and comments. It is envisaged that this manual will continue to be modified and reviewed as aquaculture in South Africa grows in order to reflect the needs of the extension officers over time. The manual is not only intended for the training of extension officers, but is also resource material to be used in the field when interacting with farmers.

The manual consists of 13 chapters with information and supportive illustrations on introduction to aquaculture; fish biology; aquaculture species; types of fish-farm: ponds, cages and tank systems; water quality; production and shipping; feeds and feeding; harvesting; fish health and diseases; fish husbandry; cage culture; increasing production; and business and financial planning.

TT 463/P/10
ISBN: 9781770059924
Overseas price: $28.00

Pearson Nyari Stephano Mnkeni; Cornelius Chiduza; Albert Thembinkosi Modi; Joseph Benjamin Stevens; Nomakaya Monde; Isobel van der Stoep and Richard Dladla

The project was a collaborative undertaking by five organisations namely: the Universities of Fort Hare, KwaZulu-Natal, Zululand (which withdrew in 2006), and Pretoria, as well as Zakhe Agricultural Training Institute. It was conducted in the form of two case studies based in Zanyokwe Irrigation Scheme (ZIS) which uses sprinkler irrigation and Tugela Ferry Irrigation Scheme (TFIS) which uses a short-furrow irrigation system. Its main objective was to carry out research in Zanyokwe and Tugela Ferry irrigation schemes with a view to develop and implement technologies and knowledge useful for farmers in order to improve their livelihoods and those of surrounding communities. Participatory research methodologies were employed where the smallholder farmers and other stakeholders were involved in project activities. Important agronomic and socio-economic (including organisational and institutional arrangements) constraints to crop production on the two schemes were identified and action was taken together with the farmers to address the problem. The need for training of extension staff in irrgation management in order to better support farmers was highlighted.

TT 478/10
ISBN: 9781431200498
Overseas Price: $40.00

Estuaries, Economics and Freshwater: An introduction

Duncan Hay, Stephen Hosking and Margaret Mckenzie

People are attracted to and value estuaries. They are much more than important ecosystems. They are also important social and economic systems – they play an important part in the lives of thousands of people living along our coast and inland.

TT 470/10
ISBN: 9781431200023
Overseas price: $15.00

Guidelines for improved efficiency of irrigation water use Volume 3

Felix Britz Reinders

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator; and
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

TT 467/10
ISBN: 9781431200245
Overseas price: $40.00

Guidelines for improved efficiency of irrigation water use Volume 2 of 3

Felix Britz Reinders

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator; and
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

TT 466/10
ISBN: 9781431200238
Overseas Price: $40.00

Guidelines for improved efficiency of irrigation water use Volume 1 of 3

Felix Britz Reinders

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator; and
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of "measure; assess; improve; evaluate". It promotes an investigative approach to improving efficiency, rather than relying only on water accounting.

TT 465/10
ISBN: 9781770050221
Overseas Price: $30.00

Process design manual for small wastewater works

David Joseph Nozaic and Susan Delia Freese

'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 that fact that since then there have been a number of new technologies introduced into wastewater.

TT 489/09
ISBN: 9781770058262
Overseas Price: $35.00

Guide for management of waste stabilisation pond systems in South Africa

Philip de Souza & Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in he Eastern Cape and Free State.

TT 471/10
ISBN: 9781431200344
Overseas Price: $25.00

Guide for operations and maintenance of a waste stabilisation pond system

Philip de Souza & Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in he Eastern Cape and Free State. The Free State and Eastern Cape systems assessed are within the Upper Orange Vaal catchment area. There are a few other systems assessed in the Eastern Cape that do not fall under this catchment area.

TT 472/10
ISBN: 9781431200351
Overseas Price: $25.00

Manual for using electronic water quality management system (eWQMS) and waste stabilisation ponds assessment tool

Philip de Souza & Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in the Eastern Cape and Free State. The Free State and Eastern Cape systems assessed are within the Upper Orange Vaal catchment area. There are a few other systems assessed in the Eastern Cape that do not fall under this catchment area.

TT 473/10
ISBN: 9781431200368
Overseas Price: $25.00

Water related microbial disease guidelines

Ian Bailey

Many studies on the effects of water development on human health over the past fifty years have been criticized as to their validity and usefulness. Lack of adequate control, poor project design, many confounding variables, cultural bias, health indicator recall, health indicator definition and failure to analyse by age have been sited as rendering study results meaningless. Eminent researchers in the field, such as Cairncross and Birley, are equally skeptical. While instinctively it is accepted that water and sanitation do improve health, there are many opinions as to how and why.

TT 429/10
ISBN: 9781770055216
Overseas Price: $30.00

Domestic water quality research impact assessment

Sostina Shiri & David Winter

The WRC provides leadership for water-related research and development through the support of knowledge creation, transfer and application. The WRC engages stakeholders and partners in solving a wide variety of water related problems, which are critical to South Africa's sustainable development and economic growth.

TT 416/09
ISBN: 9781770058828
Overseas Price: $20.00

Development of a model for determining affordable and sustainable sanitation demand in dense settlements of South Africa

Richard Martin

The level and quality of the services that communities are to receive must be discussed with and accepted by the community members. Quite important are also 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 vandalized. 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.

TT379/08
ISBN: 9781770058040
Overseas Price: $25.00

Towards standards for municipal invoices in SA

Sarah Slabbert

The domestic water accounts (or consolidated accounts) that municipalities send out to consumers on a monthly basis are a key interface between local government and citizens. A municipal account is a unique one-on-one communication event between the municipality and the individual consumer (or customer) to whom the account is addressed. As such, municipal accounts offer a unique opportunity for municipalities to inform, educate and influence their customers and to establish their communication as clear, accurate and customer friendly. The research assessed current South African and international regulation, guidelines and research relating to accounts/invoices/bills, with special reference to domestic water accounts. This was supported by a survey of current municipal account practices, as well as a critical analysis of a representative sample of domestic water (or consolidated) accounts.

TT 458/10
ISBN: 9781770059832
Overseas Price: 25.00

Guidelines on domestic water accounts –towards a consistent approach in the RSA

Sarah Slabbert, Carmel Joseph, Annerie Allers

The domestic water accounts (or consolidated accounts) that municipalities send out to consumers on a monthly basis are a key interface between local government and citizens. A municipal account is a unique one-on-one communication event between the municipality and the individual consumer (or customer) to whom the account is addressed. As such, municipal accounts offer a unique opportunity for municipalities to inform, educate and influence their customers and to establish their communication as clear, accurate and customer friendly.

TT 457/10
ISBN: 9781770059825
Overseas Price: $30.00

"Going with the franchising flow": An exploration of partnerships for the operation and maintenance of water services infrastructure

Kevin Wall & Oliver Ive

The rapid rate of construction and commissioning of new water services infrastructure is severely challenging the public sector institutions in South Africa responsible for operating and managing this infrastructure. Innovative approaches are required. But even if all the existing water services institutions were coping with the responsibility, there would be good reason to investigate alternative institutional models, on the grounds that it needs to be found out if alternatives could be more cost-effective, and/or could offer a range of other advantages (including greater local economic development).

TT 432/10
ISBN: 9781770059627
Overseas: $25.00

Guidelines for facilitating Cooperative and Adaptive Management of Freshwater Ecosystems

Dirk Johannes Roux, Kevin Murray, Liesl Hill

Water resources management is characterised by complex problems, considerable uncertainties, limited predictability, the need for integration across disciplines, and the need for coordination and cooperation between agencies with overlapping mandates. There are multiple stakeholders and their expectations can be diverse and guided by different mental models based on different knowledge forms.

TT 404/10
ISBN: 9781770059788
Overseas price: $15.00

Seaman MT, Avenant MF, Watson M,King J, Armour J, Barker CH, Dollar E, du Preez PH, Hughes DA, Rossouw L

The South African National Water Act, Act 36 of 1998, requires that the environmental reserve be determined for each significant water body before water-use licences may be issued. Methods currently available for the determination of environmetal water requirements in South African rivers are based on perrenial rivers and are seen to be needing verification for use on non-perennial rivers. This research programme began by identifying which existing methods, i.e. those being used on perennial rivers, might initially seem to be suitable for use and where further work needs to be done (see Rossouw et al., 2005). It then took this research a step further with an overarching objective to develop a prototype methodology for determining the environmental water requirements for non-perennial rivers. This would be based on field-based knowledge acquired during comprehensive research on a range of non-perennial system.

TT 459/10
ISBN: 9781431200115
Overseas Price: $40.00

The effects of stream flow manipulation on the invertebrate hosts of malaria, bilharzia and liver fluke disease

Leo Quale, Chris Appleton and Chris Dickens

This report details the results of a desktop investigation into the relationship between regulated river flow, flow manipulation and the invertebrate hosts of malaria, bilharzia and liver fluke disease in South Africa. Literature review yielded several international case studies which informed the study, and together with expert input, all information was gathered and documented in order to understand the relationship and suggest possible flow manipulation mechanisms which may be used to control transmission of these diseases through control of their invertebrate hosts. The possible effectiveness of these flow related control mechanisms has also been assessed and the number of 'people at risk' who may benefit from flow related control is estimated.

TT 456/10
ISBN: 9781770059801
Overseas Price: $30.00

Framework and manual for the evaluation of aquatic ecosystems services for the resource directed measures

AE Ginsburg JG Crafford & KR Harris

The National Water Resource Strategy aims to strike a balance between the use of resources for livelihoods and conservation of the resource. This process invariably requires negotiation of trade-offs. These trade-offs are principally between the resource quality on the one hand and the beneficial use of water on the other. The framework developed through this project to achieve this is explicitly congruent with methods used by DWA in the determination of Resource Directed Measures and Source Directed Controls. Definition of the benefits yielded by an ecosystem have been based on the Millennium Ecosystems Assessment framework and comparative risk assessment methodology is used to develop the causal chains linking ecological production to the defined ecosystem services. Two case studies have been developed to illustrate the framework.

TT 462/10
ISBN: 9781770059979
Overseas Price: $35.00

This Framework and Manual explores how these scenarios and their associated trade-offs should be evaluated.

Water Quality Overview and Literature Review of the Ecology of the Olifants River

Ralph Heath, Trevor Coleman, Johan Engelbrecht

In the light of the ongoing water quality problems in the Olifants River, Mpumalanga, a review of water quality studies done on the system was commissioned to provide this information for other studies on this system. An overview of the economic activities in the catchment provides the background for the water quality problems to which the system is exposed. Resource Quality Studies, Dept. of Water Affairs, started monitoring the catchment in 1983 and have monitored a number of parameters in their routine monitoring programme. The review also covers water quality results from specific studies in the catchment.

TT 452/ 10
ISBN: 9781770059894
Overseas Price: $25.00

Public participation in the drafting of catchment management strategies made simple

Derick du Toit & Sharon Pollard

The focus of the document is to guide CMA personnel and others working on their behalf in the structuring of public engagement in the drafting and implementation of the CMS. The document is made up of simplified step by step guide. Each section is taken directly from the CMS guideline which is a national official document published by DWA in 2007and each task is developed in terms of steps. The requisite level of public engagement is suggested on the left and the 'how' for each task is presented. There are 10 TASKS, each with step-by-step tables.

TT 455/10
ISBN: 9781770059795
Overseas price: $35.00
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Guidelines for improved efficiency of irrigation water use Volume 2 of 3

Felix Britz Reinders

The activities undertaken during the course of the project have contributed to local knowledge on issues regarding irrigation water use efficiency. The outcomes have created new knowledge in that:

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator; and
- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of "measure; assess; improve; evaluate". It promotes an investigative approach to improving efficiency, rather than relying only on water accounting. The main output of the project was the compilation of guidelines for improved irrigation water management from dam wall release to root zone application. The guidelines are aimed at assisting both water users and authorities to achieve a better understanding of how irrigation water management can be improved, thereby building human capacity, allowing targeted investments to be made with fewer social and environmental costs. Using lessons learnt during the WRC project, best practices and technologies were introduced and illustrated.

TT446/10
ISBN: 9781431200238
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Integrated Management of Water Hyacinth in SA

Marcis Byrne, Martin Hill, Mark Robertson,Anthony King, Ashwini Jadhav, Naweji Katembo, John Wilson, Ryan Burdvig and Jolene Fisher

Water hyacinth, Eichhornia crassipes (Martius) Solms-Laubach (Pontederiaceae) is South Africa's most damaging floating aquatic weed. Despite notable successes with the biological control of other floating aquatic weeds, and a concerted biological control effort against water hyacinth, its populations continue to reach newsworthy proportions on major rivers and dams. Hill and Olckers (2001) ascribed the variable success of the biological control programme on water hyacinth in South Africa to variable climatic conditions, eutrophication of aquatic ecosystems, interference from integrated control operations, the hydrology of infested systems and techniques for establishing biological control agents. The research presented in this report addresses the effect of temperature and nutrients on the growth of water hyacinth and some of its biological control agents and investigates the interaction of herbicide application with biological control. This has been done in light of discovering a sublethal dose of herbicide which will retain water hyacinth plants in a system to maintain populations of the agents. In addition, a management plan has been developed to guide water managers as what action should be taken in terms of combining biological control with herbicidal control under different climatic and nutrient conditions.

TT 454/10
ISBN: 9781770059757
Overseas price: $35.00
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Ecohydraulics for South African Rivers: A Review and Guide

James C.S. and King J.M. (Editors)

This project was aimed at synthesizing existing knowledge on ecohydraulics in South Africa and then packaging it in the form of a Review and Guide document. The Guide provides theories and techniques related to ecohydraulics as well as the ecological context and perspective for the application of ecohydraulics. Thus building capacity amongst engineers and ecologists and contributing towards the effective management of our aquatic environment. The Guide will also provide an overview of the current state of ecohydraulics research in South Africa, serving as a useful point of reference for identifying and prioritising future research needs for ecohydraulics in South Africa.
It is of importance to note that the techniques and theory presented in this document deal exclusively with ecology and ecohydraulics within a river context, with the intention

that environmental hydraulics in its broader sense, which typically include biological and chemical aspects in lakes, estuaries and wetlands, will be addressed in subsequent research projects. Furthermore, it is necessary to point out that the hydraulic theory that is presented in this document assumes that the user of this Guide will have a graduate level of understanding of river hydraulics. However, the content is presented in such a way as to ensure that water resource practitioners and managers as well as researchers across a wide spectrum of disciplines, should find the document informative and useful.

TT 453/10
ISBN: 9781770059603
Overseas price: $35.00

Application of Ecological informatics Modelling Techniques for predicting harmful Algal Blooms

Carin Elizabeth van Ginkel, Sandra du Plessis, Johannes Jacobus Bezuidenhout

The study showed that eutrophication and the associated problems is a real threat to South African fresh water resources but that modelling methods can assist in managing the problem. The list of recommendations needs to be taken further by a number of stakeholders, e.g. the Department of Water Affairs, future CMA's, Universities and other researchers in order to:

a) Determine the necessary variables and monitor these for future modelling exercises.
b) Include total microcystin monitoring in impacted fresh water resources at least during the summer periods to enable resource managers to issue warnings to all potential impacted stateholders.
c) Initiate and test available management options to minimise serious eutrophication levels in South Africa.
d) Manage the risk imposed by the cyanobacterial blooms and the associated toxins produced in the water resources, on drinking water facilities and the health of recreational users.
e) Develop short-term forecasting tools, for the algal blooms of Microcystis and Ceratium, with on-line water quality monitoring for early-warning and real-time forecasting for reservoir managers.
f) Investigated the cause and effects for changing composition of the phytoplankton of these five reservoirs.
g) Monitor at different depths to determine the best depth for abstraction for treatment purposes.

The successful use of the hybrid Evolutionary Algorithm Method to develop predictive tools for algal blooms indicated the necessity to develop capacity (both human and equipment) in South Africa to use the Hypbrid Evolutionary Algorithm (HEA) RULE set development in all research spheres, as the method is applicable to any type of numerical data and can be applied to any research field.

TT451/10
ISBN: 9781770059535
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Integrated water quality management: A new mindset

Lee Ann Boyd; Robyn Lesley Tompkins; Ralph Gregory Melville Heath

The conceptual model is based on the premise that good water quality is in everyone's best interests. This "Change of Mindset" IWQM management approach "breaks down" the management of water quality into smaller management units. At the same time, both the horizontal and the vertical reporting framework is established. This structure is aimed at addressing the problem of implementation of quality standards across the country, and also improving enforcement by reducing the volume of reports that should highlight problem areas and allow for prioritisation of regulatory or remedial action. A further benefit of the IWQM management framework is that responsibility for water quality is based on significantly smaller geographical areas, and accountability to the adjoining areas (horizontal accountability) and to the next level of management (vertical accountability) is established with the creation of the management unit. This allows accountability for water quality to be focused on smaller management units, rather than diffused upever higher levels of management. Finally, the IWQM approach allows water quality information to be packaged for a broader audience, as reporting is simplified to provide information on whether or not a management unit is within the specifications of its critical control points (CCPs) or not; rather than extensive technical reports to national level through the management chain.

TT 450/10
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Financial and economic feasibility of drainage

Robert Jack Armour and Machiel Frederick Viljoen

It was strongly suggested and agreed upon at a final Reference Group meeting for WRC project 1352, that the project team prepare a consultation proposal to meet with relevant stakeholders for technology transfer of the results produced in the project. This is due to the fact that this research successfully integrated and linked models and

results from different disciplines (soil science, hydrology and agronomy) with economic models at micro (per hectare, sub-WUA and WUA) level and social welfare models at the regional level. This enabled the researchers to determine the long term impact (cost and benefits) of different salinity management options and provided valuable information required for decision making at different levels.

In this regard the results show that for the different levels:

- Drainage installation and consequent leaching, is a better option financially, environmentally and socially than changing to more salt tolerant crops at farm, WUA and regional level;
- The project results clearly show that to reduce the risk of income loss due to irrigation salinity, drainage and leaching are necessary;
- At regional level the direct and indirect effects of modeled improved drainage (and subsequent investment in higher value crops) proved far greater than the costs of the drainage; produced the highest index for socio-economic welfare (ISEW); and an increase of employment in irrigation farming and related industries over the long term.

To reinforce the message of the technology transfer results to be presented, brochures will be handed out at the technology transfer meetings and a web-page will be introduced that will include links to the relevant WRC reports, the user friendly technology transfer report, and other updated and interesting salinity and drainage related information.

TT 448/09
ISBN: 9781770059511
Overseas price: $35.00
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Impact assessment of the water administration system

David Winter

Since 1985 the Water Research Commission has been working closely with the DWAF together with NB Systems in developing water management systems that simplify the task of managing canal water for irrigation purposes. This has resulted in the production of a broad range of research reports that have been focused on the development of the Water Administration System (WAS).

The WAS program is designed to be a water management tool for irrigation schemes, Water User Associations (WUA's), Catchment Management Agencies (CMA's) and water management offices that need to manage their water usage, distribution and accounts. It is an integrated database-driven system with many water management capabilities that include handling any number of farmers, abstraction points and measuring stations on canal networks, pipelines and rivers. The system involves simplified and controlled ways of managing water allocations, use, distribution and billing.

The main objective for developing the WAS program was to minimise water losses for irrigation schemes that work on the demand system and that distribute water through canal systems. The program consists of seven modules that are integrated into a single program that can be used on a single PC or multi-user environment. These seven modules can be implemented partially or as a whole, depending on the requirements of a specific scheme or office.

TT 447/09
ISBN: 9781770059504
Overseas price: $25.00
Exclude postage

Assessing the impact of in-field rainwater harvesting and conservation research

James Nelson Blignaut and Xolani Rudolf Sibande

The Water Research Commission (WRC) has been supporting the Agricultural Research Council (ARC) at Glen near Bloemfontein and various other organisations over the past 15 years to conduct research and development for in-field rainwater harvesting (IFRWH) techniques and the dissemination of knowledge among the members of 42 villages surrounding Thaba Nchu. The WRC approached ASSET Research to conduct an investigation, using the McMaster University's research impact assessment tool, as to the uptake and impact of IFRWH in those villages.

TT 444/08
ISBN: 9781770059436
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Wetland valuation volume IV: A protocol for the quantification and valuation of wetland ecosystem services

JK Turpie and M Kleynhans

VOLUME 11: WRC REPORT TT443/09
WETLAND VALUATION VOLUME IV: A PROTOCOL FOR THE QUANTIFICATION AND VALUATION OF WETLAND ECOSYSTEM SERVICES

This study builds on three earlier volumes on wetland valuation and includes a review of current understanding of wetland ecosystem services to provide a protocol for

the quantification and valuation of wetland ecosystem services. The report is written for planners and decision-makers wishing to understand the purpose and potential for use of wetland valuation in a variety of decision-making contexts, and to guide them in the setting of terms of reference for specialist studies. In addition, the report aims to guide student and professional resource economists in their understanding of the purpose of and trade-offs in valuation studies, the choice of their detailed methodological approach and the role of biophysical specialists in wetland valuation. Although the report provides advice on how to achieve relatively rapid estimates of wetland values, it does not offer a shortcut tool for rapid valuation by non-professionals.

TT 443/09
ISBN: 9781770059351
Overseas price: $30.00
Exclude postage

WETLAND VALUATION VOLUME III: ASSESSMENT OF THE LIVELIHOOD VALUE OF WETLANDS

JK Turpie

VOLUME 10: WRC REPORT TT 442/09
WETLAND VALUATION VOLUME III: A TOOL FOR THE ASSESSMENT OF THE LIVELIHOOD VALUE OF WETLANDS

Millions of South Africans are directly dependent to some extent on natural systems to sustain their livelihoods, and wetlands are considered particularly valuable in terms of the variety and abundance of services they provide. Understanding the degree to which wetlands contribute to people's livelihoods may be vital in steering decisions that minimize negative impacts or enhance the benefits that wetlands have for communities, such as their contribution to household income. This study developed a simple index for the assessment of a wetland's importance to people's livelihoods through understanding the level of dependence of surrounding communities on a wetland. The tool outlines the way in which the index parameters are estimated at a rapid, intermediate, or comprehensive level, depending on the budgetary constraints or the level of confidence required. Since the index produces a result which is in comparable units, the results can be used to assess the relative importance of a wetland compared to others in the catchment or even nationally, and to rank, or prioritize, different wetlands in terms of management priorities.

TT 442/09
ISBN: 9781770059344
Overseas price: $30.00
Exclude postage

WETLAND VALUATION VOLUME II: CASE STUDIES

JK Turpie

VOLUME 9: WRC REPORT TT441/09
WETLAND VALUATION VOLUME II: WETLAND VALUATION CASE STUDIES

This report, one of the outputs of the Wetland Health and Importance (WHI) research programme and one of four on the value of wetland ecosystems, documents five case studies selected to fill some important gaps in wetland valuation in South Africa, as well as to provide examples of studies carried out at different levels.

TT441/09
ISBN: 9781770059337
Overseas price: $32.00
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WETLAND VALUATION VOLUME I: SERVICES & THEIR VALUATION

JK Turpie, K Lannas, N Scovronick and A Louw

VOLUME 8: WRC REPORT TT440/09
WETLAND VALUATION VOLUME I: Wetland ecosystem services and their valuation: a review of current understanding and practice

This report, one of the outputs of the Wetland Health and Importance (WHI) research programme and one of four on the value of wetland ecosystems, reviews the wetland valuation literature to ascertain how wetland valuation has been approached internationally, and how international and local experience can guide best practice for approaching wetland valuation in South Africa. Wetlands are recognised as being valuable ecosystems which provide water, food and raw materials, services such as flood attenuation and water purification, and intangible values such as cultural and religious value. Despite this, and legislation to protect them, they are increasingly threatened, with more than half the world's wetlands having been lost already. Wetlands may be degraded due to market failure (where markets do not reflect true values or costs) and government failure (perverse incentives, lack of well-defined property rights leading to open access and ignorance of decision makers as to the value of wetlands). Economic valuation helps to compare the real costs and benefits of ecosystem use and degradation, and allows more balanced decision-making regarding the protection and restoration versus degradation of wetlands.

TT 440/09
ISBN: 9781770059320
Overseas price: $30.00 Exclude postage

Assessment of two wetlands in the Kamiesberg uplands

Donovan Charles Kotze, Heather Louise Malan, William Nolan Ellery, I Samuels and L Saul

VOLUME 7: WRC REPORT TT439/09
ASSESSMENT OF THE ENVIRONMENTAL CONDITION, ECOSYSTEM SERVICE PROVISION AND SUSTAINABILITY OF USE OF TWO WETLANDS IN THE KAMIESBERG UPLANDS
There is a long history of use of the wetlands in the Kamiesberg area. Even for the present generation they represent an important resource to a community that is relatively poor.

This study, a joint initiative between the WRC-funded Wetland Health and Importance Research group and the Agricultural Research Council (ARC): Range and Forage Unit, reports on an investigation of the geomorphology, vegetation and utilisation by humans, of two wetlands (Langvlei and the Ramkamp) which are situated just outside of Leliefontein in the Kamiesberg area of the Northern Cape. The historical settlement patterns and land-use in the area are described, and the information collected was used to establish the environmental condition of the wetlands, the ecosystem services they are likely to deliver and how sustainable the use of those systems is likely to be. Sustainability was assessed both from a sociological, and an ecological, point of view.

TT 439/09
ISBN: 9781770059313
Overseas price: $30.00
Exclude postage

Assessing the sustainability of wetland use

Donovan Charles Kotze

VOLUME 6: WRC REPORT TT438/09
WET-SUSTAINABLE USE:
A system for assessing the sustainability of wetland use

WET-SustainableUse has been developed to assess the ecological sustainability of wetland use, focusing on grazing of wetlands by livestock, cultivation of wetlands and harvesting of wetland plants for, for instance, crafts and thatching. WET-Sustainable Use asks to what extent the use of the wetland has altered the following five components of the wetland's environmental condition: (1) the distribution and retention of water, (2) the erosion of sediment, (3) the accumulation of soil organic matter (SOM), (4) the retention of nutrients and (5) the natural species composition of the vegetation in the wetland. WET-SustainableUse assists the user in answering these questions by providing a set of indicators for each of the five components, and a structured way of scoring these indicators and deriving an overall score for each component.

TT 438/09
ISBN: 9781770059306
Overseas price: $30.00
Exclude postage

Assessing cumulative impacts on wetlands at catchment scale

WN Ellery, S Grenfell, M Grenfell, C Jaganath, HL Malan and DC Kotze

VOLUME 5: WRC REPORT TT437/09
A method for assessing cumulative impacts on wetland functions at the catchment or landscape scale

This volume, part of the series on Wetland Health and Importance, describes methods which enable the assessment of the effects on wetland functionality of the cumulative impacts of human activities at a landscape scale. It uses two metrics - the land cover change impact metric and the loss of function metric to produce a functional effectiveness score that is translated to functional hectare equivalents. The land cover change is based on the recognition that wetland structure and function are fundamentally affected by the hydrological regime. The loss of function metric describes the relationship between the magnitude of impact and wetland functionality for a total of 6 ecosystem services: A) flood attenuation, B) stream flow regulation, C) sediment trapping, D) nitrogen removal, E) phosphate removal or F) toxicant removal. These metrics are based on limited field testing and need verification.

TT 437/09
ISBN: 9781770059290
Overseas price: $30.00
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Aquatic invertebrates - indicators of human impacts in SA wetlands assessment of temporary wetlands

M Bird

VOLUME 3: WRC REPORT TT435/09 aquatic invertebrates as indicators of human impacts in South African wetlands

The recent emphasis on wetland protection and management has created an urgent need to develop assessment tools to establish and monitor human impacts in wetland ecosystems so as to prioritise wetlands for conservation and rehabilitation actions and to monitor the effects of these actions. Biological assessment or "bioassessment" is

one of the means of investigating wetland condition and involves the evaluation of a wetland's ability to support and maintain a balanced, adaptive community of organisms having a species composition, diversity and functional organisation comparable with that of minimally disturbed wetlands within a region. Potential indicator groups for bioassessment purposes include macrophytes, algae and diatoms, aquatic invertebrates, birds and fish.
This volume describes the use of macro-invertebrates for the assessment of the condition of a wetland.
E Day, JA Day, V Ross-Gillespie and A Ketley

TT 435/10
ISBN: 9781770059276
Overseas price: $30.00
Exclude postage

VOLUME 2: WRC REPORT TT434/09 THE ASSESSMENT OF TEMPORARY WETLANDS DURING DRY CONDITIONS

This volume, part of the series on Wetland Health and Importance, describes methods which enable the user to assess the condition of temporary wetlands when they are dry. In extreme cases, a seasonal wetland may not be obvious, and methods are provided to aid in the recognition of wetlands in such cases. The soils underlying most wetlands are exhibit characteristic colouration and this is described. Certain invertebrates, in particular Branchiopod crustaceans, characteristically inhabit this type of wetland and methods for the determination of the presence of these are described. In addition, certain plants are characteristic of this type of situation, and these are also described. However, no single indicator provides adequate information about wetland presence, type, hydroperiod, biodiversity, function and principle ecological and hydrological drivers. In extreme cases the most cryptic of wetlands may show none of the indicators.

TT 434/09
ISBN: 9781770059269
Overseas price: $30.00
Exclude postage

VOL 1: HANDBOOK TO THE WETLAND HEALTH & IMPORTANCE RESEARCH PROGRAMME

E Day and HL Malan

VOLUME 1: WRC REPORT TT 433/09
TOOLS AND METRICS FOR ASSESSMENT OF WETLAND ENVIRONMENTAL CONDITION AND SOCIO-ECONOMIC IMPORTANCE: HANDBOOK TO THE WHI RESEARCH PROGRAMME

Volume 1 of this series, one of the outputs of the Wetland Health and Importance (WHI) research programme, distils the major findings of the different components of the project and their implications for future work in the management or assessment of wetland environmental condition and socio-economic importance in South Africa. This series of 11 volumes addresses the assessment of wetland environmental condition using aquatic invertebrates and macrophytes as well as the assessment of temporary wetlands during dry conditions. There is a metric for the broad-scale assessment of impacts and ecosystem services and methods and case studies on the assessment of socio-economic and sustainability studies. (Volume 4 publication expected late 2010.)

TT 433/09
ISBN: 9781770059252
Overseas price: $30.00
Exclude postage

Towards The Realization of Free Basic Sanitation: Evaluation, Review and Recommendation

Nozibele Mjoli, Gillian Sykes and Tracy Jooste

Access to a basic sanitation service as a right is enshrined in the Constitution of South Africa (Act 108 of 1996). In terms of Section 24(a), 'everyone has a right to an environment that is not harmful to their health or well-being.' This clause has been interpreted as a right to basic sanitation for all. Municipalities have a constitutional mandate of ensuring access to water and sanitation services for all including the poorest households. Despite the drafting of a Free Basic Sanitation (FBSan) strategy by the Department of Water Affairs & Forestry (DWAF) in mid-2004, the process of approval for this strategy has been slow due to the realization by government that provision of free basic sanitation service was more complex than free basic water. Municipalities are faced with a challenge of balancing financial resource allocation to the eradication of basic sanitation infrastructure backlog by 2010 and provision of free basic sanitation services to the poor. Therefore, there is a need to identify successful and cost effective approaches of implementing subsidies for basic sanitation infrastructure and provision of free basic sanitation services. Financial models and innovative strategies are required to assist the municipalities to provide sustainable free basic sanitation services to poor households and to finance ongoing O&M for these services. Good practice must be identified and scaled-up where possible.The aim of this study was to assess the experience of municipalities in the implementation of FBSan services and to develop economic and financial models for sustainable FBSan service. Based on the findings of the study recommendations were made for improving the delivery of FBSan services to poor.

TT 420/09
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The basement Aquifers of Southern Africa

Titus RA, Beekman HE, Adams, S and Strachan L

The report consists of several reviewed papers. The papers were sourced from various researchers that have worked on basement aquifers in southern Africa. The resulting synthesis document will be used by the hydrogeological community as a basic reference to basement aquifers. The paper titles and authors are:

- Basement aquifers of southern Africa: Overview and Research Needs - Shafick Adams
- A tectonic and geomorphic framework for the development of basement aquifers in Namaqualand: a review - Rian Titus, Andreas Friese, Shafick Adams
- Groundwater exploration and development - Karim Sami
- Groundwater exploration and development of basement aquifers in Botswana - Flenner Linn
- Groundwater chemistry of basement aquifers: A case study of Malawi - James Chimphamba, Cosmo Ngongondo, Prince Mleta
- A methodological approach to recharge estimation of semi-arid basement aquifers – the central Namaqualand case - Shafick Adams, Rian Titus, Yongxin Xu
- Basement aquifer Groundwater recharge, storage and flow - Jürgen Kirchner
- Factors that control sustainable yields in the Archean basement rock aquifers of the Limpopo province - Martin Holland, Kai Witthüser
- Hydrogeochemistry of fluoride and salinization mechanism of groundwater in the Singida region, central Tanzania - Hudson H. Nkotagu
- Hydrogeochemical processes that influence the groundwater chemistry of basement aquifer systems, Namaqualand - Rian Titus, Shafick Adams, Kai Witthüser, and Yongxin Xu
- Towards sustainable utilization of basement aquifers in southern Africa - Eberhard Braune, Shoni Mutheiwana
- Current practices and future needs for managing basement aquifers in Zimbabwe - Sam Sunguro, Hans Beekman
- Challenges of basement aquifers in southern Africa - Christopher J. Lovell
- Groundwater management in southern Africa - Mutsa Masiyandima
- Aspects of groundwater management that is pertinent to basement aquifers in the southern African development community (SADC) - Kevin Pietersen

TT 428/09
ISBN: 978 1 77005 8989
Overseas price: $ 25.00
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Enabling effective learning in catchment management agencies: A philosophy and strategy

D Roux, K Murray E van Wyk

It is the responsility of catchment management agencies (CMAs) to manage water resources in their respective water management areas. The nature of the functions they have to perform and the complicating and complex internal and external realities within which they operate create very demanding circumstances. It is therefore imperative that Cmas are effective learning organisations. This means they should adept at acquiring knowledge, creating knowledge, transferring knowledge and, importantly, adapting when necessary.

This document provides some historical background to the knowledge movement and describes different types of knowledge. It also provides an encyclopedia of terms that define various commonly -used terms and concepts in this field.

TT 421/09
ISBN: 978 1 77005 8958
Overseas price: $20.00
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A Planning Framework to Position Rural Water Treatment in South Africa for the Future

Chris Swartz

A number of recent WRC Projects (738, 1531, 1599) Showed that serious problems exist with the treatment of drinking water for non-metropolitan areas. These problems are acute in rural areas, and include lack of capacity, poor operation and maintenance, lack of management involvement, commitment and resources, as well as a general lack of knowledge and understanding of the importance of effective drinking water treatment.

TT 419/09
ISBN: 978 1 77005 8897
Overseas price: $25.00
Excl postage

Review of Regulatory Aspects of Water Services Sector

Daniel Malzbender, Anton Earle, Hameda Deedat*, Brian Hollingworth*, Palesa Mokorosi

The purpose of regulation is to ensure that the service providers or operators of water services deliver in accordance with the law and the policy of the government. This research examined the international literature and case studies where the concept of a "regulator" is more understood as referring to an entity that is separated from the line departments of government. Whether the institutional form is government as regulator or an independent entity as regulator conceptually makes no difference to its objectives or its basic task. The international focus on independent regulators relates largely to effectiveness. The limited survey conducted as part of this research suggests that within South Africa, stakeholders, outside of national government, appear to favour an independent regulator because, it is said, that DWAF will be unable to fulfill simultaneously the three roles it defines for itself as regulator, supporter and enabler. The unfavorable side of an independent regulator is the cost and the requirement for skills that are in short supply. The research found that the legislation, regulations and policy that a regulator would have to apply are already well defined. Further, it was found that there are a number of core skills such as finance, economics and engineering that are required irrespective of the range of aspects that will be regulated. Depending on the functions and mandate, regulation will require between 48 and 80 direct staff and cost between R40 and R67million per annum. A similar estimate for an independent regulator suggests staff of between 65 and 112 and annual costs of between R63 and R99million per annum.

TT 417/09
ISBN: 978 1 77005 8866
Overseas price: $20.00
Excl postage

Effective Groundwater Management in Namaqualand: Sustaining Supplies

Kevin Pietersen, Rian Titus and Jude Cobbing

The purpose of this guide is translate the scientific and technical knowledge gained through research on the hydrogeology of basement aquifers into a user-friendly format for the Department of Water Affairs and Forestry (DWAF), local authorities and the end-users. The guide is not intended for operators of water supply schemes, but rather for water resource planners. The guide has two overarching sections that deal with the issues of groundwater exploration and exploitation in a systematic manner.

It is subdivided as follows:

1. What is groundwater?
2. The importance of groundwater in Namaqualand
3. Namaqualand aquifer systems
4. Locating groundwater resources in Namaqualand
5. Selecting drilling targets
6. Borehole design
7. The drilling process and the importance of data collection
8. Determining the sustainable yields
9. Understanding the water balance
10. Managing the water resource
11. Water quality considerations

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ISBN: 9781770058880
Overseas price: $25.00
Excl postage

Manual for Index of Habitat Integrity (Section 2, Model Photo Guide) Module G Volume 2

Mark Graham; Marina Delana Louw

The manual consists of the following modules:
Module A: Ecoclassification and Ecostatus models
Module B: Geomorphological driver assessment index (GAI)
Module C: Physio-Chemical Driver Assessment index (PAI)
Module D: Fish response assessment index (FRAI) Volume 1 &2
Module E: Macro-Invertebrate response Assessment Index (MIRAI) (Volume 1)
Module F: Riparian vegetation response assessment Index (VEGRAI)
Module G: Index of Habitat integrity.

TT 378/09
ISBN: 978 1 77005 8019
Overseas price: $20.00
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BASIC SANITATION SERVICES IN SOUTH AFRICA Learning from the past, planning for the future

David Still, Nick Walker and Derek Hazelton

The purpose of this study has been to investigate whether the improvements made are working, and whether they are financially sustainable. In its coverage the study is biased towards rural sanitation, as the overwhelming majority of South Africans without proper sanitation live in rural areas. The study finds that with few exceptions the practice since 1994 has been to provide funds for the initial capital costs of sanitation projects and not for operation

and maintenance. The reason for this is that funding for new infrastructure is typically provided to municipalities by central government as grant funding, while the funding for operation and maintenance is required to come from the municipal coffers. Strictly speaking the funding for operation and maintenance is covered by the Equitable Share grant, in terms of which most poor municipalities receive an operations subsidy of between R20 and R60 per month for sanitation for every poor family in their area. However the equitable share is an unconditional grant and in practice this is not seen by local government as funding that has to be spent on operation and maintenance of services. Research indicates that the funding is typically used to finance the municipal overhead costs, as well as to finance other infrastructure projects not covered by the MIG grant. This practice, of building sanitation infrastructure while not allowing for adequate maintenance in the future, whether it is basic VIP sanitation or full waterborne sanitation, is shortsighted and will result in South Africa facing a sanitation crisis in the medium term.

TT 414/09
ISBN: 978 1 77005 8804
Overseas price: $30.00
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Development of a toolkit for strategic asset management

Peter Dunn, Ronnie McKenzie, Caryn Seago

A key element for ensuring greater understanding of strategic asset Management 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 received little attention in many international initiatives, and that which has as a result led to poor uptake. It is therefore key that the linkages of SAM are made to the daily operations of water services, maintenance, planning and strategic decision making.

TT 413/09
ISBN: 978 1 77005 8750
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PRODUCTIVE USE OF DOMESTIC PIPED WATER FOR SUSTAINING LIVELIHOODS IN POOR HOUSEHOLDS

NICKY NAIDOO, CIARAN CHIDLEY, GENE MAIN & MICHELE VRDOLJAK

The major question raised by the research is whether water for productive use should be subsidised. This research report has demonstrated that water is being used for productive use and the various uses to which this water is being put. The research report also highlights that poor households using water for productive use 122% more than poor households that do not. The levels of water debts are high and that 40% of the households surveyed indicate that they pay for water, when possible, demonstrates both that water affordability can be low amongst the poor and that the provision of more water to households for beneficial use may experience financial sustainability challenges. This research indicated that the majority of water users surveyed have stated that they would use water if it were available. It is suggested that wanting to use water in such a manner and actually using the water are not the same thing. This research also indicates that households with higher levels of service use more water for productive use than those with lower service level standards.

TT 412/09
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Nitrate in groundwater

Gideon Tredoux, JFP Engelbrecht & Sumaya Israel

Groundwater constitutes the main water resource in the rural areas and on farms. Surveys show that nitrate in groundwater is common in arid and semi-arid regions of southern Africa often exceeding drinking water specifications. High nitrate levels is the most frequent reason for groundwater sources to be declared unfit for drinking, i.e. exceeding 10 mg/L as N (Marais, 1999). Hence, a large percentage of newly drilled boreholes are rejected for human consumption due to excessive nitrate but communities in many rural areas still consume water with nitrate N exceeding the World Health Organization limit of 10 mg/L. Such non-potable groundwater gives rise to a health threat. Based on the latest information, groundwater in South Africa has high nitrate values, often exceeding 50 mg/L (as N), mostly in a band 100 to 250 km wide, stretching from east to west along the northern boundary of the country, across the four northernmost provinces. Anthropogenic inputs constitute the major source of high groundwater nitrate but research has shown that in certain cases nitrate also originates from the natural soil organic nitrogen pool. The indications, also from our neighboring countries, are that the present situation is unsustainable and anthropogenic nitrogen inputs need to be managed and reduced. Managing anthropogenic nitrogen inputs presents a great challenge for the sustainable use of groundwater.

Report No: TT410/09
ISBN: 978 1 77005 8736
Overseas price: $15.00 Excl postage

Water Resources of SA: 2005 Study: Executive Summary

Middleton B.J. Bailey A.K.

The knowledge and processes involved in accounting for water resource availability continues to benefit from new insights, knowledge and data. The Water research Commission has been very 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, 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.

TT 380-82/08
ISBN: 978 1 7700 58132
Overseas price: $70.00
Excl postage

Enabling effective learning in catchment management agencies: A philosophy and strategy

D Roux, K Murray E van Wyk

It is the responsility of catchment management agencies (CMAs) to manage water resources in their respective water management areas. The nature of the functions they have to perform and the complicating and complex internal and external realities within which they operate create very demanding circumstances. It is therefore imperative that Cmas are effective learning organisations. This means they should adept at acquiring knowledge, creating knowledge, transferring knowledge and, importantly, adapting when necessary.

This document provides some historical background to the knowledge movement and describes different types of knowledge. It also provides an encyclopaedia of terms that define various commonly -used terms and concepts in this field.

TT 421/09
ISBN: 978 1 77005 8958
Overseas price: $20.00
Excl postage

Civil Society Dialogue in Water Resources Management: Lesson from four local-level experiences of river systems

Ernita van Wyk, Tamsyn Sherwill, Charles M. Breen and A.B. Nkhata

Increasingly civil society is expected to participate in and even lead processes that direct behaviors' in relation to the sustainable use of natural resources. Within this context, civil society groups and organizations are encouraged to enter into dialogue with others to expose issues constructively and to promote shared understanding and learning. The ability of such groups to use dialogue to reflect and learn and to apply the learning to subsequent actions becomes an important way of coping with change and uncertainty. Civil society groups have a particular opportunity in that, even though they may be structured informally, formal and even statutory, they are able to operate as communities of practice and to conduct their business with a degree of flexibility and innovation.

The rules that guide natural resource allocation and use follow a common property regime. This means that the resource and its users are co-dependent in complex ways so that the rules for resource protection and use have to be continually reinforced or renegotiated over time. Within such a regime, civil society groups who act to influence the resource or society in relation to the resource, do so within the context of shared rules defined by the values that society attaches to the resource and the services that emanate from the resource. Thus in order for civil society groups to sustain their operations in ways that are seen as legitimate, such groups, their rules and actions, must be sanctioned by society.

TT 383/09
ISBN: 978 1 77005 8224
Overseas price: $25.00
Excl postage

Guidelines for the Utilisation and disposal of wastewater sludge, Volume 4, Requirements for the beneficial use of sludge at high loading rates

Jacoba Elizabeth Herselman, Lucian Willem Burger and Priya Moodley

Seeking innovative solutions for the handling of wastewater sludge requires a paradigm shift in our perception and understanding of wastewater sludge as a resource and

not a waste product. Such a shift creates an opportunity for local authorities to generate a range of economic and social spin-offs to the benefit of their local communities. The Water Research Commission (WRC), and the Department of Water Affairs and Forestry (DWAF) developed this guideline series to support sustainable wastewater sludge management in South Africa. The aim of the project was to develop a series of guidelines to encourage the beneficial use of wastewater sludge but also provide solutions in cases where beneficial use is not feasible. Rather than develop a single guideline to address the range of sludge management options (beneficial and non-beneficial uses), 5 separate Guideline Volumes were developed. Volume 1 and 2 were published in 2006 as part of project K5/1453 while Volume 3, 4 and 5 were completed through a follow-up project K5/1622.

TT 350/09
ISBN: 9781770057104
Overseas price: $25.00

WET-Origins

William Ellery, Michael Grenfell, Suzanne Grenfell, Donovan Kotze, Terence McCarthy, Stephen Tooth, Piet-Louis Grundling, Heinz Meckedahl, David le Maitre, Lisa Ramsay

Three main branches of research into wetlands were identified during a workshop held in early 2002, wetland rehabilitation, wetland health and integrity and wise use of wetlands.
The wetland rehabilitation was prioritised for two reasons. Firstly, it is estimated that South Africa has lost approximately 50% of its wetlands, and wetlands are increasingly being recognised as providing valuable services. And secondly, there has been substantial government expenditure on wetland rehabilitation through the Working for Wetlands project, which is linked to the Expanded Public Works Programme. This project was co-funded by Working for Wetlands to 50% of the budget.
The main objectives were: The project leader must help to make these objectives meaningful.

- Prioritisation of wetland areas for conservation and rehabilitation
- System rehabilitation
- Methodologies for rehabilitation (what about them???) Improve or develop???
- Synergy with other programmes (establish??)
- Institutional arrangements (establish or strengthen??)
- Performance auditing

WET-Management Review

Donovan Kotze, Charles Breen, Innocent Nxele, John Kareko

1. TT 321/09 WET-RoadMap: A Guide to the Wetland Management Series
2. TT334/09 WET-Origins: Controls on the Distribution and Dynamics of Wetlands in South Africa
3. TT335/09 WET-Management Review: The Impact of Natural Resource Management Programmes on Wetlands in South Africa
4. TT336/09 WET-RehabPlan: Guidelines for planning Wetland Rehabilitation in South Africa
5. TT337/09 WET-Prioritise: Guidelines for prioritizing Wetlands at National, Regional and Local Scales
6. TT338/09 WET-Legal: Wetland Rehabilitation and the Law in South Africa
7. TT339/09 WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by Wetlands
8. TT340/09 WET-Health: A Technique for Rapidly Assessing WET-Health
9. TT341/09 WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation
10. TT342/09 WET-RehabEvaluate: A Manual for the Performance Evaluation of Wetland Rehabilitation Projects

This series of documents provides all the information that is needed for the rehabilitation of wetlands, consultants or for private land. Owners who wish to monitor the state of, and / or rehabilitate, wetlands on their property, or for use by programmes such as Working for Wetlands.

TT 335/09
ISBN: 978177005 6343
Overseas price: $30 00
Excl postage

WET-RehabPlan

Donovan Kotze,William Ellery, Mark Rountree, Michael Grenfell, Gary Marneweck, Innocent Nxele, Charles Breen, John Dini, Allan Bachelor, Erwing Sieben

This project was co-funded by Working for Wetlands to 50% of the budget.

1. TT 321/07 WET-RoadMap: A Guide to the Wetland Management Series
2. TT334/09 WET-Origins: Controls on the Distribution and Dynamics of Wetlands in
3. TT335/09 WET-Management Review: The Impact of Natural Resource Management Programmes on Wetlands in South Africa
4. TT336/09 WET-RehabPlan: Guidelines for planning Wetland Rehabilitation in South Africa
5. TT337/09 WET-Prioritise: Guidelines for prioritizing Wetlands at National, Regional and Local Scales

6. TT338/09 WET-Legal: Wetland Rehabilitation and the Law in South Africa
7. TT339/09 WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by wetlands
8. TT340/09 WET-Health: A Technique for Rapidly Assessing WET-Health
9. TT341/09 WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation
10. TT342/09 WET-RehabEvaluate: A Manual for the Performance Evaluation of Wetland Rehabilitation projects

TT 336/09
ISBN: 978 1 77005 6350
Overseas price: $25.00
Excl postage

River ecoclassification manual for ecostatus determinitation (version 2): Module G: Index of habitat integrity section 1: TECHNICAL MANUAL

Kleynhans CJ, MD Louw & M Graham

The habitat integrity of a river refers to the maintanace of a balance of a balanced compostion of Physico-chemical and habitat characteristics on a temporal and special scale that there are comparable

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-AQUEUS 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 behavior. 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

JN Rossouw, W Kamish and AHM Gorgens

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

S R Pollard, H C Biggs, D Robert

South Africa is in the process of implementing IWRM, which by definition is a process based on managing the behavior 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
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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 Mm^3/a
- Groundwater Exploitation Potential (dry years) = 32 Mm^3/a
- Borehole yield without artificial recharge and continuous abstraction = 28 Mm^3/a
- Borehole yield with artificial recharge and 6-month/a abstraction = 41 Mm^3/a
- Existing use = 9 Mm^3/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
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A task oriented approach to participation: PLEASE DOWNLOAD FROM http://www.wrc.org.za/

Burt JC; 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
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Water as a human right, made easy! Workbook 1: PLEASE DOWNLOAD FROM http://www.wrc.org.za/

Dericj du Toit, Teresa Sguazzin

Report No: TT 269/07
ISBN: 978 1 77005 435 6
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Human Rights project WORKBOOK 2: PLEASE DOWNLOAD FROM http://www.wrc.org.za/

Dericj du Toit, Teresa Sguazzin

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
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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)

G R Basson A & Rooseboom

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 J R

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

JR Vegter

Report No: TT135/00
ISBN: 1 86845 643 9
Overseas price: $ 20 00
Excl postage

Hydrogeology of Groundwater: Region 3 – Limpopo Granulite-Gneiss belt

JR Vegter

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

JR Vegter

Report No: TT 209/03
ISBN: 1 86845 027 2
Overseas price: $20 00
Excl postage

Hydrogeology of Groundwater: Region 19 – Lowveld

JR Vegter

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

AC Woodford and L Chevallier

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

Vegter 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 that 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 7005 545 2
Overseas price: $20-00 Excl postage

KSA 2:

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module A:Ecoclassification And Ecostatus Determination

C J Kleynhans, M D Louw

Report No: TT 329/08
ISBN: 978 1 7005 677 0
Overseas price: $20-00
Excl postage

River Ecoclassification Manual For Ecostatus Determination (Version 2) MODULE D: Volume 1: Fish Response Assessment Index (FRAI)

C J Kleynhans

Report No: TT 330/08
ISBN: 978-1-77005-678-7
Overseas price: $30-00
Excl postage

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module D vol 2: Reference frequenxy of occurrence of fish species in SA

C J Kleynhans, M D Louw, J Moolman

Report No: TT 331/08
ISBN: 978-1-77005-681 7
Overseas price: $25-00
Excl postage

River Ecoclassification Manual For Ecostatus 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 Ecostatus Determination (Version 2) MODULE F: Riparian VegetationResponse 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)

M Graham; M D Louw

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

J M King, R E Tharme and MS De Villiers

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

D J Roux, L Hill and W Strydom

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

J Burt, A McMaster, K Rowntree & R Berold

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 & IJ deMoor

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 &IJ deMoor

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)

IJ de Moor, JA Day & FC de Moor

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)

JA de Moor, AD Harrison & IJ de Moor

Report No: TT 201/02
ISBN: 1 86845 900 4
Overseas price: $50-00
Postage inclusive

• Volme 10: Guides to the freshwater invetebrates 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 Maganbeharie, 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
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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
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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
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Overseas price: $20-00
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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
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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, Kleynhans 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 Tsitsikama 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
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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.

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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
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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.

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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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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.

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ISBN: 978 1 77005 700 5
Overseas price: $30-00
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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.

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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".

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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.

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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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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 eThekwini 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.

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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.

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Excl postage

The view from below: Citizen Voice and regulation in water services to the poor

D Hemson, R Shirley & C Munthree

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 communi-

ties 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 were 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 provided very useful infor-

mation 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, heath 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 Arica'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 dicision-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 (ISMMEs) 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 ISSMEs 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; Kasselman 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: Volume2 of 5: Requirements for the agricultural use of wastewater sludge

Snyman HG; Herselman JE; Kasselman 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-Mmotla. 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

Ramotlhola 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 documents from the series:

Quality of domestic water supplies
Vol: 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 –
Vol 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 –
Vol 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-
Vol 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. 1S0 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, synfuel 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 177005 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 bet 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; Premlall 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 to 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 infra-

structure 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
ISBN: 1 77005 431 6
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
ISBN: 1 77005 472 3
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.

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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

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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 Averbeke

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.

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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; Jarmain C; Clulow A; Mengistu M

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Nutritional status of South Africans with specific reference to malnutrition

Wenhold F; Faber M

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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-ISCW). 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.

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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.

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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.

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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.

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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.

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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 (Firm 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.

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Building capacity in irrigation management with wetting front detectors

R Stirzaker; CSIRO; Stevens J; Annandale J; Maeko T; Steyn M; Mpandeli 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.

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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
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Micro-irrigation for smallholders: Guidelines for funders, planners, designers and support staff in SA

Du Plessis FJ; Van Averbeke 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.

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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.

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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.

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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
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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.

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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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