

# *Knowledge Review*

2006/07



Water Research Commission

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# Introduction

## *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**

During the year under review the WRC effectively functioned according to its mandate as reflected by its mission which, as in previous years, provided the framework for its strategic and operational initiatives, and in accordance with the organisation's core strategy and business plan as approved by the Minister of Water Affairs and Forestry. The WRC has fulfilled the role of a 'hub' for water-centred knowledge, reporting to and supporting its shareholder, the Government of South Africa through the Minister of Water Affairs and Forestry, the Department of Water Affairs and Forestry (DWAF), other Government Departments (national, provincial and local), and all other related players within the water sector and related sectors. Throughout the year, the WRC has been strongly attuned to the needs of the end-users who benefit from the water-centred knowledge that emanates from their support. The WRC continued to function as a networking organisation, linking the nation and working through partnerships. The WRC employed innovative strategies to develop novel (and practical) ways of packaging and transferring knowledge which includes, for example, policy briefs and other technology-based products aimed at serving decision makers, the water sector and the community at large.

Water quantity and quality are critical to South Africa's long-term sustainability. The WRC has further built on decades of research and development and science-based knowl-

edge that have collectively provided the basis for the development of policies and strategies that allow for the sustainability of South Africa's water resources. This emphasises not only the important role that water-centred knowledge has played in the past, but its increasing importance in providing the country with knowledge which will allow it to deal successfully with the many emerging challenges that will affect our limited water resources in future years. The WRC plays a crucial role in this regard. During 2006/07, the WRC continued to provide leadership and coordinated research which, in turn, created the knowledge that allowed South Africa to manage water quantity and quality judiciously and, in so doing, to continue to achieve sustainability. As in the past, the broad spectrum (natural and social sciences) of research supported by the WRC during this financial year has created knowledge and supported its transfer to ensure that South Africa avoids any undesirable future scenarios.

Since 2005/06 marked the 5th year of operation of the WRC as a dynamic water-centred knowledge hub, the organisation's Board and Management decided that it was an opportune time for an external review. During July 2006 the WRC underwent an Institutional Review. The Review, which was carried out by a group of local and international experts, addressed the organisation's relevance, effectiveness and efficacy. The aim was to provide the WRC Board and Management with feedback on strategy and operations for the period 2001/02 to 2005/06. The Institutional Review found the WRC to be a relevant organisation with a sound and broad research portfolio. It also indicated that the performance of the WRC has continuously improved and that the WRC has an adaptive management responding to national transformation imperatives. The WRC was found to be aligned to sustainable development and poverty eradication; its governance arrangements were found to be good and its capacity-building initiatives for research were found to be effective. The Institutional Review reported an overwhelmingly positive view from stakeholders with regard to their relationships with the WRC. The WRC is viewed as responsive and receptive to new and innovative ideas as well as being an honest broker in the sector and a consensus builder. It is also viewed as a reliable, objective, transparent and impartial organisation

with good alignment with different stakeholder groups. The Review supported the WRC initiative in Africa and its support to NEPAD. Although the overall findings of the Review were very positive, the Review panel also indicated areas that can be improved further. The recommendations of the Review informed the WRC future core strategy and business plan.

During 2006/07 the WRC continued in strengthening its support to South Africa by creating and disseminating water-centred knowledge, building capacity through research and establishing new research competencies, and further identifying medium- to long-term future research needs that will allow sustainability of the resource and related services. The WRC also continued to strengthen its role in Africa in support of South Africa's Government initiatives and NEPAD and further linking the South African water sector and the research community to global knowledge and initiatives. The WRC strengthened its national, regional and global profile, building strong water-centred knowledge links and both initiated and undertook key roles in a number of national, African and global initiatives, with many staff members serving in key leadership positions.

Building capacity in researchers continued to be an important function of research and, in many areas of research supported by the WRC, it is evident that students who had participated in earlier WRC projects are currently leading WRC-funded research projects and are serving as members of reference groups/steering committees as well as reviewers of new proposals. The WRC has also supported DWAF's 2025 Initiative and has undertaken a study assessing needs and mechanisms to support capacity building for water services in local government. Other national initiatives led by DWAF have also been supported by the WRC. Examples are the Women in Water, Sanitation and Forestry Awards initiative and the SA Youth Water Prize.

Another ongoing challenge is the appropriate state-of-the-art dissemination and application of WRC-created knowledge. During the course of the year the WRC created a new mechanism for knowledge dissemination through policy and technical briefs. In an effort to share knowledge effectively with national policy and decision makers, a set of briefing notes was generated. The organisa-

# Introduction (continued)

tion undertook many knowledge transfer workshops and exhibited and participated in many scientific, technical and professional fora.

## ***Building the water-centred knowledge base – capacity building***

During 2006/07, the WRC continued to contribute towards capacity building and strengthening the water-centred knowledge base in South Africa. The issues of building the knowledge base (capacity building) and the dissemination, application, transfer and sharing of water-centred knowledge are interlinked and are of great importance to the relevance of the organisation. The challenge of building capacity and improving knowledge dissemination and application is crucial to the WRC.

During the current year (2006/07) the WRC has maintained its support to students, with special emphasis on historically disadvantaged students. Currently about 580 students are supported by WRC projects, of whom about 66% are from historically disadvantaged backgrounds. This clearly indicates that the WRC strategy to improve capacity building through its research projects continues to bear fruits.

Science councils continue in their support by building capacity and the number of students supported by consultancy firms via WRC projects is also significant. The increase in the number of students in non-academic institutions may be a result of the WRC strategy of building research networks and research consortia.

Organisation	Number of disadvantaged students	Total number of students
African Water Institute (AWI)	2	2
Anchor Consultancy (linked to UCT)	2	12
ARC	3	5
Arcus Gibb (Pty) Ltd	2	2
Cape Peninsula University of Technology	2	2
Chris Swartz Water Utilization Engineers	10	10
Coaltech 2020	2	2
Conningarth Economists	3	3
Council for Geoscience	2	3
CPH Water	1	1
CSIR	25	31
DH Environmental Consultants	0	1
Digby Wells and Associates	2	4
Durban University of Technology	2	2
Emanti Management (Pty) Ltd	2	3
Environmental Business Strategies cc	1	1
GEOSS	1	1
Golder Associates Africa (Pty) Ltd	5	8
Industrial and Urban Infrastructure (Pty) Ltd	2	2
Maluti Water	2	2
Mvula Trust	2	2
National Museum, Bloemfontein	0	1
Nelson Mandela Metropolitan University	2	4
Nepid Consultants	1	1
Ninham Shand	3	5
NMMU	0	1
Partners in Development cc	2	2
Pegram and Associates	0	1
PICWAT	2	2
Pulles, Howard and de Lange (now with Golder)	3	5
Rand Water	10	16
Rhodes University	21	29

Organisation	Number of disadvantaged students	Total number of students
Rural Integrated Eng	7	8
SA Institute for Aquatic Biodiversity	8	15
SASRI	3	3
SAWS	3	4
Sigma Beta	1	4
Siyaphambili Development Consulting	2	2
Source Strategic Focus	3	3
Southern Waters Ecological Research and Consulting	2	7
SRK	6	8
Sustainable Environmental Technologies	1	1
TBR Project	1	1
Tshwane University of Technology	23	24
Umgeni Water	8	10
Umhlaba Consulting	1	3
University of Cape Town	20	50
University of Fort Hare	14	14
University of Johannesburg	5	11
University of KwaZulu-Natal	43	69
University of Limpopo	2	2
University of Pretoria	21	37
University of Stellenbosch	21	31
University of the Free State	14	26
University of the North West	3	14
University of the Western Cape	32	42
University of the Witwatersrand	13	17
University of Venda	4	4
William Harding	0	1
Zakhe Training College	2	2
Zitholele Consulting (Pty) Ltd	1	1
<b>Total</b>	<b>381</b>	<b>580</b>

# Introduction (continued)

One of the important areas requiring the building of competence is that of local government. The WRC serves as the implementing agent for DWAF with regard to the Water Information Network (WIN-SA). The WIN-SA sector initiative is growing in strength. WIN-SA is aimed at knowledge sharing and capacity building for local government.

## *Investing in the creation of water-centred knowledge*

### *Investing in the creation and sharing of knowledge*

Water is fundamental to life: water quantity and quality are keys for quality of life, the health and well-being of both human beings and the environment and the country's economic and social sustainability. Having sufficient water of good quality is a continuous challenge facing South Africa. Since South Africa is located in a semi-arid geographical zone, the country views its water as a scarce commodity. Thus, South Africa is characterised by a continual quest for innovative ways of using water optimally. Wise/effective ways of managing water will result in 'having more for less'. Effective management necessitates having the right knowledge and information at one's disposal. During 2006/07 the WRC continued to serve the South African Government and, more specifically, the Minister of Water Affairs and Forestry, its shareholder, DWAF, and supported the water sector and all relevant institutions and partners by providing them with high-quality and appropriately packaged knowledge to inform the decision-making processes and the application of technology which relates to water resource management and the provision of water and sanitation services. The WRC supported policy development and implementation through the provision of the required knowledge.

The WRC continued to address the issue of climate change. Climate change and the linked phenomena of extreme events require both understanding and adaptability. This is again a key challenge facing South Africa as espoused by the Minister. The WRC supports South Africa in its endeavours to develop adaptive strategies to ensure the sustainability of the country's water resources and services in the face of continuous changes in climatic conditions and potential extreme

events, which may severely affect existing infrastructure or further diminish our scarce water resources.

With regard to knowledge dissemination, the WRC continues to search for different mechanisms to improve knowledge sharing, dissemination and transfer. During 2006/07 the WRC finalised 72 research projects and published 105 research reports, which were distributed widely within the water sector. In addition to publishing research reports, regular publications such as *Amanzi*, the *Knowledge Review* and *The Water Wheel* and a number of policy briefs, the WRC undertook two Open Days and many technical workshops aimed at sharing knowledge.

The research portfolio of the WRC for 2006/07 was developed based on a needs analysis including medium- to short-term as well as explicit and implicit needs. South Africa's water problems/issues are reflected in this portfolio with the aim to scientifically build the required solution and, where possible, the capacity for its use. The process of setting the research portfolio was a result of many interactions at various levels with both the local and the global water sectors. The portfolio was also informed by scientific developments which can be applied to water research so as to provide beneficial solutions.

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. The Institutional Review also supported the research portfolio and the KSA-based structure, with its four water-centred KSAs (as mentioned above), supported by the knowledge-centred KSA. This structure continued to form the core operating framework for WRC-funded R&D and was further consolidated during the year and became accepted generally.

During the year under review, the WRC supported 314 research projects, of which about 77% (243 projects) were active projects (ongoing and new) and about 23% (71 projects) were finalised. The active projects comprised 187 ongoing projects and 56 newly initiated

projects that commenced during 2006/07. The various mechanisms of funding included both non-solicited projects, accommodating projects within the broad research strategy of each KSA, and solicited projects, where research projects are developed in accordance with clear terms of reference, aimed at solving specific problems. The WRC supported 67 solicited projects, which translates to about 28% of active projects.

In comparison with the previous year, the year 2006/07 shows a 6.5% decrease in the number of projects, i.e. 314 projects vs. 336 projects in 2005/06. This is a slight reduction compared to the 26% reduction reported during the previous year (number of projects was reduced from 454 (during 2004/05) to 336 (during 2005/06). This indicates that the drive for improvement of project management has resulted in achieving a reasonable number of projects. In addition, this trend reflects a strategic drive to address the needs of the South African water sector where research problems are often very complex and require larger projects of a multidisciplinary nature. As indicated by the number of active projects the trend in reduction of overall project numbers is not affecting the number of current ongoing projects. The number of active projects is similar to that of previous years with a difference of less than one per cent deviation (i.e. two projects, 245 in the previous year and 243 projects during the year under review). However, there is an increase in the proportion of ongoing projects as a percentage of total active projects, while the number of newly initiated projects has been slightly reduced. During the year under review 56 new projects have commenced while the previous year indicated 70 new projects. The reduction of the number of new projects is directly related to the number of ongoing active projects.

### *Utilisation of funds by the various KSAs*

The percentage utilisation of research project funds (based on amounts actually paid out) by the KSAs during 2006/07 indicates that about 49% in comparison to about 46% (2005/06) was invested in projects that focused on water resources (including water-linked ecosystems) and about 51% (compared to 54% (2005/06)) in projects that focused on water utilisation (including effluent treatment and management, as well

as agriculture). This is based on the actual amount paid out to projects during the current financial year. The allocation of about 50% of the fund to issues related to resource management and 50% to water utilisation is ongoing and was supported by the recommendations from the institutional review.

Based on cash paid out, the overall investment in research projects (knowledge creation) was about R60m. This amount (paid out for research projects) reflects a 6% deviation from last year (R63.9m. during 2005/06).

Investment in the total support of knowledge creation, sharing and dissemination amounted to R85.5m. (including about R4.8m. for WIN-SA and other income leveraged for research projects during the year under review). Both the investments in research projects and in research support, expressed as a percentage of total expenditure, were close to the set budgeted ratios

(a maximum of 3%). The ratio addressing funding of the creation of new knowledge (research projects only) is the same as in the previous year. The ratio for research support is also similar to that of the previous year with only 2% difference).

### ***Making knowledge application a reality – commercialisation***

During the year under review, knowledge application, i.e. transferring of various technologies, processes and/or products developed with the support of the WRC continues to be a challenge. It required the understanding of issues of intellectual property (IP) and commercialisation. The WRC is continuing in its drive to provide the country with applied knowledge and water-related innovation. In addition, the WRC is supporting water-related innovation and its commercialisation where applicable. Often, these technologies, processes and products require commercial involvement in order to make them available

for use. With creative licensing strategies, the WRC can assist in fostering sustainable development, which, in the WRC's view, will allow transfer of technology with the aim of promoting a better quality of life for all. In this connection, a high percentage of the patent portfolio is licensed out. During 2006/07, the WRC continued in its effort to license and earn income from its licensed IP. A new IP manager has commenced duty during July. The WRC also aims to build awareness and improve IP management internally and at academic institutions. The WRC is currently developing guidelines to deal with the procedure for disclosure and commercialisation of its IP portfolio.

*This publication is an abridged version of the WRC 2006/07 Knowledge Review. The complete text is available on the CD which is attached.*

# 1 KSA 1 Water Resource Management



**Ms Eiman Karar: Director**

## Scope

The strategic focus for research in this key strategic area (KSA) is largely guided by the principles and objectives of the National Water Act (NWA) of 1998. The primary principle of the Act is that water resources should be managed to achieve optimum long-term social and economic benefits for all; this implies maintaining an optimum balance between protection of the environment and efficient utilisation. This KSA supports the implementation of the policy by developing tools and technologies for water resource assessment, guidelines and decision-support systems to support decision makers in achieving equitable and efficient allocation of water resources among competing needs.

The research puts emphasis on multidisciplinary approaches that provide decision makers and planners with appropriate tools that enable them to take cognizance of social, environmental and economic factors in the planning of water resource development.

The research focus continues to shift from supporting policy making to providing guidance for policy implementation and development of policy instruments. The challenge for research in this KSA is to provide the necessary information systems, guidelines, decision-support systems, prediction tools and technologies/methodologies that support protection of water resources and equitable allocation of water to meet the needs of the

environment, social and economic development. The NWA puts emphasis on the stakeholder participation in water resource management; this requires effective participatory tools and approaches that can support multi-stakeholder participation in water resource management at catchment level.

## Objectives

The primary objective of research in this KSA is to ensure that 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. Thus the revised aims to support the primary objective are to:

- Develop a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impact to humans)
- Provide control measures for improving the prevention, mitigation and control of pollution of water resources
- Support and improve policy reforms for promoting equitable, efficient and sustainable conservation and allocation of water resources among competing needs

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

**Thrust 1:** Water Resource Assessment and Development

**Thrust 2:** Management of Natural and Human-Induced Impacts on Water Resources

**Thrust 3:** Water Resource Protection

**Thrust 4:** Policy Development and Institutional Arrangements for Water Resource Management

## Thrusts and programmes

### Thrust 1:

#### *Water Resource Assessment and Development*

**Scope:** This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa.

- Groundwater hydrology
- Catchment hydrology
- Understanding and predicting hydro-climatic variability
- Development of appropriate techniques for evaporation monitoring
- Water quality assessment studies and information systems
- Real-time mapping of daily rainfall over South Africa

### Thrust 2:

#### *Management of Natural and Human-induced Impacts on Water Resources*

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

- Developing predictive tools and adaptive measures to global climate change
- Human-induced impacts
- Integrated flood and drought management

### Thrust 3:

#### *Water Resource Protection*

**Scope:** Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources,

and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater

- **Groundwater protection**
- **Protection and management of surface water quality**
- **Urban water resource management**
- **Low flows and streamflow reduction activities**

#### **Thrust 4:** *Policy Development and Institutional Arrangements for Water Resource Management*

**Scope:** This thrust focuses on instruments supporting effective water resource management, ranging from support for the development of appropriate policies and their implementation to research concerning the establishment of governing bodies and institutional arrangements (at catchment, national and transboundary levels). The thrust supports research on tools and methodologies for decision support for IWRM, aims to provide strategic support for new policy development and improve the understanding regarding the effective functioning of institutional structures for implementing IWRM.

- **Decision support for IWRM at catchment and WMA level**
- **Water policy development and strategic policy support**
- **Institutional arrangements and processes for IWRM at catchment, WMA and national level**
- **Transboundary water resource management**
- **Governance, law and regulation**
- **Integrated catchment management**

#### **Research portfolio for 2006/07**

The knowledge base generated in this KSA will help South Africa to move away from a sectoral approach to water resource management to a more integrated approach that promotes co-ordinated development of water, land and related resources in order to achieve social equity and economic growth. The research will continue to contribute to the development of a skilled and competent pool of experts who can support the implementation of national water policy and also provide leadership for the sector at regional

and global levels. The current emphasis of the research portfolio continues to support the implementation of the National Water Resource Strategy through the following broad ways:

- Through integrated water resource assessment (developing knowledge of the different components of the resource in terms of quantity and quality and its condition in relation to reference conditions)
- By developing and refining tools and methods to support implementation of resource-directed measures (RDMs) and source-directed controls (SDCs)
- By providing greater understanding of threatening process to water resources such as global climate change, water resource degradation, over-commitment of the resource, and impacts of land use and water storage and diversion on the water resource
- By providing tools for the assessment of policy and management options (such as modelling, decision-support systems, and predictive tools)
- By providing data and tools for assessment of the progress of resource management programmes, and their successful refinement.

The research community during the past funding cycle has been given an opportunity through the non-solicited proposal stream of funding to respond to the water resource management challenges. In 2006/2007, the opportunity will be given to research community to respond to the water resource management challenges through both the solicited and non-solicited proposal streams of funding. Continued consultation with stakeholders will take place at local and regional level. This will be an important task to identify future research needs and priorities.

#### **Budget for 2006/07**

The approved funding of the research portfolio for 2006/07 leads to a committed funding budget of R28 415 046. The focus of this portfolio will continue along the current trends.

**Herewith a list of the new projects which commenced between 1 April 2006 and 31 March 2007.**

## **Core Strategy**

### **Strategic context**

South Africa has a high-risk hydro-climatic environment. This is illustrated by mean annual precipitation (MAP) that ranges from < 100 mm to over 1 200 mm, with an average of approximately 490 mm. Linking this low rainfall rate to the high level aridity results in a mean annual runoff (MAR) of less than 10% - a very low percentage when compared to the world average. However, it is not the average conditions that complicate water resource management per se but rather issues such as inter- and intra-annual variability of the hydrological system or the differing responses of the various components of the hydrological system to rainfall variability.

Nevertheless, sufficient water resources have been developed to date for South Africa (about 320 dams) to ensure that all current requirements for water can be met without impairing the socio-economic development of the country. The storage capacity of the dams is in the order of 32 400 x 106 m3/a. This represents 66% of the total MAR of 49 000 x 106 m3/a. This high development and regulation of water resources has caused significant changes in the flow regimes of rivers resulting in negative impacts on the environment and loss of ecosystem functioning. Further, the outcome of poor land-use practices has resulted in sedimentation of river channels, lakes and reservoirs, and changes in hydrological processes.

In addition, deterioration of the quality of water resources is due to increases in salinity and nutrient loads from irrigation (irrigated agriculture) and also the domestic, industrial and mining sectors. Increased human activities have led to the exposure of the water environment to a range of chemical, microbial and biological pollutants as well as micro-pollutants. The mining and industrial sectors, especially, produce high concentration of wastes and effluents that act as non-point sources of water quality degradation and acid mine drainage.

Despite the above complexities, the development of water resources has supported both economic and social development in South Africa. In the economic sector, water has been utilised for industry, mining, hydropower generation, infrastructure and

# 1

## KSA 1 (continued)

### Water Resource Management

transport purposes providing South Africa with export earnings. In the agricultural sector water resource development has resulted in well-needed employment through subsistence and commercial agriculture, livestock production, fisheries and tourism. The provision of safe water supply and sanitation to many communities in South Africa has been important to reduce morbidity and mortality rates of waterborne and water-related diseases such as cholera, diarrhoea and malaria.

However, to continue to provide the above economic security and social well-being, the water resource base requires protection. Environmental degradation is inextricably and causally linked to problems of poverty, hunger, gender equality and health. The scale of water resource issues is best formulated in a number of critical issues that research needs to address in water resource management:

- Will there be sufficient water to support both the environment and future economic growth taking into account international rights and obligations and water use of strategic importance?
- Will we be able to allocate water resources equitably while coping with extreme events such as floods and droughts due to global warming?
- Can water quality be maintained and enhanced?
- Will reforms in the water sector:
  - Bring us closer to the millennium development goals (MDGs)?
  - Ensure broad and effective participation in water resource management?

Science, technology and innovation will be critical to address the above complex challenges. This is because water resource managers will need to make informed choices in an environment of conflicting and uncertain alternative actions, which are best made with the full benefit of research and analysis. Clearly the need for improved, more efficient management of water resources and the more accurate knowledge of the hydrological cycle for better water resources assessment underlines the need to implement a system approach which includes the social, environmental and economic dimension for a sustainable development.

Thus, in line with WRC aims, the KSA intends to provide the country with applied

knowledge and water-related innovation, by translating needs into research ideas and, in turn, by transferring research results and disseminating knowledge and new technology-based products and processes to end-users.

#### Needs analysis

The KSA aims to be pro-active and responsive to the water resource management needs in South Africa. Therefore, the KSA needs a strong relationship with its stakeholders and needs to adopt several approaches to improve its understanding of the water sector's needs and aspirations.

Through this process a number of outcomes are envisaged which include:

- Establish research needs
- Identify diverse perspectives on research issues
- Get or buy-in/ownership of the research portfolio
- Establish legitimacy of the research portfolio
- Achieve balance in the research portfolio
- Identify critical issues
- Profile stakeholders
- Achieve active engagement
- Establish partnerships
- Establish support base for water research.

The methodologies followed in the needs analysis process are varied and include:

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

During 2005 a series (6 in total) of workshops was held with a number of stakeholders in various provinces. These workshops were a follow-up to national workshops held by KSA 1 and KSA 2. The national workshops contributed to the development of strategic focus issues, research needs and priorities for future research as well as methods of operation. The next stage in the process involved a further participation process to derive input from a wider range of stakeholders to refine the outcomes of the initial workshops and to incorporate local ideas, suggestions, needs and requirements. The participants were drawn from spheres of government, water boards, research institutions and universities.

The themes for discussion included: building end-user awareness and capacity, technology transfer to implementers and research needs/issues. Most of the recommendations have implications wider than the WRC. Some of the pertinent issues related to the development of the research portfolio are:

- End-user awareness and capacity
  - A deeper understanding of water issues needs to be developed in end-users rather than only a notional understanding
  - Awareness building needs to support the implementation processes
  - Knowledge is required about local issues, areas and systems
  - The WRC needs to coordinate and engage with partners to promote training in the water sector (including capacity building projects between government departments).
- Technology transfer to implementers
  - The research portfolio need to incorporate tools for transferring and sharing knowledge i.e. training programmes, models and decision support systems, special events, case studies, pilot applications, media etc.
  - Research projects need to define the end at the beginning and involve end-users in the research process.
- Research needs/issues
  - The implications of mine closure to the water environment (groundwater strategy for regional closure, disposal of brine from groundwater desalination plants, apportionment of liabilities with respect to impacts of ground- and surface waters, decanting and abandoned mines)
  - Developing an understanding of ground- and surface interactions
  - Developing equitable mechanisms for allocation of water resources
  - Developing management strategies for development of river and estuarine margins, wetlands, lakes, impoundments, groundwater and catchment areas
  - Developing water information and monitoring systems
  - Groundwater development in primary and dolomitic aquifers
  - Protection of water quality (eutrophication, radioactivity etc.)

- Understanding of impacts of recreational use on water resources
- Issues addressing water resource use for recreation purposes
- Addressing sedimentation issues (brought down by rivers, marine ingress, etc.)
- Strategic water resource planning (alternative sources, trans-boundary issues etc.).

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

- Through integrated water resource assessment (developing knowledge of the different components of the resource in terms of quantity and quality and its condition in relation to reference conditions)
- By developing and refining tools and methods to support implementation of RDMS and SDCs
- By providing greater understanding of threatening processes to water resources such as global climate change, water resource degradation, over-commitment of the resource, and impacts of land use and water storage and diversion on the water resource
- By providing tools for the assessment of policy and management options (such as re-allocation of water between users,

modelling, decision-support systems, and predictive tools)

- By providing data and tools for assessment of the progress of resource management programmes, and their successful refinement.

While providing research support to implement the NWA is crucial to the KSA's business, this KSA needs to support water resource management actions at global, regional and local level. In addition to challenges, identified at the 2nd World Water Forum, four further global challenges have been identified for the future:

- **Water and cities:** Acknowledging that urban areas are increasingly the focus of human settlements and economic activities, and that they present distinctive challenges to water managers
- **Water and industry:** Focusing on industry needs and the responsibility to respect water quality and taking account of the needs of competing sectors
- **Water and energy:** Recognising that water is vital for all forms of energy production, and that there is a need to ensure that energy requirements are met in a sustainable manner
- **Ensuring the knowledge base:** Reflecting that good water policies and management depend upon the quality available to decision-makers.

The outcomes of the above process were incorporated into the KSA's strategic processes and will assist in identifying future research projects and programmes (including priority-setting). The KSA aims to continue to be proactive and responsive to the water resource management needs in South Africa.

### *Overview of technological trends related to needs*

Research on water resource management, especially water resource assessment studies, has been characterised by the general trend towards improving the levels of detail and accuracy in water resource observations and modelling techniques. A number of projects have been initiated to address knowledge gaps in water resource processes and how these can be simulated in areas that are deficient in data and information. The knowledge gained through research on hydro-pedology, process hydrology and other water resource processes has made improvements in understanding surface water/

groundwater and water quality interactions possible in a number of local environments. Water resource modelling processes and concepts are set to be gained through further improvements which will be based on knowledge documented in recent research projects on water resource processes.

Limited availability and poor quality in data on land surface variables is still a major challenge in water resource management. The installation of additional field gauges such as the recently commissioned rainfall gauges on some mountain tops especially in the coastal regions, the increased access to radar and satellite data sources through better cooperation with international space agencies and institutions that collect satellite data have continued to supplement the much needed resources in water resource management research. The WRC has supported new installations of water resource data recording tools. Most of these installations are targeted at addressing data requirements in specific projects, with provisions to accommodate other projects that will require the same tools in the future. Important recent acquisitions of data observation tools have included surface layer scintillometers (SLS), with a number of researchers benefiting from the use of large aperture scintillometers (LAS) for agrometeorological and hydrological studies.

The WRC and CSIR have collaborated in the acquisition and use of eddy covariance systems for water use monitoring in commercial forests, alien plant forest and various types of natural forests. With increased field instrumentation, especially the use of more demanding equipment that can measure several hydro-climatic and soils variables at very short intervals of a few seconds, our project teams continue to face a number of challenges in their research work. These challenges include the increased data observation costs, shortage of adequately competent human resources to analyse and use observed data, remoteness of most measurement areas, higher security requirements at measurement sites, lack of continuous power supply, difficulty in collecting large volumes of continuous records at short intervals and worst of all, vandalism as well as theft in some areas. The WRC has been involved in addressing most of these challenges on field-based case studies. Of interest to local technological trends, was the establishment of continuous and reliable flow of observed

# 1

## KSA 1 (continued)

### Water Resource Management

records. The GPRS Direct to Web technology which utilises the GSM cell-phone network to deliver data directly from field sites to a web server was used. Measurements are now consistent and timeously recorded and saved at regular time intervals. This GSM- and internet-based technology has made it possible to use a range of measurement intervals which stretch from a few seconds to several hours or days. This technology, when coupled to high performance data analysis software, the super-fast PCs with processors of several GHz will allow recording analysis and interpretation of large volumes of data that could never be imagined using manual techniques. Security breaches and equipment malfunction are also reported to technicians at their remote locations using the same GPRS Direct to Web technology.

The South African climate is characterised by highly variable rainfall regimes with increasingly higher incidences of drought and flood conditions. In the dry seasons and drought periods many of the rivers are usually meandering low flow or dry channels, while floods bring fast flowing and highly scouring conditions in the river channel and surrounding catchment areas. The design of sediment extraction works is usually dependent on imported guidelines and technology which frequently results in the construction of poorly performing structures. In a recent WRC project researchers have identified the shortcomings of imported sediment abstraction technology and developed hydraulic guidelines for the layout, design and maintenance of river diversion structures in South Africa. The documents which were published from this research are expected to provide further guidance to local design, construction and maintenance of sediment extraction works.

The steady improvement in remote sensing technologies that has taken place in the recent past and is expected to continue into the future is creating opportunities for better water resource assessment and management. Although research has already contributed to realisation of some of these opportunities, great potential exists for further exploitation of these technological trends for the benefit of the water sector.

Examples of value already added by previous WRC research in this connection include the following:

- The use of radar, in conjunction with airborne sensors, to gain an adequate understanding of rainfall processes in clouds and develop the ability to augment rainfall through appropriate in-cloud intervention
- The use of radar and satellite data in conjunction with ground-based observations in an integrated real-time system for measuring and mapping rainfall over South Africa
- The use of integrated rainfall measuring systems in conjunction with real-time river-flow modelling to generate GIS-based flood forecasts.

Improved satellite observation capabilities are constantly opening fresh avenues of investigation into hydro-climatological processes (e.g. heat storage and evaporation) over both land and ocean surfaces. Such investigations are the key to better understanding of climate variability and therefore climate prediction and ongoing water resource assessment. Prospects of continuous monitoring of soil moisture content from space have also been enhanced. Results, used in conjunction with appropriate numerical models, will further enhance accuracy of streamflow and flash flood forecasting.

The resource water quality is continuously deteriorating through human related activities. The microbial water quality is influenced by the growing informal settlements near water resources where the lack of sanitation mostly contributing to the load of pathogens to the water environment. Whilst the chemical water quality deterioration are caused by industrial and agricultural activities. Monitoring of water quality could be very expensive and new means of assessing the health risk to humans and animals and the ecological systems needs to be developed. This could include modelling of the water quality and the development of risk evaluation tools that would be cost effective and could be used to manage the resource water quality.

New developments in this regard are being investigated to be adapted for the SA conditions and needs.

#### Key stakeholders

The major stakeholders remain the same and fall within three groups:

- 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

- Major water users including farmers, mines, industries, water service providers and civil society
- South Africa shares many rivers with its neighbouring countries, therefore, the governments and major water-user groups from these countries constitute the 3rd 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 the key stakeholders.

### Strategic Initiatives Undertaken During 2006/07

#### National initiatives

Members of the KSA served on the executive committees of the following learned societies:

- South African National Committee for the International Association of Hydrological Sciences (Committee Member)
- National Disaster management Advisory Forum (Committee member)
- WISA Council member
- Member of the WISA Management sub-committee.

The KSA is also involved in a number of national working groups/project steering committees:

- Member of the Technical Advisory Group (TAG) on Water systems planning (DWAF – Water Resource Planning Directorate)
- Integrated Water Resource Planning Systems User Forum (Renias Dube)
- Various recruitment interview panels for DWAF
- WISA 2008 Organising Committee
- External Examining for the IWRM Honours course at the University of KwaZulu-Natal
- International Hydrological Programme
- HELP 2007 organising committee

The KSA is also facilitating the authors writing workshop for the book by the Resources for the Future Publishers (RFF) and initiated by the World Bank book on Policy Frameworks

for Transforming Water management in South Africa 13-15 March. The KSA is the lead author for the chapter on 'Democratising Water Management through Institutional Reforms':

Discussion forums were held with a number of local stakeholders to introduce the KSA research portfolio and strategic intent. This included meetings between Siemens and DWAF, HSRC; gender portfolio, Intercede joint venture between CSIR and SIWI on Transboundary Waters.

The KSA took a major part in the training of the Parliamentary Portfolio Committee on IWRM.

### National Workshops

- The Water Summit, May 06
- Water Services Leadership Group annual workshop
- DWAF Compliance and Enforcement formative workshop
- DWAF/IWMI annual Forum
- Catchment management Strategy National Roadshow
- Waste Discharge Charge System final launch
- DWAF/WRC strategic planning workshop
- Crocodile-West Marico CMA launch
- Women in Water Award
- Water research show cases at the University of Pretoria
- DWAF – RDM Strategic Planning session
- Inaugural Meeting of the South African National Committee for UNESCO-IHP
- DWAF – Artificial Recharge Strategy
- Groundwater resources management and protection in Africa.

Research conducted by this KSA has been mentioned in the media (including radio interviews):

- Water Scarcity in a programme: Rights and recourse, SABC 3. Feb 07
- Dr Mhita radio and TV Nov 06
- Water and Sanitation Dr Mhita
- Water and Sanitation IWRMP
- Amanzi, April, June, August and Dec 2006 issues
- Licence to Limit – Groundwater Use Authorisation Under Scrutiny Water Wheel V5 No.2, April 2006
- Building an Evaporation Monitoring Toolkit Water Wheel, V5 No. 4. July 06

- Database Helps SA Keep Pledges to Neighbours Water Wheel, V5 No. 5 August 06
- CLIMATE CHANGE: The Last Straw for Communities at Risk? Water Wheel V5, no. 1 Jan 07
- Water The Tie That Binds Eastern Cape Community. Water Wheel V5, No. 1 Jan 07

### African initiatives

- A presentation was delivered to a Mali Delegation visiting the WRC
- Presentation was made to the Inter Academy Panel (IAP) during their conference hosted by the WRC
- An invited speaker from the KSA contributed to the All Africa Technology Diffusion Conference in SA, 2006
- Participated in the Waternet Research initiative through the University of Witwatersrand research group
- Participated and presented in the African Water Workshop (FP7 project) hosted by the WRC
- Participated in the Southern Africa UN Habitat project annual Meeting – Limpopo Basin Study.

The WRC is involved in a WaterNet-led Challenge Programme (Project PN 17) in the Limpopo Basin: The Challenge of Integrated Water Resource Management for Improved Rural Livelihoods: Managing Risk, Mitigating Drought and Improving Water Productivity in the Water Scarce Limpopo Basin.

### International initiatives

- The KSA attended an International Development Law Organisation course on Law, governance and regulation in IWRM. The KSA then joined the alumni and organised for the same course for SADC. The course was hosted by the WRC for capacity building; local participation was sponsored by the WRC. Another course will be organised for the Parliamentary Portfolio Committee on Water upon their request during the course of this financial year.
- As a Steering Committee member of the CGIAR Comprehensive Assessment, the KSA chaired a one day session at the Stockholm World Water Week.
- The KSA attended the Water Information Summit for the South and North Americas upon invitation.

- The first African Water (WRC/EU joint project) steering committee meeting was attended by the KSA.
- Spanish Science and Technology delegation's visit to South Africa. SA-Spain Joint Scientific Workshop. Workshops dealt with the identification of suitable research topics for bi-national cooperation. Groundwater component – Shafick Adams.
- The KSA was involved in the revitalisation of the International Hydrological Programme (IHP) National Committee. The IHP is a programme under the auspices of UNESCO to address water resource management issues. As a result a South African bid for a symposium 2007 was prepared with the title 'Hydrology for the Environment, Life and Policy (HELP) in Action: Local Solutions to Global Water Problems Lessons for the South'.
- The KSA is a Collaborator in the TIGER remote sensing and GIS partnership. Project K5/1683 involves the use of this partnership in integrating our research into the European Research groups working on Soil moisture monitoring using satellite images. A workshop was organized where the European partners from Vienna and our local researchers interacted and shared thoughts and knowledge on the use of radar satellites in soil moisture assessments.

## Growing the Knowledge Base

### Capacity-building initiatives

Progress to date on ongoing projects indicates that the number of students undergoing post-graduate training at tertiary institutions under WRC-funded projects in this KSA was estimated as 163 in total, of which 98 students are from previously disadvantaged backgrounds (see table below). In total 16 project leaders are women (in 05/06 the total was 29) and 9 project leaders are Black males (12 in 05/06). This is in line with the set targets. This figure represents approximately 24% and 15%, respectively of total projects (was at 25% and 15% respectively in 2005/06).

The table below illustrates the number of post-graduate students who benefited from WRC-funded research in this KSA. This is in line with the set targets.

# KSA 1 (continued)

## Water Resource Management

Contractor	Students from disadvantaged backgrounds	Total
Conningarth Economists	3	3
CPH Water	1	1
CSIR	7	9
GEOSS	1	1
Maluti Water	2	2
Ninham Shand	3	5
NMMU	0	1
North-West University	0	9
Pegram and Associates	0	1
Rand Water	2	2
Rhodes University	0	3
SAWS	3	4
Siyaphambili Development Consulting	2	2
Source Strategic Focus	3	3
Southern Waters Ecological Research And Consulting	2	7
SRK	6	8
University of Cape Town	6	15
University of Free State	5	9
University of KwaZulu-Natal	13	24
University of the Western Cape	25	31
University of Pretoria	5	12
University of Venda	4	4
University of Stellenbosch	4	4
William Harding	0	1
University of the Witwatersrand	1	2
Total	98	163

### *Knowledge-sharing and leadership*

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). During the course of 2006, staff participated in both the WRC Open Days held at the Universities of Western Cape and Pretoria.

The following workshops were held in support of research outcomes related to:

- The Impact of Deep Rooted Trees on the Hydrological Balance (UKZN, -19 September 2006)
- National Water Resource Assessment and Planning - 23 April 2006
- River Hydraulics Research
- Improved Estimates In Water Resources Assessments Using Hyperspectral Imagery (UKZN – 15 May 2006)
- Design Flood Hydrology Methodologies for Dam Safety – 8 May 2006 (Cape Town)
- Surface Water Resources of South Africa – 29 May 2006
- Soil Moisture Measurement from Space – 23 November 2006
- Meetings and workshop with Prof. Dr. Dr. Heinrich H.D. Meyer from the Technical University of Munich, Germany 8-11 August on the WRC Veterinary Compound & Health Project (No. K5/1686)

### **Some other external workshops / conferences**

- Attended WISA Conference (21- 25 May 2006)
- Attended the TIGER International Workshop (20 November 2006)
- European South African Science and Technology Advancement Programme (ESASTAP) – 26 September 2006 Parliamentary Training Session – January 2007
- UNESCO IHP Meeting – 20 September 2006
- South African Weather Services - International Conference on Extreme Weather events – 9 to 10 May 2006
- UWC Open Day - 4 July 2006
- Strategic Planning – 31 July 2006
- Water Resource Management in Africa – 16 August 2006
- WaterWatch: Combining Remote Sensing and Economic Analysis to Assess Water Productivity - a demonstration project in the Inkomati Basin (23 August 2006).

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

- 35 technical reports
- Popular articles (The Water Wheel)
  - Licence to Limit – Groundwater Use Authorisation Under Scrutiny. The Water Wheel V5 No. 2, April 2006
  - Building an Evaporation Monitoring Toolkit. The Water Wheel, V5 No. 4. July 06
  - Database Helps SA Keep Pledges to Neighbours. The Water Wheel, V5 No. 5 August 06
  - Climate Change: The Last Straw for Communities at Risk? The Water Wheel V5, No. 1 Jan 07
  - Water the Tie That Binds Eastern Cape Community. The Water Wheel V5, No. 1 Jan 07

### *Implementation Plan*

#### *Research portfolio for 2006/07*

The primary objective of the research in this KSA remains the same as developed for 2005/06. However, the secondary aims have been streamlined to reflect the needs analysis process. Thus the primary objective is to ensure that water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research portfolio for 2006/07 addresses this primary objective as reflected by the following revised aims to:

- Develop a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impact to humans)

- 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.

The research portfolio for 2006/07 is presented in Table 1, which provides an overview and description of research thrusts and programmes. The plan reflects changes in the portfolio from the previous plan based on feedback from the needs analysis, and consultation with stakeholders and Board input. These are:

- Redefining the thrusts and programmes as reflected in their descriptions
- Integration of the current Thrust 2: Integrated Water Resource Development into the other thrusts
- Development of the new Thrust 3: Water Resource Protection
- Changing the programme Groundwater Occurrence in Fractured Rock Aquifers to Groundwater Hydrology to reflect an emphasis towards quantification and well-field identification
- Collapse of the programme Institutional Development and Collaboration in the Eastern Cape into the other programmes of the various thrusts.

Table 1 presents a research portfolio of current projects that are grouped into strategic thrusts and programmes which address the objectives of this KSA.

#### *Expected outcomes*

The knowledge base generated in this KSA will continue to assist South Africa to move away from a sectoral approach to water resource management to a more integrated approach that promotes co-ordinated development of water, land and related resources in order to achieve social equity and economic growth. The research will also contribute to the development of a skilled and competent pool of experts who can support the implementation of the national water policy and also provide leadership for the sector at regional and global levels.

# KSA 1 (continued)

## Water Resource Management

**Table 1**  
Overview and description of thrusts and programmes for KSA 1

<b>Thrust 1: Water Resource Assessment AND DEVELOPMENT</b>	
<b>Scope:</b> This thrust focuses on developing a scientific understanding of the hydrological cycle (and inter-linkages) in order to promote a systematic assessment and variability of the quantity and quality of water available for development in South Africa.	
<b>Programme 1:</b> <i>Groundwater hydrology</i>	<b>Scope:</b> This programme focuses on improved understanding of groundwater resources. The programme attempts to: Characterise various geological provinces in terms of groundwater occurrence and development potential; develop techniques and protocols for groundwater exploration; estimate aquifer parameters using innovative techniques, and develop systems for better resource managements.
<b>Programme 2:</b> <i>Catchment hydrology</i>	<b>Scope:</b> This programme seeks to establish and continuously provide current information on how much water is naturally available in South Africa and its distribution in time and space. The programme links the climate, vegetation, soil, and water management variables to water flows in an integrated perspective for the better management of South African catchments. The hydrology of South Africa is characterised by very high natural variability in space and time and for management purposes research needs to provide a scientific explanation and adequate quantitative understanding.
<b>Programme 3:</b> <i>Understanding and predicting hydro-climatic variability</i>	<b>Scope:</b> The ultimate goal of this programme is to better forecast the variability of rainfall, flow and groundwater recharge. This is of great importance for water resource management. The ability to forecast at very short time scales (48 down to a few hours ahead) would greatly benefit flood management and disaster mitigation activities. At longer time scales (e.g. inter-annual or seasonal scales) the ability would greatly assist decisions concerning seasonal water allocation to various users and the environment. Forecast models range from the empirical (based on statistical relationships using various oceanic and atmospheric predictors) to the mechanistic (based on the use of dynamic models encapsulating best understanding of influential atmospheric and oceanic processes). The latter are usually scale-specific. Therefore, because rainfall at local scale depends on processes operating at all scales, forecasting by means of the dynamic modelling approach depends on learning, through projects in this programme, to use different-scale and different-type models interactively, while ensuring that local forcing factors such as topography, soil moisture, etc. are adequately accounted for.
<b>Programme 4:</b> <i>Development of appropriate techniques for evaporation monitoring</i>	<b>Scope:</b> Actual evaporation (transpiration included) is the most poorly quantified and, after rainfall, the largest single component of South Africa's water budget. Variations in evaporation greatly influence the amount of water available for all uses. Uncertainties in measuring or estimating evaporation have a profound effect on the reliability of water resource assessment. In this programme, research which investigates and delivers improved methods of evaporation measurement and estimation will be undertaken.
<b>Programme 5:</b> <i>Water quality assessment studies and information systems</i>	<b>Scope:</b> 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 level, improve the way in which water quality information is conveyed and the identification of emerging water quality issues.
<b>Programme 6:</b> <i>Real-time mapping of daily rainfall over South Africa</i>	<b>Scope:</b> Rainfall, the primary input into South Africa's water budget, is poorly estimated by the current national rain-gauge network which provides an insufficient (and steadily declining) number of point measurements, also inadequately distributed over South Africa's surface. Recognising these serious inadequacies, the WRC, in 1993, initiated investigations into the feasibility of integrating rain-gauge and remote sensing (radar, satellite) technologies in developing a national system for the spatially continuous measurement of rainfall in real time, which would satisfy all water resource assessment requirements. With several pilot studies successfully completed, this programme now researches the implementation of a country-wide rainfall monitoring system.

## Thrust 2 : Management of Natural and Human-Induced Impacts on Water Resources

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

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

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

**Programme 2:**  
*Human-induced impacts*

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

**Programme 3:**  
*Integrated flood and drought management*

**Scope:** 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.

# KSA 1 (continued)

## Water Resource Management

<b>Thrust 3: Water Resource Protection</b>	
<p><b>Scope:</b> Research in this thrust focuses on the generation of information and understanding in order to improve water quality management, with reference to point sources as well as diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater.</p>	
<p><b>Programme 1:</b> <i>Groundwater protection</i></p>	<p><b>Scope:</b> This programme focuses mainly on identification, quantification, prediction and management of the impacts on groundwater quality of intensive land-uses. Research will be done to identify the greatest threats to groundwater quality; this will include the documentation of existing data on the extent, spatial distribution, propagation and types of contaminants and their associated sources. The programme outputs will establish:</p> <ul style="list-style-type: none"> <li>• An improved understanding of the relationship between polluting activities (sources) and quality effects in the groundwater, i.e. understanding the origin of pollutants, the pathways by which these pollutants could flow into the environment and the ultimate fate of these pollutants.</li> <li>• Options for management and mitigation of the impacts on groundwater quality of intensive land uses. The programme also investigates the natural occurrence of hazardous constituents in groundwater, with the aim of developing strategies for minimising potential negative effects on groundwater and surface water users.</li> </ul>
<p><b>Programme 2:</b> <i>Protection and management of surface water quality</i></p>	<p><b>Scope:</b> Increased industrialisation and development lead to the exposure of the water environment to a range of chemical, microbial and biological pollutants as well as micro-pollutants. Furthermore, improved analytical techniques lead to continual reduction in detection limits of pollutants. Research in this programme is aimed at providing strategies for improving the prevention, mitigation and control of pollution of surface waters, based on sound understanding of the scope, significance and impacts of changes in water quality. The programme addresses both point sources and diffuse sources of pollution, which can result from activities within the water environment or on the catchment surface.</p>
<p><b>Programme 3:</b> <i>Urban water resource management</i></p>	<p><b>Scope:</b> An integrated approach to water resource management is essential to sustainability of the urban and peri-urban cities of South Africa. In many cities, water shortages stem from inefficient use and degradation of the available water by pollution. This programme will search for a better integration of land-use and water management within the overall environmental management, standardise water quality regulations and increase incentives and sanctions for their enforcement.</p>
<p><b>Programme 4:</b> <i>Low flows and streamflow reduction activities</i></p>	<p><b>Scope:</b> Scarcity of knowledge has been identified in licensing related to low flows, in surface water – groundwater interactions and in tools for measurement of low flows when physical structures cannot be used. This research will seek to develop solutions to maintain high quality flows in river systems that comply with the Water Act of 1998. These low flows and SFR studies will provide clear directions to the licensing of SFRA and the maintenance of high quality flows in rivers. These studies will focus on developing methods or/and equipment for defining and estimating streamflow reduction due to activities such as agriculture, forestry and industry that can be used by the licensing agents. The research will support the current initiatives in the compulsory licensing of streamflow reduction activities. Methods developed should clearly stand out as the preferred solutions in South Africa through how they are proposed, developed and implemented.</p>

#### Thrust 4: Policy Development and Institutional Arrangements for Water Resource Management

**Scope:** This thrust focuses on instruments supporting effective water resource management, ranging from support for the development of appropriate policies and their implementation to research concerning the establishment of governing bodies and institutional arrangements (at catchment, national and transboundary levels). The thrust supports research on tools and methodologies for decision support for IWRM, aims to provide strategic support for new policy development and to improve the understanding regarding the effective functioning of institutional structures for implementing IWRM.

**Programme 1:**  
*Decision support for IWRM at catchment and WMA level*

**Scope:** Information, tools and methodologies for assessing and finding equitable balance between social, ecological and economic aspects of decision-making regarding protection, development, allocation and management of water resources. Determining how to influence the quantity of water use and maintain the quality of water through a combination of economic and legislative measures as well as through education and persuasion.

**Programme 2:**  
*Water policy development and strategic policy support*

**Scope:** Acquiring and interpreting information on the impact of water-related public policy and disseminating related knowledge and information to officials in government departments and representatives of water users in different use sectors. Capturing and dissemination of 'stories' (case-based) and best practices for IWRM at policy, planning and implementation levels.

**Programme 3:**  
*Institutional arrangements and processes for IWRM at catchment, WMA and national level*

**Scope:** Generating knowledge and understanding to support the design and development of appropriate institutional structures, functions and processes for the implementation of participatory IWRM, including both statutory and non-statutory organisations and social groupings. Developing appropriate business models for water management institutions. Improving understanding and tools for building capacity to manage and participate in IWRM.

**Programme 4:**  
*Transboundary water resource management*

**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.

**Programme 5:**  
*Governance, law and regulation*

**Scope:** Supporting improved understanding, consistent interpretation and further development of water law and regulation, including linkages and harmonisation with other legislation. This programme addresses customary law as well as conventional law.

**Programme 6:**  
*Integrated catchment management*

**Scope:** The programme establishes understanding of links and connectivities between the different biophysical components of the water resource system at a continuum of scales. The NWA requires water management to address the whole hydrological cycle as a single system. To do this properly, knowledge on how an intervention in one part of the system impacts elsewhere in the system must be acquired.

# KSA 1 (continued)

## Water Resource Management

### Research Projects for 2006/07

The findings for projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2006 and 31 March 2007.

### Completed

#### Thrust 1: Water Resource Assessment and Development

##### Programme 1: Groundwater Hydrology Recharge mechanisms in TMG aquifer systems

Groundwater Group, Department of Earth Science, University of the Western Cape  
No 1329

The TMG as a regional fractured rock aquifer system may still become a main source of future water supplies to augment both agricultural and urban requirements in the Western and Eastern Cape Provinces in South Africa. Although groundwater recharge is widely recognised as the key factor in determining the sustainable management of groundwater resources, no comprehensive study of groundwater recharge of TMG aquifer systems has yet been undertaken.

Among a few case studies carried out, the Kammanassie area was comprehensively investigated because of the availability of comprehensive data and a well-documented problematic groundwater supply scheme. Several methods were applied to crosscheck the results, including the Chloride Mass Balance (CMB) mixing model, statistical methods, the water level fluctuation methods (RIB and CWD-CRD). Numerical modelling proved to be an excellent tool for use in the verification of the water balance scenarios for recharge estimation in the case of the Kammanassie area. At a regional scale, a soil-water balance model can be used to provide a guide value. This method is applied for the 19 hydrogeological units demarcated in the

TMG region during this project. The average recharge rate of the TMG is about 30 mm/a. The highest recharge rate is 137 mm/a associated with 1 842 mm/a at rainfall station No. 0022116 in the hydrogeological unit 5; the lowest recharge rate is 0.7 mm/a associated with 164 mm/a at Station No. 0048043 in the hydrogeological Unit 13. The regions with a recharge rate of more than 35 mm/a occur in the hydrogeological Units 5, 6, 8 and part of the hydrogeological Unit 17. A rough estimate for the TMG hot springs recharge would be about 5 mm/a.

Cost: R800 000  
Term: 2002 -2005

##### Geothermal studies of TMG aquifer systems Umvoto Africa cc No 1403

The best estimate of the background crustal heat flow from the pre-Cape basement terrain in the Western Cape Province is 76 MW/m<sup>2</sup>, obtained from a thermal gradient of 21.5 K/km in the deeper (190 to 290 m) interval of a 300 m borehole into the Cape granite at Skuifraam in the Berg Water Project area. Groundwater moving through the TMG aquifer system transports substantial quantities of heat (amounting to at least 27 MW at the Brandvlei hot spring alone) and thereby alters the subsurface temperature field, so that the measured heat flow in overlying stratigraphic units, such as in the Bokkeveld Group at the Birkenhead site near Stanford, is locally lowered to 50 to 55 MW/m<sup>2</sup> (and may locally be raised elsewhere around discharge points). The quantitative spatial mapping and in situ temporal monitoring of local geothermal gradients and spring-discharge temperatures, in association with the combined modelling of fluid and heat advection in the TMG aquifers, could provide a powerful and relatively inexpensive new tool, both for groundwater exploration (storage and flow determination) and for the monitoring and interpretation of impacts due to large-volume abstraction.

Cost: R150 000  
Term: 2002 -2003

##### Programme 3: Understanding and predicting hydro-climatic variability Development of a continuous simulation modelling system for design flood estimation in SA

School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal, Pietermaritzburg  
No 1318

The estimation of design floods is necessary for the design of hydraulic structures. The under estimation of design floods will result in the failure of hydraulic structures with consequent economic losses and possible loss of life. The over design of hydraulic structures results in inefficient use of resources. The choice of an acceptable and cost-effective engineering solution is dependent upon having reliable estimates of the frequency of floods, both in terms of peak flows and volumes of water.

A number of methods are available for determining design floods. In the absence of adequate streamflow data, most of these methods are event-based approaches. Event-based methods have a number of shortcomings which include the implicit assumption that the exceedance probability of the simulated streamflow is the same as that of the input design rainfall and that antecedent soil moisture conditions prior to large storm events are not accounted for.

This research observed that the limitations of event-based approaches to design flood estimation can be overcome by adopting a continuous simulation approach to rainfall-runoff modelling where the major processes responsible for converting the input catchment rainfall into runoff are explicitly modelled. After investigating several existing design flood estimation techniques, a continuous simulation modelling (CSM) technique based on the ACRU model was developed.

The ACRU daily time step model was revised and new modules added to convert it into a design flood estimation technique. Some key additions to the ACRU model included disaggregating daily rainfall into hourly totals

to improve estimations of peak discharge; merging rain gauge and radar data to improve the estimation of aerial rainfall and the use of the fine resolution space-time String-of-Beads model to simulate long series of rainfall. The method of disaggregating rainfall introduced in the project brought a stochastic element into the model, using a procedure that can be applied in other models. The study concluded that realistic modelling of larger quaternaries was only possible after you have disaggregated the catchment to smaller units and then model each sub-catchment as a number of HRUs. The results from this study have shown that the use of the ACRU model as a CSM can simulate the hydrological responses from an operational catchment, despite the challenges related to data and operations in the catchment. The output from the CSM has been shown to produce reasonable and consistent estimates of design floods, particularly in smaller catchments.

### **Recommendations**

The researchers observed the urgent need to increase the monitoring and recording of hydrological variable. The few available records were noted to be a major limitation to the potential of the developed modelling tools. Increased monitoring is a major national challenge. Suggestions to increase national monitoring have been taken to the Parliamentary Portfolio Committee on Water. It is estimated that R150 million/year for at least 8 years is required to take our national water management recording processes to a competitive level, a level where we can be assured that our planning is efficient and that it is based on realistic input data.

Cost: R1 460 000  
Term: 2002 -2005

### **Skills comparison of dynamic and empirical down-scaling methods for Southern Africa from a seasonal climate modelling perspective** *SA Weather Services, Pretoria Office* **No 1334**

The main emphasis of the project was to assess the ability of an advanced state-of-the-art, albeit computationally expensive, method of down-scaling large-scale climate predictions to regional and local scale as a seasonal rainfall forecasting tool for southern

Africa in order to improve seasonal outlook information for hydrological purposes. Down-scaling the large scale to more localised seasonal rainfall over Southern Africa had previously been shown to be feasible, but further research in down-scaling, with both improved spatial and temporal resolution, was required. The main aims of the project were to:

- Set baseline forecast skill levels, using statistical models
- Compile an appropriate general circulation model (GCM) climatology of a sufficiently large ensemble
- Nest dynamic regional climate models in the GCM-simulated large-scale fields
- Compare the nested scheme's forecast skill with the baseline skill levels.

Ultimately, various down-scaling techniques and raw GCM output were compared to one another over the 10-year period from 1991/92 to 2000/01 and also to a baseline prediction technique that uses only global sea-surface temperature (SST) anomalies as predictors. The various down-scaling techniques described in this study include both an empirical technique called model output statistics (MOS) and a dynamical technique where a finer resolution regional climate model (RCM) was nested into the large-scale fields of a coarser GCM. The study concluded by investigating the internal variability of the RCM.

The study addressed the performance of a number of simulation systems (no forecast lead-time) of varying complexity. These systems' performance was tested for the December-January-February (DJF) rainfall for both homogeneous regions and for 963 stations over South Africa, and compared with each other over a 10-year test period from 1991/92 to 2000/01. For the most part the simulation methods outscored the baseline method that used sea-surface temperature (SST) anomalies to simulate rainfall, thereby providing evidence that current approaches in seasonal forecasting are outscoring earlier ones. Current operational forecasting approaches involve the use of GCMs which are considered to be the main tool whereby seasonal forecasting efforts will improve in the future. Moreover, advantages in statistically post-processing output from GCMs as well as output from regional climate models (RCMs) were demonstrated. Skill should

further improve with an increased number of ensemble members. However, multiple realisations are not required to describe the internal variability of the nested system, which suggests that increasing the ensemble size would mainly contribute to probabilistic forecast skill.

The potential for using dynamical and statistical down-scaling methods and their combination for modelling South African seasonal regional rainfall variability has thus been demonstrated. In addition to expanding on the number of ensemble members, the test period of 10 years should be increased in order to test the robustness of the results presented here since this test period may be too short to unequivocally demonstrate which simulation method is the best. An increased ensemble size can also be considered to test the probabilistic skill levels of these systems and how they can be used in an operational seasonal forecasting environment that demands a description of forecast uncertainties.

Cost: R450 000  
Term: 2002 -2006

### **Extension of the South African National Microbial Water Quality Monitoring Programme (NMMP) to include groundwater** *Division of Water, Environment and Forestry Technology, CSIR, DWAF and the Department of Health* **No 1277**

The general purpose of this report and 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. The monitoring design described in this manual focuses only on water quality and only on one aspect of quality, namely microbial quality that reflects the degree of faecal pollution because of the associated human health risks.

Cost: R600 000  
Term: 2001-2003

# KSA 1 (continued)

## Water Resource Management

### *Programme 5: Water quality assessment studies and information systems*

#### *Microbial groundwater monitoring protocols refinement*

CSIR

No 1494

The general purpose of this manual is to describe how a national microbial monitoring programme (NMMP) for groundwater could be implemented on a national scale.

This report 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.

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.

Groundwater monitoring on a national scale is currently being carried out by the Department. However, it focuses mainly on water quantity variables (water levels, etc.) and chemical quality (TDS, major ions, pH, etc.). Three levels of monitoring are envisaged of which one (Level 1) is extensively implemented. The three levels refer respectively to:

- Baseline monitoring (in unimpacted aquifers)
- Catchment monitoring (in impacted aquifers)
- Local impact monitoring (typically project specific and focused on aquifer zones).

The monitoring design described in this manual focuses only on water quality and only on one aspect of quality, namely microbial quality that reflects the degree of faecal pollution because of the associated human health risks.

Cost: R700 000

Term: 2004 – 2006

### *Programme 6:*

#### *Real-time mapping of daily rainfall over South Africa*

##### *Daily rainfall mapping over South Africa through radar, satellite and gauge*

##### *measurements: Infrastructure and capacity building*

##### *Meteorological Systems and Technology (METSYS)*

No 1426

During 2003 the South African Weather Service (SAWS) took a major step forward in publishing real-time daily rainfall products on its website, the main one being an integrated product combining rain-gauge, weather radar and satellite-determined rainfall fields in a way which uses the strengths of each platform whilst minimising their individual weaknesses. The above achievement was the result of the WRC-funded SIMAR projects reported in WRC Report Nos. 1151, 1152 and 1153 of 2004.

Whilst these measurements of rainfall at high temporal and spatial resolution immediately found favour with users, they also received some criticism, in particular from DWAF's flood studies unit, who questioned the accuracy of certain rainfall estimates. Acknowledging the need for more rigorous quality assessments and improvements, where necessary, this project (No. K5/1426) was undertaken to further refine products, with the main focus being on correcting shortcomings attributable to infra-structural and capacity-building weaknesses.

#### **Specific objectives were to:**

- Improve the real-time precipitation measuring infrastructure over South Africa for water resource and flood warning applications.
- Establish a real-time precipitation database over South Africa.
- Transfer technology to end users that will utilise the systems already developed and to be further refined in DARAM.
- Build capacity in the application of remote sensing technology for improved precipitation monitoring.

The majority of the activities initiated with the purpose of achieving the objectives are ongoing initiatives that will carry on well

beyond the lifetime of this project. Bearing this in mind, the main objectives of this project are nevertheless judged to have been achieved successfully. An ambition held over and above the formal objectives, to routinely generate and publish rainfall fields at temporal resolutions finer than 24 hours, did not materialise. The aim of producing 12-hourly, 6-hourly and even more frequent rainfall fields is, however, well within grasp.

Each of the platforms used for rainfall measurement, namely surface rain-gauge networks, radar networks as well as satellite data, came under the spotlight.

New quality check procedures for the processing of the real-time rain-gauge data (including that derived from new cell-phone technology) were developed and implemented.

Measures to improve the calibration and maintenance of radars were implemented, resulting in a system that constantly monitors the performance of the radars in the network. A new scheme to remove ground clutter from the radar precipitation fields was also developed and implemented. Errors introduced into radar rainfall fields through deficient sampling at longer ranges, especially during stratiform-rain conditions, were reduced through the dynamic determination of usable radar ranges in such conditions. Plans were developed to expand the radar network within South Africa and also within the region, with SAWS collaborating with Mozambique and Botswana Meteorological Services in this regard.

A new satellite rainfall scheme was developed using the MSG-channels corresponding to those of the Meteosat 7 satellite on which the majority of the products generated during SIMAR had been based. The new scheme showed marked improvements related to resolution, but further studies are to be conducted in conjunction with EUMETSAT with the aim of developing new precipitation algorithms utilising the advanced capabilities of the 12 MSG channels.

The development of human capacity to utilise the products being generated in DARAM was a major outcome of the project, resulting from a three-tier approach:

- Capacity development on an individual basis – where individuals working on the processing and analysis of data were targeted. Shortcomings in their education and skills make-up were identified and appropriate short courses, supplemented by in-house training, were conducted.
- Capacity development on an organisational basis – this entailed users or prospective users of DARAM products at an organisational level learning to deal with the data. It included participation in workshops on data interpretation as well as the provision of information specifically related to the use of real-time data.
- Capacity development at grass-root level – here students at tertiary institutions were targeted and taught the basic concepts of data generation, quality checking, utilisation in problem-solving, etc. The training in this regard took the form of field projects which were conducted using different observational platforms that included rain-gauges, radars and satellites.

The DARAM project clearly highlighted the lack of rainfall observation infrastructure. As a solution, the SA Weather Service Recapitalisation Plan was conceived and will be a crucial part of the modernisation and revitalisation of the South African meteorological and climatological infrastructure. It will support improved rainfall estimations and related applications.

Cost: R 1 214 000  
Term: 2003-2005

## **Thrust 2:** **Management of Natural and Human-induced Impacts on Water Resources**

**Programme 2:**  
**Human-induced impacts**  
**Pilot study: Setting resource-directed measures for groundwater**  
*Parsons and Associates*  
**No 1427**

From a groundwater perspective, Groundwater Resource Directed Measures (GRDM) assessment is more important than the Reserve on its own. While the Reserve

only addresses the role groundwater plays in meeting basic human needs and sustaining aquatic ecosystems such as rivers and wetlands, GRDM allows the use and protection of the entire groundwater resource to be addressed holistically. Four levels of GRDM assessments are recognised – desktop, rapid, intermediate and comprehensive – each providing an increased level of confidence.

### **The objectives of this project were to:**

- Review and implement methods developed to set RDM for groundwater through an appropriate case study
- Refine and adapt methods as a result of lessons learnt during the pilot study
- 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 GRDM assessment was undertaken. Additional data and information were collected, through a hydrocensus, for the study area where data were 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.

Cost: R 900 000  
Term: 2004-2006

## **Quantification of the groundwater contribution to baseflow** *Parsons and Associates* **No 1498**

A prototype model was developed in a modular fashion to accommodate inclusion of results of parallel research being undertaken by DWAF and the WRC. Using data sets generated during the Groundwater Assessment Phase II Project, the Pitman Model was modified to facilitate the quantification of the groundwater contribution to baseflow. This entailed consideration of recharge, groundwater discharge to streamflow and abstraction.

The revised Pitman model was then included in the SPATSIM software, and tested in a number of quaternary catchments across South Africa. The model was calibrated

against existing WR90 simulated monthly time series data. In general terms, the revised algorithms appeared to generate results that were intuitively realistic as well as replicate hydrographs produced using the original Pitman Model while taking into account groundwater factors. Some problems were encountered in dolomitic catchments, but these are thought to be the result of the modelling approach used by WR90 and not the result of problems with the modified Pitman Model.

Based on the calibration and testing of the revised Pitman Model in 17 quaternary catchments, guidelines were developed for estimating the groundwater parameters used in the model. Incorporation of the modified Pitman Model into the SPATSIM software has provided hydrologists with a useful tool to quantify surface - groundwater interaction at a catchment scale. Proper training in the use of the software is required yield reliable results.

Cost: R198 000  
Term: 2004 - 2006

## **Chemical and biological assays and sentinel species for EDCs** *Department of Urology, University of Pretoria* **No 1505**

There is increasing global concern over persistent bio-accumulative chemicals, their potential for bio-magnification, and, even more worrying, synergistic/additive effects of endocrine disruptor chemicals (EDCs) in mixtures. EDCs are chemicals that interfere with the structure or function of hormone-receptor complexes and may be disruptive at very low exposure levels. The damaging impact of EDCs on health is internationally no longer an issue of dispute. Globally the environmental load of EDCs has reached critical levels at which human and wildlife is at risk.

The stream into the study area of the project receives effluent from sewage treatment plants, industries and informal settlements in the catchment areas.

The objective of this study was to determine whether sufficiently high levels of EDCs exist in the general environment to exert adverse health effects on aquatic or terrestrial animals or humans in the nature reserve.

# KSA 1 (continued)

## Water Resource Management

This report summarizes the scientific background relevant to the study with emphasis on chemical residue analyses, endocrine disruptive metals (EDMs) and bio-assays for oestrogenicity and dioxin and dioxin-like PCBs. It also reviews the use of possible bio-sentinel aquatic and terrestrial animals. This is followed by separate chapters on analytical chemistry and in vitro bio-assays. *Clarias gariepinus* (sharp-tooth catfish), *Xenopus laevis* (African clawed frog), *Bulinus tropica* (freshwater snail) and *Rhodomys pumilio* (striped mouse) were evaluated as possible biomarker species for EDC exposure. The impact of active biomonitoring (ABM) on fish and snail species in the resource, the effect on macro-invertebrates (SASS5) and the possible role of plants in the wetlands were addressed separately. All the information gathered was integrated in a qualitative scenario-based health risk analysis and a toolkit recommended for future use.

Cost: R2 000 000

Term: 2004–2007

### *Eco-hydraulic modelling in river systems* *Centre for Water in the Environment (CWE),* *University of the Witwatersrand* **No 1508**

'Eco-hydraulics' is a widely used term with a multiplicity of interpretations. In this study it was considered to mean the specification of hydraulic variables that contribute to the definition of riverine habitat.

The key aims in this study were to:

- Review the findings and issues generated by previous research on the subject of eco-hydraulic modelling in river systems
- Develop tools/methods for eco-hydraulic assessments at stream level
- Apply the tools/methods to at least two sets of case studies.

The project involved a local and international review of eco-hydraulics. In this review, the types of information required for ecological studies in the context of the current South African legislation were investigated. The various hydraulic models in use were also assessed. These models can be classified into:

- Deterministic hydraulic models (these were further investigated under the sub-headings of 1D, 2D and 3D according to the number directions of motion considered)

- Empirical frequency distribution models Simplified models (for predicting hydraulic variables in cases where appropriate relationships can be established)
- Lateral distribution tools (for predicting velocities across a cross-section).

A software tool for predicting resistance in rivers was developed as one of the key study outputs. This tool uses photographic matching to provide resistance coefficients. The resistance coefficients are key parameters in deterministic models. The software tool, which is part of the project report, is supported by a photographic database of several important South African rivers, site descriptions equations and procedures for determining resistance coefficients. In developing the database based software tool for predicting resistance, surveys were done to define the cross sectional profile of the river channel in sufficient detail to identify features of interest to river scientists. These surveys were also to enable hydraulic measurements and analysis to be undertaken at sufficient levels of resolution. Surveys were preferably undertaken during low flow conditions to incorporate all significant changes in slope along the profile. The profiles were surveyed from bank to bank of the macro channel and included the location and type of in-stream, marginal and riparian vegetation.

Photographs of each site were taken from subsequent identifiable and repeatable positions. The photograph positions are:

- Across the channel along the surveyed cross section
- Facing upstream and downstream with the surveyed cross-section in the foreground
- Site view – a photograph showing cross-section, upstream and downstream.

The study also involved the development of additional software to support the estimation of other model inputs such as topographic data. Topographic data was used as the main input in 2-D hydraulic models. Techniques for interpolation of spatial data to produce spatially explicit visual maps were also developed and added as support tools for key models such as River 2D.

The research also looked at how hydraulic data should be interpreted in ways that are meaningful to ecologists. This process re-

sulted in confirming the existing habitat classification for vertebrates and proposing new habitat classes for invertebrates. The proposed habitat classification for invertebrates was influenced by the availability of more data and information in the hydraulic characteristics of river sections. Additional support software was developed to simulate the depth and velocity distributions using actual hydraulic measurements in river sections.

This study observed that the current understanding of the linkages between hydraulics and ecology was very limited. While the study did not focus on these links, it addressed some of the linkages which is evidenced by the work leading to the proposed new habitat classes for invertebrates. The study also identified several gaps in the tools that are currently used in eco-hydraulics and made suggestions on how these can be bridged. In a few cases the study team addressed some gaps through the development and provision of additional software which is packaged with this report.

The study recognised that the major focus of future research in eco-hydraulics should be on the links between hydraulics and other physical, chemical and biological characteristics of the river ecosystem.

Cost: R1 800 000

Term: 2004–2007

### *Programme 3:* *Integrated flood and drought* *management Updated guidelines and* *design flood hydrograph techniques for* *dam safety.* *Ninham Shand Consulting Engineers (Pty)* *Ltd* **No 1420**

Given the unfavourable spatial and temporal distributions of rainfall over large regions of South Africa, the water supplies needed for the economic development of the country has had to be assured by storage. Some 3 700 dams with a height greater than 5m are currently listed in the Register of Dams maintained by the Dam Safety Office of DWAF. Potentially, all dams that are large enough to warrant listing on the Register potentially pose a public safety hazard, but of particular concern would be the 252 dams classified as 'Large Dams'. For this reason, dam safety

legislation was promulgated in 1986, which prescribed the safety evaluation of all registered dams on a five-year cycle by approved professional persons specifically registered for that purpose by the Dam Safety Office.

In the early 1990s the South African National Committee on Large Dams (SANCOLD) issued a set of Guidelines on Safety in Relation to Floods (SANCOLD, 1991), as well as a compendium of South African Design Flood Determination Techniques (Alexander, 1990) to provide guidance to those charged with evaluating the safety of existing dams, as well as to the designers of new dams. More than 16 years have elapsed since the publication of the SANCOLD Guidelines, which have by now informed safety evaluations for hundreds of registered dams.

This project reviewed and evaluated the footprint achieved by these Guidelines. In this research the researchers worked towards updating these Guidelines in terms of international best practice. In the project flood hydrograph-related information contained in the streamflow records of the last three decades were also brought into the project to update the data used in South African design flood practices. Other project objectives included:

- To establish updated Guidelines for the safety evaluation of dams in relation to floods
- To derive a methodology for design flood hydrograph estimation based on joint occurrence of flood peaks and flood volumes, through analysis of historically measured flood hydrographs in all regions of South Africa
- To develop a modernised set of design tools for the generation of complete flood hydrographs for dam safety evaluation or spillway design.

The project was carried out in 4 phases. The first phase was an assessment of local and international practices regarding dam safety in relation to floods. This phase was followed by data collection and the Improvement of Flood Hydrograph Generation Techniques for South Africa for Dam Safety Purposes. Phase 3 involved the development of a 'Design Flood Hydrograph Toolbox', the purpose of which is to support the various components of dam safety evaluation in relation to floods. The final project output, which is

reported in a separate report, was a review of the SANCOLD Guidelines on Dam Safety in Relation to Floods. This report also included insights into specific aspects of the existing SANCOLD Guidelines as well as recommendations for updating these Guidelines or replacing them.

The key observations were that the existing SANCOLD Guidelines were outdated and that they were based on inefficient techniques that resulted in both under-estimates of floods in some cases as well as over-designs in some cases. It was also noted that the existing guidelines did not use the most up-to-date hydrological regimes which have some of the highest rainfall and flows in over a 100 years. It was observed that the existing guidelines also left out risk assessments and analyses which are now important in most countries. The observations made on the national and international safety evaluation of dams in relation to floods as well as the methodology and software developed in this project can be used to improve the dam safety assessments and designs. In the longer run, this research project recommended that further work should be done by DWAF, SANCOLD and the WRC to take this research into new official SANCOLD guidelines for dam safety. The research project was reported in three reports and a software CD with the Design Flood Hydrograph Toolbox.

Cost: R 1 349 800  
Term: 2003-2006

### *National flood now-casting system towards an integrated mitigation strategy*

*Department of Civil Engineering, University of KwaZulu-Natal  
No 1429*

This project, building on previous research and development, aimed to put an effective, efficient, readily available national flood-forecasting system in place, to use this system to forecast flood inundation levels routinely and alert disaster managers, vulnerable people and industry, in order to mitigate the effects of floods. The intention was to have recent information (merged satellite, radar and gauge estimates of rainfall) distributed from the NDMC/DWAF: PSU (National Disaster Management Centre/DWAF: Public Safety Unit) to sensitive regions to enable flood

nowcasts/forecasts (with horizons of 1/2, 1, 2, 4, 8 hour, etc.) to be given in as much detail as required. This would also have entailed interacting and working with local disaster managers and local authorities to convert flows to inundation levels as well as providing training initiatives (annual courses, presentations and software) for local disaster managers using simulated weather systems to augment training on historical events.

Soon after the inception of the project, it became clear, however, that the objectives as listed (despite initial enthusiastic acceptance by role-players) were excessively over-ambitious in the light of the lack of clear definition of the roles (as well as changing roles) of various institutions involved in flood warning and management, and the severe lack of institutional capacity required to roll out the national flood nowcasting system as originally envisaged.

A very large and important part of the project was consequently devoted to formal and informal consultation and interaction with role-players, and presentations at meetings with national leaders and decision-makers in SAWS, NDMC and DWAF, extending to the Metros. This activity was undertaken in order to create awareness of the needs for, and potential benefits of, a national flood nowcasting system, to provide the necessary background knowledge and to clarify optimal institutional arrangements. The technical issues of determining areas at risk, establishing physical communication links and developing appropriate catchment models to be able to extend forecasts/nowcasts to ungauged catchments continued to receive attention.

There were three major outcomes from the project, setting the stage for further development:

- New insights were gained into the existing and desired capacities, roles and responsibilities of institutions. As a result, SAWS accepted the responsibility for flash flood forecasting at a meeting held in Bethlehem on May 10, 2005, with DWAF retaining the responsibility of forecasting floods in larger catchments. The repercussions of this decision were profound and include the:
  - Need within SAWS for hydrological modelling of the rainfall-runoff

# KSA 1 (continued)

## Water Resource Management

relationship in catchments where people and property are vulnerable. Weather forecasters will be the channels of warning to local Metros and regional DMs, not only for severe weather which they do now, but also for flash floods.

- Need for information on the wetness of the surface of the catchments concerned. SAWS has decided to deploy soil moisture probes at selected sites to telemeter information on a daily basis to their data-base. This will allow ground validation of remote sensing of soil moisture indicators by satellites, a task built into a new WRC Project No. K5/1683: Soil Moisture from Satellites: Daily Maps over RSA.
- New flood-related knowledge resources have been generated and made more widely available
- Technical advances, such as the development of a hazard atlas and adaptation of an appropriate distributed catchment model (the Topkapi Model) have been accomplished.

Cost: R 1 314 000

Term: 2003-2006

### Thrust 3: Water Resource Protection

**Programme 1:**  
**Groundwater protection**  
*Statistically-based regionalised flood frequency estimation study for SA, using systematic, historical and palaeoflood data*  
**SRK (CE) Inc.**  
**No 1260**

After the very devastating floods of the year 2000, many water infrastructure designers were worried that the design flood estimates used in civil designs were not realistic. The year 2000 flood devastation resulted in damages exceeding R1.5 billion countrywide.

In this research project the researchers investigated and developed new techniques for calculating flood estimates in water resource infrastructure designs. The project was set to address a pertinent problem in available flood estimation techniques. These techniques have been known to give vastly different results that could result in overestimation

or underestimation of floods. Flood frequency analysis in South Africa is currently based on at least three basic approaches. These are deterministic methods (rational, unit hydrograph, SCS, etc.); statistical methods such as the LP3 and Log-normal (annual maximum flood series data); and empirical methods (Midgley-Pitman, HRU 1/71 and RMF).

The study aimed at producing a nationally consistent and robust method to estimate design flood peaks and index floods using regionalised growth curves that are based on historical and palaeoflood data. The study was also motivated by the fact that the existing methods were developed on the basis of a few records taken in the past. This study looked at updating the data used in the flood estimation and also looking at palaeoflood data to stretch the data used to more than 200 years in some instances. Most infrastructure is designed for floods that occur between 1 in 100 and 1 in 200.

The observation records used consisted of an average of 51 years for systematic data, 125 years after including historical data and an average of 47 777 years after including the palaeoflood data. The applicability of the combined data may thus be taken as 1 000 years (that is twice the period of observation).

The NCAPA method for estimating the regional flood  $Q_i$  was developed in this project. This method was based on the CAPA (Mc Pherson, 1983) method which is used in DWAF.

The relative  $Q_i$  estimation performance of the CAPA and NCAPA methodologies for the regions were compared. The coefficient of determination ( $R^2$ ) for the NCAPA method was generally better. For the whole study area the  $R^2$  improves from 0.74 to 0.87 which suggested that the NCAPA methodology provides better estimates for the index flood. The study also concluded that the inclusion of historical and palaeoflood data along with the systematic records in a regional flood study, significantly extend the range of probabilities for flood peak estimations and thus provide more stable estimates that will not be subject to frequent amendments as the period of systematic observation increases. Estimation of the rarer flood events (>100-years) for especially the larger catchments can now be improved by the inclusion of

more historical flood and palaeoflood data and by assessing the influence catchment area has on the growth curves.

The work in this project also pointed out the urgency of extending flow routing records in all existing reservoirs. The need to extend palaeoflood records in other catchments is also reinforced through this study.

Cost: R773 200

Term: 2001 - 2002

**Improved methods for aquifer vulnerability assessments and protocols (AVAP) for producing vulnerability maps, taking into account soils information**  
**CSIR**  
**No 1432**

Aquifer vulnerability to contamination comprises two components: unsaturated zone vulnerability and saturated zone vulnerability. For the unsaturated zone, this project defined vulnerability as the ease with which groundwater may become contaminated by a contaminant source at the surface or in the unsaturated zone. For the saturated zone, vulnerability is defined as a function of the period of time after contaminating activities have ceased that a given contaminant can be detected in groundwater plus the volume of the aquifer throughout which the contaminant is above a preset concentration. For the unsaturated zone, the 'AQUIISOIL' (Aquifer Vulnerability Soil Assessment) approach and a modified DRASTIC approach, called 'EUZIT' (Excel-based Unsaturated Index Tool) were developed. Both approaches can be used for assessing vulnerability at the water table.

Two study sites were selected to illustrate the use of AVAP approaches to the assessment of groundwater vulnerability: the Goedeheop Irrigation Site near Secunda, and the Coastal Park Waste Disposal Site near Cape Town. It was found that the unsaturated zone vulnerabilities are relatively high for both aquifers.

A framework to support decision-making was developed to assist groundwater vulnerability assessment practitioners in understanding the role of their assessments in groundwater management and to assist them in the selection of AVAP approaches to groundwater vulnerability assessment. The framework highlights the fact that

groundwater vulnerability assessments serve as input to contaminant risk assessments, which will contribute to a cost benefit analysis. It is the outcome of the cost benefit analysis which will ultimately inform decision-making.

Cost: R 3 500 000  
Term: 2003-2007

**Programme 3:**  
**Urban water resource management**  
*Development of an estuarine water quality index for implementation in estuarine water quality management in Southern Africa*  
Department of Zoology, University of Zululand  
**No 1163**

The need to develop a classification system for estuaries that is based not only on physical and biological components, but also on water quality, was identified. However, there was a lack of estuary-related data that could be used in the setting of water resource quality objectives for Ecological Reserve determination. Most of the available data, particularly water quality data, were for rivers. This research studies were focused on choosing appropriate variables that can be used to determine water quality for estuaries, which in this study was referred to as Estuary Water Quality Integrity Index (EWQII). The main aims of the project were to develop a water quality index for estuaries that interprets water quality variables in terms of ecological/biological resource protection, to incorporate the index into a DSS using ARCVIEW as a platform to link to other meta-databases, to develop the index in such a way that it will contribute towards the classification in terms of the Ecological Reserve requirements, i.e. different integrity categories as outlined in the RDM procedures, and to integration of the water quality index with existing estuarine index scores through the DSS. The generic hierarchical approach that is followed in developing a water quality index (WQI) was followed, and it entailed selection of water quality variables, transformation of variables into a dimensionless scale, formulating and computing the index score, and ensuring accessibility and functionality of the EWQII through incorporation into a decision support system (DSS). For the selection of water quality variables to use in the EWQII, a thorough literature review was undertaken to identify the appropriate clas-

sification system to use for EWQII and also to determine which water quality variables to use for EWQII. In cognisance of the major contribution from intruding sea water to the estuaries salinity (or TDS) value, salinity was included as an important variable in the determination of estuary water quality integrity (estuaries brackish nature make them unique habitat). Another variable considered for inclusion was nutrients because water quality studies seriously recognize trophic status of water resources. Metals, with the exception of Al, Fe, and Mn, with historic data (mainly from SA Marine Water Quality Systems) were included in metals variable. Some selected organic pollutants were considered. The literature review studies showed that estuaries have fluctuating salinity and a strong gradient in ecotoxicological parameters such as pH, temperature, dissolved oxygen, redox potential, and amount and composition of particles. A theoretical or mathematical analysis which was based on three ecological zones (euhaline, mesohaline, and oligohaline) showed greater fluctuation in salinity in the mesohaline ecozone when compared to the other two ecozones. If the estuary mesohaline may be modified, this can increase the duration and magnitude of stress in some organisms. However, due to the limited amount of data available, the optimal salinity ranges for many estuaries organisms are still unknown. Estuaries do not have steady-state conditions, thus have no inter-specific biotic competition because the physical-chemical factors nullify the possibility. Both studies indicated that:

- The impact of saline regimes on estuary ecosystems cannot be predicted using tools or ecotoxicological indices from the freshwater systems
- The classification system based on salinity that may work should have to do with the distribution of estuarine fauna and functional groups that are expected in an unmodified estuary.

Use of nutrient loading models was also investigated. Available models were found to be not suitable for estuaries because they are oversimplified. The Land Ocean Interaction in the Coastal Zone (LOICZ) model for determining the nutrient mass balance of nutrient in the ecosystem was identified as the best model for estuaries when dealing with nutrient loading. However, the paucity of data in South Africa limits its use. Organic, neutral, and metallic toxicants were selected

to form part of the EWQII, and the US-EPA ecotoxicology databases were used to obtain a consistent level of data quality. Species sensitive distribution (SSD) curves were produced. This study showed that the probability of exceeding an exposure estimate with an unacceptable adverse biological effect can be estimated. In the development of the EWQII, each category of the EWQII was allocated a protection concentration or percentile hazard concentration (HCPs) with different levels of certainty for each category. In calculating the EWQII scores for best water quality indexing, the aggregation method which consolidates all variables and requires ranking of categories, was used. The EWQII was then incorporated into the decision support system (DSS). This project revealed that the available methods and approaches developed for the freshwater systems cannot be adopted as they are for use in the management of the estuarine systems. The need to reinforce estuaries research programmes strongly came out throughout the study. The results of this study are important and relevant to the Resource Directed Measures Division in DWAF because DWAF may have to consider these results in developing classification system for estuaries for integrated water resource management.

Cost: R515 000  
Term: 2000-2005

**Thrust 4:**  
**Policy Development and Institutional Arrangements for Water Resource Management**

**Programme 2:**  
**Water policy development and strategic policy support**  
*Human rights and equitable access to water*  
AWARD  
**No 1512**

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). This concept is an expres-

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## KSA 1 (continued)

### Water Resource Management

sion in real terms of the constitutional intention to provide water to meet basic human needs (currently taken to be 25 l/person per day) before water can be allocated for use by the various sectors. 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.

#### The objectives were:

- An exploration of the concept of 'water as a human right' within the context of the South African legal framework
- Enhanced understanding, capacity and competence within Local Government to implement the National Water Act and allocate water resources with consideration for the concept of 'The Reserve'
- To produce and test learning support materials regarding the concept of the Reserve
- To research, understand and document the way that access to water resources as a human right can be implemented in South Africa
- To share findings generated by a research orientation with other catchments and local governments in South Africa.

Cost: R173 000

Term: 2004-2005

#### *Strategic review of current and emerging governance systems related to water in the environment in South Africa* *Pegsys Strategic Management* *No 1514*

A particular governance system should be matched to and aligned with the biophysical and ecological processes occurring within the ecological system that supports a society or community.

#### **Interpreting Water Governance:**

The complete system of governance for water may be represented as a three-dimensional system of:

- Elements, including principles & mandate, policies & legislation, regulatory framework, institutional arrangements and practice
- Levels, from international, national, regional, local to neighbourhood levels
- Responsibilities of government, non-government organisations and civil society.

#### **International Context:**

Defining what constitutes international water law is simply due to the preponderance of customary international law at this level. For governance of water in the hydrological cycle, the most relevant initiatives are those related to climate change, management of transboundary water resources and environmental management. These initiatives and law are taken as context for the national governance evaluation.

#### **National Policy and Legislation:**

Conclusions about the broad legislative environment are relevant for water governance in South Africa such as:

- The Constitution sets the parameters for good water governance
- The legislated governance system for water has several elements, with the National Water Act and Water Services Act administered by DWAF at its core.

#### **Evaluation of the Governance Systems:**

While the policy and legal environment has been generally well developed in South Africa in accordance with government policy since 1994, the implementation of this policy and legislation has been generally uneven, inconsistent and often inadequate to meet the challenges facing the country. Therefore the key focus of the evaluation is on the regulatory environment and practice. It does this specifically from the perspective of the water governance, and prioritisation is primarily based on the associated impact on the water environment. For practical reasons, the synthesis takes a physical media approach, focusing on governance of air, land and water.

**Air Governance:** Specific issues that may benefit from further investigation include:

- Opportunities and institutional arrangements for joint planning, management and regulation of air and water quality (linked to land quality) at a catchment basin scale, through the catchment management strategy process
- The technical, procedural and institutional considerations for addressing water resource impacts as part of the air emissions licensing process.

#### **Land Governance:**

From the wide-ranging review and evaluation of land governance from a water-hydrological perspective, the following are examples of the priority issues identified:

- The opportunities for effective coordination of land use governance through catchment management processes, and appropriate mechanisms to institutionalise the required cooperative governance
- The institutional capacity of local government to effectively perform its functions related to management of the hydrological cycle, particularly around integrated development planning, municipal service delivery, waste management and land use authorisation.

#### **Water Governance:**

In addition to the water-related issues associated with land governance, specific governance issues related to the water environment include as examples:

- Governance of catchment management agencies at all levels, within a paradigm of cooperative, integrated, developmental and participatory management
- Governance considerations and mechanisms for the development of catchment management strategies through a consultative process and their alignment with local development planning (IDP, WSDP) and provincial planning processes (PDGS).

#### **Challenges to Good Water Governance:**

There are a number of fundamental challenges to improving water governance in South Africa such as:

- Change and maturity in the governance systems
- Institutional change and decentralisation.

Given the magnitude of these strategic challenges, it is remarkable that there is a

relatively effective governance system in the water and related sectors. From this synthesis and evaluation, it is apparent that an institutional champion is required for promoting coherent and harmonised implementation of water governance related to the entire hydrological cycle. While DWAF must continue to play this role at a national policy level, it is proposed that catchment management agencies provide a focus point for improving governance of water in the hydrological cycle at a catchment level.

Cost: R 500 000  
Term: 2004-2005

**Programme 3:  
Institutional arrangements and processes for IWRM at catchment, WMA and national level**

*Towards integrated catchment management in the Mlazi River: A model for participation in the South African context*

*Farmer Support Group, University of KwaZulu-Natal*

**No 1157**

In 1994, various residents, resource managers and researchers with an interest in the area around the Ntshongweni Dam were approached by Raymond Auerbach concerning social and environmental problems in the area. Although then Research Coordinator for Farmer Support Group, he was at the same time also a local farmer in a small subcatchment of the Sterkspruit, a tributary of the Mlazi River. With the help of seed funding from Umgeni Water, and the positive engagement of many people, information was gathered, a proposal was submitted to the WRC and an initial catchment management workshop was held in November 1994. At this point, the focus was on the Sterkspruit (or Mncadodo Stream), the Ntshongweni area and Dam, and the Mlazi River between Mpumalanga Township and the Dam. The programme was called the Ntshongweni Catchment Management Programme (NCMP).

When WRC approved the pilot proposal for 1995 and 1996, three more staff members were appointed in addition to the coordinator (ecologist; catchment development facilitator; and agriculture facilitator). Activities gathered momentum, with a remarkably positive response to the pamphlet (published in 1996). At the end of 1996, WRC

agreed to double the level of support, to enable the appointment of a publicity and information officer, a craftwork facilitator, an environmental educator, an office manager, a conservancies consultant and later an upper catchment agricultural facilitator (with help from Mondi), and a conservation Officer (employed by the Umlaas Irrigation Board Catchment Project). These 11 people have undertaken a remarkable range of activities over the past 6 years. Together with 6 Dutch students and several more South African students, they have built up a body of experience in integrated catchment management (ICM). The programme has grown from a small core of activities in one subcatchment, to a more comprehensive attempt to bring people together throughout the Mlazi River catchment, and also influences Metropolitan Durban through staff involvement in developing an Environmental Management System based on an understanding of the importance of ICM. The name of the programme has now been changed to the Mlazi River Catchment Programme (MRCP) to reflect this more comprehensive scope. However, as a lower level of support was given to the third phase of the programme, activities could not be extended into the lower catchment, and the staff complement was reduced from 10 staff members to 5 members.

The main activities of the programme can be described under the headings water demand management research, environmental education, rural development and community capacity building, local government development and environmental monitoring. In each of these fields, a considerable number of activities were undertaken, representing technical, social and ethical aspects of catchment management.

Estimated cost: R1 000 000  
Expected term: 2000-2001

**Promoting democracy through the IWRM process: Developing a model for sustainable relationships for the management of a scarce natural resource**

*CSIR*

**No 1294**

This research was aimed at developing an understanding of how to govern shared,

scarce natural resources. Worldwide there is increasing pressure on society to achieve equitable, efficient and sustainable use of ecosystem goods and services. The challenge that governments face is to reconcile the distribution of costs and benefits for society as a whole. The process that should underpin this reconciliation must be founded on trade-offs that have continually to be achieved through democratic processes. Only if these trade-offs are made democratically is it possible to expect the popular support that leads to compliance. In this way, attainment of equitable, efficient and sustainable use of ecosystem goods and services will reflect the extent to which democracy is institutionalised in society and the agencies that act on its behalf.

The research was conducted in the Sabie-Sand catchment in Mpumalanga Province, South Africa. The project was divided into three phases. The objective of Phase I was to develop familiarity with relevant underlying theories and to describe the social-ecological system in the Sabie-Sand catchment with respect to decision-making structures, processes and behaviours. From this, issues were selected to focus the action research phase of the project (Phase II). The objective of Phase III was to draw lessons from the research experience and to highlight the implications for the development of appropriate relationships and cultures for sharing a common property resource.

Phase I identified three models, or frameworks, that would be particularly useful in guiding the research. These were Senge's process for profound change, a form of action research known as appreciative enquiry, and Cook's model for understanding empowerment. Phase I also identified a number of issues around river resource governance in the Sabie-Sand catchment. These were:

- Large discrepancies between organizations and individuals
- Very little co-ordinated decision-making between organisations, which tend to engage government to resolve resource issues, rather than each other
- A lack of formal representation of the interests of many resource users
- A predominance of decision-making structures that were not necessarily geared to address their constituency's resource-related issues.

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## KSA 1 (continued)

### Water Resource Management

Apart from the issues identified, a number of opportunities were also identified:

- The Sabie River Irrigation Board had a vision to expand its scope to include a number of downstream users. In this way, the board would enhance its representation and empower others. This offered a significant opportunity to the research project
- The private forestry sector (global forest products) and the Kruger National Park stood out as organisations that are outward-looking, well-resourced and able to seek, engage and drive co-operative processes. They are at opposite ends of the catchment, again providing an opportunity for focus and for integrating upstream/downstream concerns.

At the end of project Phase I, differentials in levels and types of empowerment emerged as a major obstacle to stakeholders' collective capability to develop shared understanding and make wise trade-offs. Learning about what constitutes empowerment and co-operative empowerment therefore became a focus area for Phase II of the project. The Cook model of empowerment was used to guide the research team and resource stakeholders.

Phase II focused on action research. It applied strategic adaptive management (SAM) concepts in its approach. SAM is based on the acceptance of the uncertainty and variability inherent in social-ecological systems and the need to proceed with incomplete information. Thus, management should be experimental, adaptive and learning-oriented, so that learning from each round of implementation informs the next. This approach moves away from the balance of nature theory to a concept of nature as a system of hierarchical patches that are changing and diverse over space and time.

Phase II of the research project proceeded, in the first place, as a series of individual consultations with the 'well resourced' stakeholders. Once their agreement was obtained to participate further in the process, a joint workshop between the stakeholders, the research team, and DWAF was held.

There were a number of outcomes arising from the above process. Well-resourced stakeholders were willing to engage and invest in local-level informal processes, but they felt that they would benefit greatly from explicit acknowledgment and endorsement of their endeavours by DWAF. Related to this, there is a question about where the responsibility of an informal process ends, and where that of more statutory processes begins. There was also a perceived need for adequate and appropriate representation when people strive to make decisions together. There is a tension between being representative (i.e. having all groups present, but perhaps not participating equally) and building relationships, perhaps more slowly but more thoroughly and meaningfully, to achieve full representation.

The research conducted during this project has allowed the team to identify a number of important lessons regarding co-operative resource governance. These include the following:

- Relationship-building cannot be rushed (as predicted by Senge's model)
- Repeated reinforcement is important for sustaining relationships
- Stakeholders can learn to value relationships as much as the decisions they support
- Informal resource governance processes require support from formal processes, and there is a risk of failure if they are not supported
- There is a need to balance the requirements for empowerment (which takes time) representation (which can be achieved relatively rapidly, but does not necessarily lead to voluntary compliance and truly empowered resource sharing)
- Individual champions, or catalysts, play a critical role in sustaining and fostering relationships in informal resource sharing processes.

Cost: R1 416 700  
Term: 2002 - 2005

*Stakeholder participation in the establishment and governance of catchment management agencies (CMAs): Best practice guidelines*  
Department of Geography, Rhodes University  
No 1434

The NWA puts emphasis on the decentralisation 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 marginalised groups are also taken into consideration in the governance of CMAs?
- How can civil society be best organised to play a meaningful role in the management of water resources at a catchment and subcatchment level?

Cost: R 1 000 000  
Term: 2003-2005

*Water Law of South Africa*  
Maritza Uys  
No 1513

The main purpose of this project was to identify future research needs in the law-related portfolio in the KSA. The produced results were not inclusive enough to be published. It was found that the identification of water law and governance issues should therefore be approached from three perspectives:

- A statutory approach
- A customary law perspective
- A human rights view.

This will ensure that future water laws are not restricted to formal old-fashioned rules, but should be sufficiently pliable to fit into a new flexible and dynamic system of governing our scarce water resources, all integrated into a sustainable water resources management system.

Cost: R200 000  
Term: 2004-2005

## Current

### Thrust 1: Water Resource Assessment and Development

#### Programme 1: Groundwater hydrology

*A strategy for future investigations of deep groundwater systems in South Africa*  
Directorate Geohydrology, DWAF  
No 1237

Present knowledge of fractured-rock aquifers in Southern Africa is mainly restricted to the 'shallow' (i.e. upper 100 m) of the earth's surface, where the ubiquitous role of erosional unloading/weathering is an important factor controlling the occurrence of groundwater. There are, however, a number of key indicators pointing to the existence of deep groundwater systems within many of these hard-rock terrains, e.g. thermal springs and artesian boreholes. With the shift in emphasis of groundwater resource assessment from the localised to the catchment scale, there is a need to assess the role of deep groundwater systems in the hydrological cycle. Due to a lack of information on and the complexity of the deep groundwater flow system, as well as the requirement of a multidisciplinary approach, a strategy for conducting such research has to be formulated as a prerequisite to detailed investigations. The results of this research will provide guidelines to the groundwater community in terms of the conceptualisation, exploration and development of deep aquifer systems, and will also identify key areas for future research.

Estimated cost: R198 000  
Expected term: 2001-2007

*A synthesis of the hydrogeology of basement aquifers in Southern Africa: Research needs and priorities*  
Council for Geoscience  
No 1418

Basement aquifers are found extensively in sub-Saharan Africa. The only viable water supply to many rural communities is located in these aquifer systems. To contribute to sustainable resource development, all knowledge about the attributes and dynamics of groundwater occurrence in basement aquifers

needs to be consolidated. This is necessary to identify the research needs, gaps and priorities. This project aims to synthesise current knowledge relating to basement aquifers in Southern Africa. The output of the synthesis will lead to a research strategy that will address shortcomings in our knowledge base. This is a necessary project to guide future research in the hydrogeological domain.

Estimated cost: R564 430  
Expected term: 2003-2004

*Flow conceptualisation and storage determination in TMG aquifer systems*  
Department of Earth Sciences, University of the Western Cape  
No 1419

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

Estimated cost: R3 500 000  
Expected term: 2003-2008

*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 - 2008

*Flow conceptualisation, recharge and storativity determination in Karoo aquifers (with special emphasis on the Eastern Cape (Mzimvubu to Keiskamma Water Management Area)*  
SRK (CE)  
No 1565

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

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

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

Programme 2:  
*Catchment hydrology*  
Update of SA Atlas of Agrohydrology and Climatology  
University of KwaZulu-Natal  
No 1489

The South African Atlas of Agrohydrology and Climatology is one of the most extensively used WRC products. Over 1 000 hard copies have been sold, several 1 000s of map images distributed and some 50 CD Rom copies given to clients. Since its publication, however, considerable new information and technology, as well as new needs, have seen the light of day which would necessitate and facilitate not only an updated and extended,

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## KSA 1 (continued)

### Water Resource Management

but also a greatly enhanced new Atlas. The primary objective is to collate agrohydrology- and agroclimatology-related data and information from diverse research projects of various organisations and WRC projects into one co-ordinated spatio-temporal database and to utilise that information for the production of a new, electronically interactive atlas.

Estimated cost: R546 100

Expected term: 2004 - 2006

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

*School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal*

**No 1490**

Hydrological operation and planning levels in South Africa are in the process of being updated in line with the requirements of the National Water Act of 1998 (NWA). The NWA requires the establishment of catchment management agencies (CMAs) to protect, conserve, manage and control water resources in water management areas (WMAs). Developments of tools to equip CMAs have occurred, with limited integration, such that the value of these developments to water managers has been very limited. This study seeks to develop a decision support system (DSS) that will be useful for the operation and planning at CMA level. The development of the DSS will integrate existing research findings, data and available tools and will also make improvements to these tools. While national planning within DWAF has dealt primarily with relatively large scales (i.e. catchment and quaternary level) using monthly time steps, this study will focus on finer spatial and temporal resolution than was the case in the past. The finer resolution is targeted to deal with water resources at a range of scales varying from points of use to the whole WMA. Similarly, the planning aspect will handle a range of time scales varying from daily to annual.

#### **The objectives are:**

The primary objective of this project is the development of a Hydrological Decision Support Framework (HDSF) which can incorporate relevant and appropriate modelling algorithms / modules which are linked by a

common flexible and extensible database and integrated with a GIS for use at a planning and operational level by CMAs at spatial scales ranging from point of use to the entire WMA and at temporal time scales of one day. The coarsest catchment scale at which the modelling algorithms / modules within the HDSF will operate in a lumped mode is at a quaternary catchment level and, in order to model the complexities of hydrological responses within a catchment, it is envisaged that the modules will be applied at sub-quaternary catchment scales. The HDSF should simplify and ensure maximum flexibility in system configurations, utilise GIS to generate system / module inputs and have interfaces suitable for water resource managers to interrogate the system. It is envisaged that the framework developed will be able to accommodate modules not utilised in this study. The HDSF is to include a spatio-temporal database populated with quality controlled data.

The purpose of the HDSF will ultimately be to support CMAs in planning and managing water resources under their jurisdiction and to provide tools to facilitate planning and scenario analyses. Although this will require a number of different functions to be performed, the main focus in this project will be the development of an HDSF to support CMAs in the assessment of water resources and the allocation of water use licences under the new requirements of the NWA of 1998. This will require designing the framework, integration of relevant modules, or adding functionality to existing modules, design of a generic and extensible database and GIS structures and the population of these with quality controlled data at both quaternary and sub-quaternary catchment scales. A suite of relevant simulation modules best suited to the requirements of CMAs will be selected for incorporation into the HDSF. The selection of modules will be finalised after a review of user needs has been performed, but it is anticipated that a physical-conceptual process based on hydrological modules, integrated so that system analyses can be performed, will be required for the assessment of water resources and the allocation of water-use licences. It is envisaged that the HDSF will be applied on selected catchments within two WMAs which will give the opportunity to assess and refine the HDSF.

A further objective of the project is to extend the capabilities of some of the modules so as to enable the assessment of water resources and the allocation of water use licences at the level of CMAs as well as to consolidate and encapsulate existing relevant research findings into the selected simulation modules in order to refine the simulation of hydrological processes. Within the constraints of the budget and available resources, these could include an easy-to-use methodology to simulate dynamics in the catchment, refinements to hydrological processes, addition/refinement of selected water quality modules, refinements to cater for proposed new water allocation and management options such as fractional water allocation and capacity sharing / water banking, and inclusion of dam operating rules to meet IFR and other water demands. Where necessary, additions and refinements will be made to the selected modules to extend the HDSF such that it can be used operationally. These include 'ownership' of water in impoundments and near real time operations with links to climate forecasting systems.

An additional objective will be to provide user support and up-to-date user documentation for the HDSF and to assist users in the implementation of the HDSF. Thus this project will collaborate where possible with other WRC-funded research projects (e.g. No. 1318, No 1320 and No. 1430) as well as with solicited proposals currently under consideration (KSA 1: Water resources of South Africa, 2005; KSA 1: Low flows and streamflow reduction activities; KSA 4: Standards and guidelines for improved efficiency of irrigation water use from dam wall releases to root zone application; KSA 4: Technology transfer and integrated implementation of water management models in commercial farming) and with modelling efforts at DWAF (e.g. systems analysis) in order to reduce duplication of effort.

Estimated cost: R2 597 000

Expected term: 2004 - 2008

#### *Water resources of South Africa, 2005 Study (WR2005)*

*SRK (CE) Inc.*

**No 1491**

The 1990 Surface Water Resources of South Africa Study (WR90) and its predecessors have played a major role in providing key

hydrological information to water resource managers, planners, designers, researchers and decision makers throughout South Africa since the late sixties. The deliverables from the last nationwide water resource assessment in 1990, WR90, became essential tools for water resources management, planning and operational practitioners, researchers and decision makers. The 1990 study which basically focused on surface water resources has become less and less useful over the years as the water sector evolved with new legislation coming in (Water Act of 1998), changing land uses, improved knowledge and data, technological advances, and the need to answer new questions in a changing water sector. The WR2005 study seeks to quantify and assess national water resources in an integrated manner that takes into account the new water environment and addresses the shortcomings of the previous nationwide studies.

**The objectives are to:**

- Evaluate the WR90 project and its use. Critically review the outcomes of the WR90 project with regard to
  - Project implementation
  - Uses and users
  - Project impact on the water sector
  - Shortcomings and strengths
- Develop WR2005 project framework
- Develop WR2005 tools
- Develop WR2005 database
- Investigate and build a user support system for WR2005 products
- Document the project work and package products efficiently and cost effectively
- Introduce and build PDI capacity

Estimated cost: R6 700 000  
 Expected term: 2004 – 2008

**Programme 3:**  
**Understanding and predicting hydroclimatic variability**  
*MOSMEPS (Model Output Statistics applied to multimodel ensemble long-range climate prediction)*  
 South African Weather Service  
 No 1492

This project will combine single general circulation models (GCMs) into a multimodel ensemble since GCMs differ in their parameterisations and, therefore, differ in their per-

formance under different conditions. Using a suite of several GCMs not only increases the effective ensemble size, it also leads to probabilistic simulations that are skilful over a greater portion of the region and a greater portion of the time series. Multimodel ensembles are nearly always better than any of the individual ensembles. The benefits from combining ensembles are a result of the inclusion of complementary predictive information since the scheme is able to extract useful information from the results of individual models from local regions where their skill is higher. The project seeks to assemble leading forecasting models and to put into place a scheme for using models operationally in a complementary way, and assess their skill in producing probabilistic ensemble climate forecasts.

**The objectives are to:**

- Investigate the operational predictability of seasonal to inter-annual rainfall and its extremes over Southern Africa through the use of multimodel ensembles
- Investigate the operational predictability of seasonal to inter-annual occurrence of tropical cyclones over the southwestern Indian Ocean through the use of multimodel ensembles
- Test different recalibration methods linking GCM-simulated large-scale fields to rainfall
- Assess if the recalibration is an improvement over raw GCM rainfall forecasts
- Test various multimodel ensemble combination schemes
- To set up an operational multimodel prediction system at the SAWS to the benefit of the end-users of seasonal forecast products.

Estimated cost: R436 000  
 Expected term: 2004-2008

**Hydroclimatic variation over Southern Africa at intra-annual and inter-annual time scales, with special reference to the role of the oceans**  
*Department of Oceanography, University of Cape Town*  
 No 1476

Climate variability is arguably the greatest problem faced by water resource managers

in Southern Africa today. It has now been recognised that the heat content of the upper ocean and evaporation from the adjacent oceans may be of even greater value than previously anticipated in understanding the mechanisms by which the ocean influences the weather and climate variability of countries in Southern Africa. These variables may, therefore, hold the key to simulating the processes whereby sea surface temperatures influence rainfall variations which, as indicated, currently remain poorly understood. The methodologies are in line with the current state of the art and are able to accommodate possible future improvements in models, remote-sensing hardware and computational facilities.

This project aims to enhance the understanding of hydroclimatic variability and the prediction of climate variation in Southern Africa, with special reference to the role of the oceans and to addressing needs of water resource managers.

**Specific objectives are to:**

- Assess the suitability of indices used to represent hydroclimatic variation over Southern Africa from a joint ocean/atmosphere system and water-resource management perspective and address shortcomings, where necessary
- Select, assess and apply the most promising of advanced remote sensing and modelling products which would assist in achieving the remaining objectives of this project
- Test hypotheses concerning the importance of the heat content of upper ocean layers, and evaporation from the oceans adjacent to Southern Africa, in influencing the weather and climate variability of countries in Southern Africa
- Assess the degree of improvement in the predictability of climate/rainfall variations through appropriate consideration of newly identified influential oceanic variables in conjunction with the refined use of dynamic models
- Familiarise water resource managers with advances in, and capabilities and potential benefits of using improved prediction tools.

Estimated cost: R2 000 000  
 Expected term: 2004 – 2007

# KSA 1 (continued)

## Water Resource Management

### *Using enhanced knowledge of climate variability for the benefit of water resource management*

University of Cape Town  
No 1566

Research into climate variability over the past 15 years has enhanced knowledge substantially with regard to the Southern African region. Because of the sensitivity of water resources in the region to climate variability, it is imperative that this knowledge be utilised optimally for water resource management.

Consequently, this project will focus on:

- Identifying the strengths and weaknesses in current climate prediction tools from the water resource management perspective
- Assessing whether recently gained knowledge of climate variability (including knowledge resulting from locally-conducted research) and new insights from current research on climate variability related to climate change can be used to improve tools, and/or the effectiveness with which tools can be used, by water resource managers.
- Demonstrating beneficial use of best available tools or tools specifically improved for water resource management applications and transferring knowledge in this regard.
- Filling crucial knowledge gaps which are known to still exist, in as far as this is possible in the short term
- Identifying longer-term research, capacity-building and/or educational initiatives to enable water resource managers derive maximum benefit from climate modelling and forecasting tools.

Estimated cost: R1 478 000  
Expected term: 2005 – 2008

### *Programme 4: Development of appropriate techniques for evaporation monitoring*

*Refining tools for evaporation monitoring in support of water resource management*  
CSIR

No 1567

Evaporation, after precipitation, is the largest component of the hydrological cycle at the land surface. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the transpiration of plants.

There are many compelling water-resource related reasons (among them demands created by recent water legislation) for being able to measure/estimate and monitor evaporation with sufficient accuracy and precision. While many potentially suitable techniques and methods exist, there is a lack of knowledge regarding their appropriate use and capacity in applying them. Consequently, this project will aim to:

- Classify and characterise land uses/units and water-resource management applications for which evaporation measurements/estimates are needed
- Assess accuracy and precision requirements relating to evaporation measurement/estimation for various water-resource management applications
- Assess appropriateness of evaporation measurement/estimation techniques for addressing a range of key water-resource management needs
- Develop guidelines for the complementary use of measurement and estimation techniques
- Develop/refine evaporation measurement/estimation techniques, where necessary, for key water-resource management applications
- Establish a sound basis for capacity building and skills development relating to evaporation measurement and estimation.

Estimated cost: R1 600 000  
Expected term: 2005-2008

### *Programme 5: Water quality assessment studies and information systems*

*A guideline for the selection of toxicity tests in support of the information requirements of the National Water Act*  
Division of Water, Environment and Forestry Technology, CSIR

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: 2001-2002

### *Development of technical guidelines for water quality use allocation procedures under the NWA through application of the Berg River water quality information system*

Department of Civil Engineering, University of Stellenbosch  
No 1301

The implementation of the National Water Act (NWA) (Act No. 36 of 1998) is gradually unfolding at both the national scale and at the catchment scale across South Africa. The NWA provides a statutory framework for integrated water resource management (IWRM) at the catchment scale through two tiers of interlinked water resource management (WRM) strategies:

- National Water Resource Strategy (NWRS), which provides a large-scale planning framework, procedures and guidelines to ensure that water deficits or poor water quality do not arise on a regional basis at the scale of declared water management areas (WMAs) and that international water-sharing obligations are met
- Catchment Management Strategies (CMSs) inside WMAs, which ensure sustainable, equitable and optimal water resource utilisation at catchment scale with due ecological protection of the resource and with full participation by stakeholders and affected communities.

The NWA prescribes the minimum components of the CMS and prime amongst these are the formulation of water allocation principles and a Water Allocation Plan for each WMA (Section 9). However, for individual catchments in which water 'stress' (water supply deficits or unacceptable water quality) exists or threatens, or where redress of past discrimination in terms of water use is urgently needed, the NWA requires the compulsory re-allocation of water, followed by compulsory licensing on the basis of elicited licence applications (Sections 43-47).

Because the NWA implementation is still in its initial stages, no compulsory re-allocations have hitherto been undertaken, even though the initial screening of catchments in preparation for the first edition of the NWRS has indicated a number of catchments which fall in that category. Consequently, no deep understanding currently exists of what would constitute best practice procedures in the water allocation process. From the DWAF Strategic Plan for the period 2001-2005 it is evident that the earliest compulsory licensing that is foreseen would be during 2004. There is, therefore, time in hand to engage in a learning process so as to develop adequate understanding of what the compulsory re-allocation and licensing procedures need to entail both in a technical WRM context and in a participatory WRM context.

This project is proposed as such a learning process, but focuses on a very particular part of the allocation challenge, namely the allocation of 'Water Quality Use'. Intuitively, allocation may be associated with water quantity, but a significant innovation of the NWA is that it defines 'water use' very broadly – amongst others to include the use of the resource to dispose of waste (Section 21). It can be expected that allocation procedures based on 'water quantity use' of the resource will be developed by DWAF fairly readily during the next few years, but the same cannot be expected of allocation procedures of the 'water quality use' of the resource. The complexity of point and non-point delivery and transport processes that determine the water quality constituent loads in a catchment, the relatively poor water quality databases and the role that statutory resource quality objectives are required to play in WRM (Section 13 of the NWA) all indicate that a focused

research effort is required to unpack the conceptual and technical components of the water quality part of the allocation challenge.

**The research aims to:**

- Develop a conceptual framework for water quality use allocation procedures
- Develop and disseminate technical guidelines for water quality use allocation procedures.

Estimated cost: R683 000  
 Expected term: 2002 -2004

**Review of research needs and priorities for water quality assessment studies and information systems**

*Umgeni Water  
 No 1424*

Arising from the National Water Policy of 1997 (which can be termed 'executive policy') is a suite of new component or 'operational' policies, related to various aspects of the management, protection, development and use of water resources. Some very significant changes have occurred in the way in which water quality is managed, both from a resource point of view (through the resource-directed measures) and a source point of view (source-directed measures). Policy at the operational level has advanced in both these areas. In addition, the institutional landscape of water resource management, which includes the management of water resource quality (and water quality within that context) will change significantly in the short- and medium-term, as catchment management agencies and other local-level water management institutions begin to play progressively greater roles in everyday water resource management.

Water quality is often ignored in resource assessment. This project will provide a strategic framework for research investment by identifying research gaps and priorities. The project aims to:

- Review research needs and priorities for water quality assessment, with a focus on water quality assessment studies and water quality information systems, arising from recent South African water quality policy development and implementation initiatives associated with resource-directed measures as well as source-directed measures

- Provide strategic guidance to the WRC for future research in this area

Estimated cost: R200 000  
 Expected term: 2004-2005

**Thrust 2:  
 Management of Natural and Human-induced Impacts on Water Resources**

**Programme 1:**

**Developing predictive tools and adaptive measures to global climate change**

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

The WRC is currently funding a project to investigate the potential impact of global and regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality, water quality and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function, with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R 2 500 000  
 Expected term: 2005 - 2008

# KSA 1 (continued)

## Water Resource Management

### Programme 2:

#### Human-induced impacts

*Fluoride in drinking water and its effects on human health and nutrition (A component project of the research programme on sustainable groundwater management and utilisation in the Northern Cape)*

*Faculty of Dentistry, University of the Western Cape*

**No 1094**

Contributing to the poor domestic water supply and quality in the Northern Cape are high fluoride levels, this study, through systematic analysis, is investigating the impact of poor water quality, high in fluoride, and the potential for low-cost treatment.

Estimated cost: R318 000

Expected term: 1999-2007 (extended)

#### *Development of a system of simplified methods of vegetation water use based on the principle of limits to evapotranspiration*

*Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch*

**No 1319**

Water resource managers will increasingly need to assess whether proposed changes in land use within catchments are likely to significantly reduce the quantity and temporal availability of water to downstream users. Such decisions need to be based on the relative annual water use of the existing and proposed new crops or vegetation. The National Water Act makes provision for declaring certain land-covers (forests and crops) as SFRAs but it is likely that other land-cover changes may also have a significant impact in some situations. The principle of limits to evapotranspiration will allow for the limiting factors to be identified in particular situations and thus for a screening of land-cover changes based on the likely impacts. It could also provide a useful framework for interpreting the impacts of regional climate change in South African situations.

In selecting a model to use in this study, the research team considered easy availability of the model, proven scientific credibility and application in hydrological studies, good documentation, a balance between simplicity and realism, and applicability to a wide range of vegetation types. The concept of identifying limits and controls on the pro-

cess of ET was also key to this project, and central to the development of a broad water use framework. Suitability for linkage to a user-friendly interface to permit model use by non-specialist users was a further consideration. Against these criteria, the WAVES model was selected as the most suitable model. The original version of this model was developed by the Land and Water CRC of the CSIRO in Canberra, Australia. In this project this model was revised with permission from the developers to meet the project objectives and adapted to local conditions.

The project aimed at developing a framework of understanding of the major controls of evapotranspiration (ET) in different types of vegetation and crops in South Africa. This research is expected to lead to a better understanding of how changes in land-cover will impact on surface water yields; and also to propose simpler approaches of assessing these impacts, easing the task of simulating water use in the wide variety of vegetation, both indigenous and alien.

The updated WAVES model was simulated to determine ET and transpiration for a variety of land covers. The simulated outputs were compared with field based measurements from scintillometry, Eddy Covariance, Bowen Ratio and Heat Pulse Velocity techniques. It was observed in the project that the WAVES model gave good correlation with measured ET and transpiration for most of the vegetation types. The climate controls in ET were also very evident in the study as the availability of soil water restricted ET which occasionally rose after rainfall and fell in drier periods in the cases of certain shallow root forests such as fynbos. The researchers also noted that, while the plant growth module in WAVES is far simpler than that in many other process-based models, it allows the green leaf biomass to be adequately simulated over time, and models the various constraints imposed on both growth and transpiration.

In this project a user-friendly prediction tool to allow non-specialist modellers to assess the water use of various land cover types was developed through the improvements to the WAVES model. The version of WAVES developed in this project is a CD-based product that will be distributed with the research report for the benefit of a wide variety of researchers, water resource managers, conservationists and students.

It was also observed in the study that further work will be important to improve the value that will be gained from the use of the updated WAVES model. Important areas for further research work include linking ET changes to streamflow in a spatial context; parameterising more vegetation types for inclusion in the models; and investigating the water use of aquifer-dependent vegetation in the drier parts of the country. This will ensure that a high priority is given to further species of alien invasive plants that are suspected of bringing about significant hydrological changes and will highlight and enable the regulation of aquifer utilization to avoid permanent ecosystem damage.

Estimated cost: R1 013 000

Expected term: 2002 -2005

#### *Community-based research on the influence of rehabilitation techniques on the hydrology of degraded catchments*

*School of Applied Environmental Sciences, University of KwaZulu-Natal (Pietermaritzburg)*

**No 1316**

Two neighbouring communities of Mnweni and Okhombe in the Amazizi and Amangwane Tribal Wards have both embarked upon intensive job creation programmes which have focused on the rehabilitation of degraded areas. Both areas are situated in the foothills of the Drakensberg which forms the main catchment area for KwaZulu-Natal. Loss of grass cover on these steep mountain slopes has resulted in poor water infiltration, increased runoff and severe soil erosion. Soil erosion is seen as a major threat to water resources and land productivity. The communities have been assisted in their erosion control efforts by various institutions including the University of KwaZulu-Natal, Farmer Support Group, CSIR, Dept. of Agriculture and KwaZulu-Natal Nature Conservation services.

One of the objectives of this project is to implement participatory monitoring whereby the rural participants record and analyse differences and change. This will provide an opportunity for learning where the people contribute to the monitoring process and are empowered to take subsequent decisions. In this way local capacity is enhanced and the communities become involved in technologies that fit local and environmental conditions.

#### The research aims to:

- Determine the effect of different rehabilitation techniques on runoff and soil loss
- Identify and prioritise rehabilitation interventions for establishing baseline conditions in the study areas
- Establish land users' perceptions on soil erosion and rehabilitation in conserving water
- Determine soil conservation measures that will be socially acceptable and physically effective in communal areas.

Estimated cost: R984 000  
Expected term: 2002 -2007

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

*Department of Chemistry, Technikon Northern Gauteng  
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 -2004

#### *A guide to conduct eutrophication assessments for rivers, lakes and wetlands* *Ninham Shand (Pty) Ltd No 1343*

Eutrophication is the enrichment of waters with plant nutrients which results in an array of symptomatic changes, amongst which increased production of algae and aquatic macrophytes, deterioration of water quality and other undesirable changes that interfere with water uses. In South Africa, eutrophication has been recognised as a priority water quality problem for over 30 years. DWAF recently completed a study that assessed the eutrophication status of a number of South African water bodies. It was found that the extent of eutrophication of reservoirs and river systems has increased since the problem was first identified in the 1970s.

A recent study commissioned by the WRC found that South Africa's policy and approach to eutrophication control has been inadequate over the last 20 years. It also found that the lack of policy development, monitoring, research, reporting and capacity development has greatly diminished the country's ability to deal with the problem. A strong need was identified to remobilise and redevelop its capacity to manage eutrophication. The publication of this report was followed by a workshop to discuss research and capacity building within the field of eutrophication. Assessment of the eutrophication problem was identified as the highest priority research area.

Three products are envisaged to emanate from this project: a eutrophication assessment guide, an Internet-enabled version of the guide and the outline and course material for a short course on eutrophication assessment which uses the eutrophication assessment guide as primary text.

#### The research aims to:

- Provide professional guidance to practitioners in using assessment protocols that are aligned with national catchment water quality assessment studies to assess eutrophication-related catchment and receiving water body characteristics
- Provide a means by which local and international best eutrophication assessment practice (methodologies and protocols) can be captured and made available to a wide range of catchment assessment practitioners in Southern Africa
- Develop tools and course material that can be used to fast-track capacity building in eutrophication-related water quality assessment and management.

Estimated cost: R669 700  
Expected term: 2002 -2004

#### *An investigation and formulation of methods and guidelines for the licensing of SFRA's with particular reference to low flows* *School of Bioresources Engineering and Environmental Hydrology, University of KwaZulu-Natal No 1428*

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

# 1

## KSA 1 (continued)

### Water Resource Management

#### The objectives are:

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

assist in hydrological assessments for the consideration of water use authorisations. These will form an SFRA component of the planned Water Allocation Toolkit, the components of which can be applied consistently across regions, are transparent in approach and are adaptable in that they can be upgraded or amended with minimum disruption

- To ensure the compatibility of Reserve determination methodologies and the results thereof with SFRA and other water use estimates and available hydrological information through consideration of specific months and daily flow records for various assurance of supply levels
- To test these products through the application of the guidelines in at least four catchment case studies
- To improve the research capacity in South Africa in the field of land-use hydrology and integrated water resource management and the skills of water resource managers involved in water-use licensing, particularly SFRA.

Estimated cost: R3 800 000

Expected term: 2004 - 2007

#### **Mine-water irrigation return flow** *Institute for Groundwater Studies, University of the Free State* **No 1507**

Project No 1149 evaluated the practice of irrigating with neutralised acid mine water on a commercial scale with different water qualities and on different soil types. The rationale behind this project was that most of the dissolved calcium and sulphate in the neutralized acid mine drainage would precipitate within the soil profile, thereby causing a significant reduction in the salt load percolating to groundwater. The current project aims, amongst others, to evaluate the environmental impact and sustainability of such an irrigation practice and will extend these investigations with more detailed groundwater observations, the description of aquifers, plume migration and the final impact of various pivot arrangements on groundwater resources. This information is required in order to assess the impact large-scale irrigation with mine effluent will have on water quality over the long term, so that informed decisions about its application can be made.

#### The objectives are:

- Determination of hydraulic interaction of irrigated mine water with the underlying aquifers
- Assessment of the effect of irrigation on the hydrology and water quality at opencast colliery spoils
- Determination of salt migration and attenuation from irrigated areas under natural and spoils conditions
- Quantification of the potential regional effects of large-scale mine water irrigation on the groundwater quality and quantities in Mpumalanga
- Compilation of a comprehensive database and document which can be used as decision-making platform for future mine water irrigation in the Mpumalanga coalfields
- The establishment of criteria for site selection/operation, monitoring, determination of impacts and mitigation methods for mine water irrigation areas.

Estimated cost: R445 650

Expected term: 2004 – 2007

#### **Persistent organic pollutants (POPs) in the environment** *North-West University* **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 -2008

### **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 off 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. Similar 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 -2008

### **Thrust 3: Water Resource Protection**

#### **Programme 1: Groundwater protection**

*A multitracer study of the origins, systematics and hydrological linkages of high nitrate concentrations in Bochum District, Northern Province*  
*Schonland Research Centre, University of the Witwatersrand*  
**No 1328**

In large tracts of the Northern Province with millions of inhabitants who rely almost exclusively on groundwater supplies, high nitrate values are reported. High nitrate concentra-

tions in drinking water may lead to methemoglobinemia, impairment of the blood to transport oxygen in infants, whilst sustained exposure to high nitrate levels may cause intestinal cancer in adults. The results of this study are intended to produce strategies and guidelines for the mitigation of high nitrate concentrations which, it is expected, will find direct application in the current investigation which logically can be extended into a region in which an enhanced understanding of the systematics of excessive nitrate levels in groundwater is a high priority.

Estimated cost: R300 000  
Expected term: 2002 -2003 (extended)

#### **To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater**

*Council for Geoscience*  
**No 1431**

The South African groundwater database does not support identification of areas with high concentrations of trace metals that may form a potential hazard due to incomplete data and difficulties in detecting these trace metals. In this project a geochemical modelling approach will be adopted to determine the presence of trace metals in groundwater. The objectives of the project are: verification of prediction of naturally occurring trace constituents in groundwater by field sampling at appropriate test sites; setting up of leaching tests; verification of geochemical and geological models; and development of a GIS map that identifies areas of special concern.

Estimated cost: R 900 000  
Expected term: 2003-2007 (extended)

#### **Field investigations to study the fate and transport of DNAPLs in groundwater**

*Institute for Groundwater Studies, University of the Free State*  
**No 1501**

Studies on the fate and transport of organic pollutants in groundwater have, to date, been done on an ad hoc basis. DNAPL movement in the subsurface is density-driven and extremely complex. This project will consolidate knowledge about the fate and transport of DNAPLs in groundwater in a systematic manner.

#### **The objectives are:**

- Identify flagship field sites where DNAPL site characterisation methods and natural attenuation processes will be evaluated and tested during the project
- Evaluate rapid methods for the delineation of DNAPL-contaminated zones
- Conduct field- and laboratory-scale based studies in order to identify and predict critical factors for DNAPL flow and transport under South African aquifer conditions
- Assess the viability of natural and enhanced attenuation processes of DNAPL-contaminated zones
- Establish methodologies for DNAPL site characterisation
- Develop guidelines for the construction of conceptual models of DNAPL-contaminated sites
- Develop appropriate guidelines for monitoring systems of DNAPL-contaminated sites.

Estimated cost: R3 058 000  
Expected term: 2004 - 2007

#### **Programme 2: Protection and management of surface water quality**

*The assessment of short-, medium- and long-term impacts on groundwater quality associated with the filling of dolomite cavities*  
*Metago Environmental Engineering*  
**No 1122**

De-watering of the dolomite aquifers overlying ore-bearing reefs has, since the 1960s, resulted in the formation of a large number of cavities in the dolomite compartments on the West Rand. These cavities need to be filled both for safety reasons as well as to prevent further inflows of surface water which would lead to aggravated ground instability and accelerated recharge of the mine void. The State Technical Committee for Sinkholes has raised the alarm about the potential for groundwater contamination when the cavities are filled with various mine waste materials, including slimes and waste rock. This investigation will focus on the impacts arising from the future filling of cavities and assess the effectiveness of alternative fill materials and methods in reducing those impacts. Impacts will be assessed over the short-, medium- and long-term. The investigation will furthermore assess the relative

# KSA 1 (continued)

## Water Resource Management

significance of the filling of sinkholes as a source of groundwater contamination in comparison to other sources of contamination such as tailings dams, waste rock dumps, return water dams and streams, and assess the provisions of both current and pending legislation to ensure that proposals arising from the project comply with the requirements of such legislation.

Estimated cost: R440 000  
Expected term: 2000-2002

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

Stewart Scott (CE) Water Quality  
No 1212

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

Estimated cost: R 494 890  
Expected term: 2001-2007

### *PCR-based markers for identification of toxic cyanobacteria*

Department of Genetics and the Forestry and Agriculture Biotechnology Institute (FABI), University of Pretoria  
No 1502

The quality of many water sources in South Africa is declining. The decline is primarily as a result of eutrophication and pollution by trace metals. During April 2003 a blue-green algae bloom of 30 cm thick and a diameter of 4 ha was detected in the Hartbeespoort Dam. This cyanobacterial bloom did not only cause a health risk to both animals and humans, but may also result in other problems for suppliers and users of potable water. The current cyanobacterial taxonomy does not provide an unequivocal system for the identification of toxigenic and bloom-forming genus *Microcystis*. The ambiguities that exist in the cyanobacterial taxonomy are due to the expressed variability, minor morphological and developmental characteristics used for identification, classification of the genus or species level. The increasing occurrence of toxic *Microcystis aeruginosa* blooms in major water resources make identification and prediction of these toxic blooms very important. The research will contribute to the development of techniques that will aid in the rapid identification of toxic cyanobacterial strains and in assessing the potential toxicity of the strains.

#### **The objectives are to:**

- Assess the genetic diversity of a wide variety of geographically unrelated strains of *Microcystis aeruginosa* collected from selected South African dams (e.g. Gauteng and North-West Province).
- Develop an unequivocal identification system for toxigenic and bloom-forming genus *Microcystis* with the objective to manage cyanobacterial blooms by ensuring early detection of toxic strains.
- Correlate the observed fingerprint obtained using the toxin-producing *mcyb* gene to toxin levels measured in the specific strains.

Estimated cost: R668 000  
Expected term: 2004 - 2007

### *Land-use impacts on salinity in Western Cape waters*

Department of Soil Science, University of Stellenbosch  
No 1503

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

#### **The objectives are:**

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

#### **Subsidiary objectives include the following:**

- Determine and map the spatial distribution of salts across the whole Berg River catchment.

- Spatially relate salt distribution to salinity generating factors (soils and soil-forming processes, geology, climate, topography, vegetation and land use) across the whole Berg River catchment.
- Develop an improved understanding of how local tillage and other dry-land farming practices augment or reduce the mobilisation of salts.
- Conduct mechanistic modelling of salinity dynamics.
- Use the model to create small catchment-scale salt flux scenarios for various land use and water management practices that will serve to inform modelling of salt fluxes on a regional scale.

Estimated cost: R2 347 068  
 Expected term: 2004–2007

#### **Novel silicone rubber integrative passive field sampler**

*School of Environmental Sciences/  
 Department of Ecology and Resource  
 Management, University of Venda  
 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 approximate the bio-available fraction in longer exposure times. They therefore give vital information also 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:**

- 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: 2004-2007

#### **Programme 3: Pollution of surface water**

*Cyanobacteria programme: Investigation into toxin blooms and toxin promotion  
 Consortium members: PU for CHE; University of Port Elizabeth; Technikon, Pretoria  
 No 1401 (b; c)  
 1401 (b)*

Due to the ability of several genera of Cyanobacteria to produce a range of hepatotoxins and neurotoxins. Since many genera of freshwater cyanobacteria are capable of production of hepatotoxins, increase in the frequency and severity of bloom events poses a problem for potable water supply in that classical treatment methods result in cell lysis and release of these toxins. An understanding of the environmental conditions that modulate toxin production would therefore be beneficial to the management of potable water supplies. Definition of the primary parameters and a model of the mechanism of modulation of toxin production would further facilitate management and treatment. The primary objective of this work was to

determine the modulatory role of environmental orthophosphate and nitrate levels on microcystin production by the dominant microcystin producing genus in South African freshwater impoundments and to develop a model to describe the cellular mechanisms by which these environmental parameters modulate microcystin content.

#### **1401 (c)**

Cyanobacteria are a group of extraordinarily diverse Gram-negative prokaryotes. Problems may occur as a result of algal overgrowth and the production of toxins. This species periodically blooms in Hartbeespoort Dam, a popular recreational dam and a source of domestic and irrigation water in North West Province. Consequently, there was a need to conduct a study to assess the appearance pattern and persistence of the *Microcystis aeruginosa* in the Dam.

The primary aim was to investigate environmental factors that affect the occurrence, persistence and bloom formation of phytoplankton species with particular emphasis on the *Microcystis aeruginosa* in the dam.

Estimated cost: R630 000  
 Expected term: 2002 – 2005

#### **PCR-based markers for identification of toxic cyanobacteria**

*Department of Genetics and the Forestry and  
 Agriculture Biotechnology Institute (FABI),  
 University of Pretoria  
 No 1502*

The quality of many water sources in South Africa is declining. The decline is primarily as a result of eutrophication and pollution by trace metals. Cyanobacterial blooms do not only cause a health risk to both animals and humans, but may also result in other problems for suppliers and users of potable water. The increasing occurrence of toxic *Microcystis aeruginosa* blooms in major water resources make identification and prediction of these toxic blooms very important. The research will contribute to the development of techniques that will aid in the rapid identification of toxic cyanobacterial strains and in assessing the potential toxicity of the strains.

# KSA 1 (continued)

## Water Resource Management

### The objectives are to:

- Assess the genetic diversity of a wide variety of geographically unrelated strains of *Microcystis aeruginosa* collected from selected South African dams (e.g. Gauteng and North-West Province).
- Develop an unequivocal identification system for toxigenic and bloom-forming genus *Microcystis* with the objective to manage cyanobacterial blooms by ensuring early detection of toxic strains.
- Correlate the observed fingerprint obtained using the toxin-producing *mcycb* gene to toxin levels measured in the specific strains.

Estimated cost: R668 000

Expected term: 2004 – 2007

### Programme 4:

#### Low flows and streamflow reduction activities

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

Department of Hydrology, University of Zululand  
No 1168

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

Estimated cost: R770 000

Expected term: 2000-2007 (extended)

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

CSIR / Umvoto  
No 1327

There is currently a debate concerning the extent to which groundwater abstraction from TMG aquifers will lead to environmental impacts. This project aims to assess the dependency of aquatic and terrestrial TMG ecosystems on groundwater and predict impacts of groundwater abstraction. These ecosystems include wetlands, highland seeps, the riparian zone and spring discharge sites, amongst others. Specific objectives are:

- The development of predictive tools to assess the impact (or risk) of groundwater abstraction on the environment
- To improve our understanding of groundwater-dependent ecosystems (GDEs) in the TMG and the sensitivity to groundwater level fluctuations
- The use of innovative techniques to determine the impact of groundwater abstraction on the environment
- The development of indicators to monitor the effect of abstraction on sensitive ecosystems
- Coupling time series and spatial databases in order to ascertain the impacts of low flows (groundwater and surface water interaction) on the environmental system
- Improved understanding of the impact of changing low flows on freshwater ecology
- Improved understanding of the relationship between surface flow, event discharge from high-lying TMG unconfined aquifers and deep confined-aquifer discharge in maintaining wetlands or seeps
- Improved understanding of subsurface TMG discharge in maintaining coastal plain wetlands and vleis.

Estimated cost: R2 201 327

Expected term: 2002 -2007 (extended)

#### An investigation of *Jatropha curcas*: A case study

CSIR  
No 1497

Recent business initiatives have proposed the introduction of so-called 'wonder-crop' exotic species for large-scale planting in South Africa. Specifically, *Jatropha* has been identified for introduction in the KwaZulu-Natal Province. The plant has potential as bio-fuel, and thus a source of renewable energy. The motivations behind these initiatives have been the laudable themes of poverty alleviation, job creation and business development. However, questions around the potential hydrological and ecological effects of the associated land-use changes remain unanswered due to a lack of information. Due to the significant area being proposed for planting *Jatropha* and other species, DWAF (Sub-directorate: Streamflow Reduction Allocations) has drafted a discussion paper proposing that all such species be declared streamflow reduction activities (SFRAs).

### The objectives are to:

- Develop predictive capability with respect to the impacts of large-scale planting of *Jatropha curcas* on water resources through hydrological process studies and modelling using appropriate techniques
- Provide information regarding the biophysical requirements of *Jatropha curcas* and produce maps through an ARC-View GIS modelling framework
- Gauge the perceptions and levels of understanding of SFRA processes and licensing amongst users of *Jatropha*
- Provide recommendations to the WRC, DWAF, the SFRA licensing committee and other stakeholders with regards to potential SFRA declaration and regulation and specifically *Jatropha*.

Estimated cost: R750 000

Expected term: 2004 - 2007

### Thrust 4:

#### Policy Development and Institutional Arrangements for Water Resource Management

### Programme 1:

#### Decision support for IWRM at catchment and WMA level

*The value of water as an economic resource in the Great Letaba River catchment*  
Economic Project Evaluation  
No 989

Apart from separate sectoral analyses in defined sub-regions, no comprehensive comparison on the value of water for different uses has been undertaken in South Africa. The best option under these circumstances is to estimate water values through economic modelling. In view of the research backlog and the unacceptability of generalisations regarding water values, tenders were invited and approved according to specified guidelines. The outcomes of these projects will enable the determination of the value of water in different catchment areas, for various combinations of water-use sectors, following different modelling approaches by a number of competent research organisations.

Estimated cost: R795 625

Expected term: 1998-2002

### **Approval and licensing of groundwater development and use**

*Parsons and Associates*

**No 1510**

Currently, granting approval for groundwater development and use falls within the responsibility of DWAF, DEAT and their delegated regional and local authorities. Authorisation is legislated under the National Water Act (Act 36 of 1998), the Environment Conservation Act (Act 73 of 1989, and amendments) and the National Environmental Management Act (Act 107 of 1998). Unfortunately, current procedures for granting approval for groundwater use are unnecessarily restricting groundwater development. This is because the two departments follow different procedures with respect to assessing groundwater use applications

Estimated cost: R390 000

Expected term: 2004–2006 (extended)

### **Industry-government partnerships for the development of sector-based standards for the water environment**

*Karin Bowler Enterprises*

**No 1511**

The aim of this project is to develop a partnership approach between industry and government for setting of agreed environmental standards, based on the Dutch 'covenant' model and utilising the provisions of the NWA for setting minimum standards for water uses which impact on the water environment, and implementing these through the use of provisions for environmental co-operation agreements which are contained in the National Environmental Management Act. The approach is to work at pilot scale for one industrial sector and one aspect of the water environment, in order to develop a generically applicable model.

Estimated cost: R400 000

Expected term: 2004–2006

### **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: 2005–2008

### **Programme 2: Water policy development and strategic policy support**

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

*CPH Water*

**No 1569**

The NWA provides for the transfer of water use licences through a water market. A recent WRC review of the value of water to different sectors of the economy has revealed that the market mechanism has proved to be an efficient tool to effect the transfer of water to more efficient users and improve water use efficiency under South African conditions. However, due to high transaction costs, this mechanism is under-utilised. In order to utilise the efficiency of market mechanisms, it would thus be necessary to institute institutions that facilitate transfer and reduce transaction costs. On the other hand, safeguards also need to be instituted to prevent potential negative externalities associated with transfers. This project will investigate three case studies to determine which steps and institutions are required to balance these requirements.

Estimated cost: R1 500 000

Expected term: 2005–2008

### **Programme 3: Institutional arrangements and processes for IWRM at catchment, WMA and national level**

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

*Source Strategic Focus (Pty) Ltd*

**No 1563**

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

Estimated cost: R2 800 000

Expected term: 2005–2008

### **Programme 4: Transboundary water resource management**

*Implications of South Africa's trade policies for water policy and water resource management*

*University of Pretoria*

**No 1564**

This project is to develop a strategic understanding of the linkages between trade policies and water policy in South Africa, and the implications of trade policies for water resources and water management, as well as to identify points or issues for future related research to support policy development,

# KSA 1 (continued)

## Water Resource Management

analysis and implementation in the water sector and linked economic sectors.

Estimated cost: R 530 000  
Expected term: 2005 -2007

### Programme 6:

**Integrated catchment management**  
*Influence of spills and releases on the river geomorphology downstream of a selection of existing dam spillways*  
PD Naidoo Associates  
**No 1314**

Hydrologists have long been challenged to document the degree to which human activities and uses of land and water have altered flood regimes and low-flow conditions. In recent decades, growing concern for the protection of biological diversity has led to increased scrutiny of the consequences of human-induced hydrological alteration to natural ecosystems.

Typical hydrological alteration takes place with the construction of a dam in a watercourse, usually eliminating or reducing a range of natural floods previously experienced in the river. This has a number of consequent effects on the river regime downstream of the dam wall. One consequence of such hydrological alteration is the changes in the channel geomorphology in the zone just downstream of a spillway. Since a dam acts predominantly as a silt trap, and spills and artificial releases from the dam are largely sediment free, the zone most susceptible to geomorphological change is the region just downstream of the dam spillway. Erodable material in this zone is the first that is vulnerable to attack and the material is selectively transported and deposited downstream. The extent to which this occurs is dependent on the quantity and energy of the release or spill from the dam. These changes have the effect of altering the habitat available for the sustainability of the river ecology, particularly in the zone within a few kilometres of the dam wall.

Environmental laws in South Africa now demand that artificial releases from dams meet the various instreamflow requirements (IFRs) for environmental purposes. This implies that new dam outlets be designed to meet a range of planned environmental releases from low base flows and freshets to larger

flushing type flows designed to achieve pre-determined environmental objectives. The larger flushing releases may typically be of the order of the average annual flood in size and can represent a significant part of the dam's volume.

The purpose of this study is to research the geomorphological changes that have occurred on a range of existing dams in South Africa with a view to expanding the knowledge available to teams involved in the IFR determination process. This will enable better assessments to be made of the magnitude of environmental releases that are required to achieve the objectives of flushing flows and to identify both the beneficial and negative environmental effects of such releases.

The main aim of the project is to develop an understanding of the degree of geomorphological changes on river reaches, that have occurred just downstream of the spillways of a selection of South African dams and to relate these changes to a defined range of influencing criteria.

Estimated cost: R500 000  
Expected term: 2002 -2004

**A catchment management strategy for the Kat River**  
Kat River Valley Water Users Association  
**No 1496**

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

### The objectives are to:

- Continue to develop the socioeconomic capacity of the community of the KRV
- Establish cooperative governance of the resources of the Kat River between DWAF, the KRVWUA and the communities of the

catchment, within the context of the Fish Keiskamma WMA

- Establish the criteria for acceptance by DWAF of the allocation schedule and the catchment management strategy
- Undertake a yield analysis to establish the water yield that can be reliably provided by the Kat River
- Assess the Reserve for the Kat River
- Develop RQOs for the Kat River
- Establish existing lawful use of the water resources of the Kat River
- Reach agreement among the WUA members on a water allocation schedule for license applications
- Establish strategic and contingency water requirements for the Kat River
- Establish the downstream water requirements of the users of the Great Fish River, into which the Kat River flows
- Design and initiate a monitoring programme that will assess the various water uses, Reserve flows and water quality, and the resulting state of the river.

Estimated cost: R2 100 000  
Expected term: 2004 - 2007

## New Projects

**Thrust 1:**  
**Water Resource Assessment and development**

### Programme 1:

**Groundwater hydrology**  
*The use of <sup>222</sup>Rn as a hydrological tracer in natural and polluted environments (NS)*  
CSIR  
**No 1685**

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

- Is justified as a tool for use during baseflow studies in South Africa when compared to existing geochemical and isotopic parameters
- Concentrations vary with groundwater age, chemistry, depth or flow rate
- Concentrations vary with seasons

- Can be used to distinguish between different geological features or point sources of pollution
- Has application as a tool to optimise the positioning of passive treatment works, assess risk, or calculate financial liability at mine sites.

Estimated cost: R 1 367 745  
Expected term: 2006-2009

### **Programme 2:**

#### **Catchment hydrology**

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

CSIR

**No 1684**

The quality of water resource research outputs, among other factors, depends on the accuracy and level of detail in available data resources. The finer spectral resolution of a hyperspectral imagery which allows for the detection of surface materials and their abundances, as well as inferences of biological and chemical processes, is set to improve local data resources. In this project, hyperspectral imagery will be used in the processing and analysis of remote sensing imagery to measure and characterise the spectral signatures of selected land-cover classes, to map selected and classified land-cover classes in study catchments as well as to contribute towards an envisaged spectral library for vegetation in Southern Africa.

Expected term: R643 700  
Estimated cost: 2006-2008

### **Programme 3:**

#### **Understanding and predicting hydroclimatic variability**

*The role of antecedent conditions in determining rainfall characteristics during the early part of the rainfall season (NS)*

University of Cape Town

**No 1681**

The early part of the rainfall season is a critical period for water resources in South Africa. Initial rainfall and its characteristics (frequency and intensity) determine the saturation of soils, contribution to runoff and associated reservoir storage levels as well as farmers' preparations for planting. It is the character of the climate and how it interacts

with local and regional conditions such as vegetation, soils and the topography that largely determines soil moisture levels. This project will aim to:

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

Estimated cost: R 1 642 600  
Expected term: 2006-2010

### **Thrust 2:**

#### **Integrated Water Resource Development**

### **Programme 2:**

#### **Human-induced impacts**

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

University of Pretoria

**No 1686**

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

Estimated cost: R 1 900 000  
Expected term: 2006-2009

#### **The determination of annual phosphorus loading limits and land-use-based phosphorus loading models for 30 key South African dams in relation to their present and likely future trophic status**

W Harding (Private Consultant)

**No 1687**

South Africa is almost totally reliant on storage in dams for water supply, with, in many cases, a large proportion of the flows to these dams being comprised of polluted return flows and wastewater effluents from urban developments. These return flows are characterised in the main by elevated concentrations of phosphorus. Ideally the management (reduction/prevention) of eutrophication focuses on phosphorus attenuation. However, in South Africa phosphorus elimination from wastewater and other effluents is not targeted as a priority. With eutrophication as the cause, the most common impact is the increasing, both in extent and duration, development of noxious cyanobacterial aggregations, with the associated risks of cyanotoxin production. Cyanotoxins are notoriously difficult and costly to remove from raw potable waters. The project aims to categorise a suite of key South African dams in terms of:

- Their current trophic status
- The current matrix of phosphorus sources contributing to the total annual phosphorus loads to each of these dams (based on land use)
- Setting each dam's total maximum annual phosphorus load (TMAPLs)
- Identifying from the land-use-based loading profile where nutrient attenuation management practices should be focused.

Estimated cost: R243 750  
Expected term: 2006-2007

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

Council for Geoscience/Univ of Cape Town

GEOSS

**No 1690**

Since South Africa is such a water-scarce country, it is important for managers to have accurate information of all aspects of water resource management. This includes knowledge of the level of compliance of water

# KSA 1 (continued)

## Water Resource Management

users to water use licence legislation. In the Berg River catchment for example, compliance to water use legislation is checked by DWAF on a case by case basis. This is a tedious and time consuming procedure. Remote sensing can be used to detect and map past and current water use. This can be compared to current water use licenses in the WARMS database. The aims of the project are therefore to:

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

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

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

*University of Pretoria*  
**No 1693**

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

#### **The main objectives of this project are:**

- Based on stakeholder involvement (e.g. DWAF, etc.) and previous studies (including areas that are experiencing water stress), identify regionally significant water-bearing structural features and

geological domains for further detailed groundwater reconnaissance and exploration (to be based on utilising integrated groundwater exploration approaches, viz. hydrocensus, tectonics and geodynamics analysis, strain analysis for field structural mapping, remote sensing, etc.)

- Conceptualize flow dynamics (interconnectivity, regional directional permeability and transmissivity) and flow paths (including dating and tracing of deep water) in the identified water-bearing structural features and geological domains
- Determine storage capacity and storage coefficients (and sustainability yield constraints) of the various geological domains and its reliability during droughts using appropriate investigative techniques.

Estimated cost: R3 400 000  
Expected term: 2006-2010

### *Production of microcystin standards and evaluation of cyanobacterial hepatotoxin quantification methods and their relative suitability for screening and quantification*

*Nelson Mandela Metropolitan University (NMMU)*  
**No 1695**

Cyanobacterial hepatotoxins pose a serious threat to human and livestock health. Many water-testing laboratories in South Africa, however, lack the resources to effectively monitor levels of these toxins, partly due to the increasing difficulty in obtaining cyanobacterial hepatotoxin standards. This project intends to produce cyanobacterial hepatotoxin variants (the main MCYST variants and nodularin) and to assess the feasibility of maintaining a supply to researchers and water-testing laboratories. Clearly toxin production represents an opportunity for commerce development and more effective and applicable research can be achieved by the increased availability of toxin variants. A recent WRC report (No. 1288) highlighted the need to increase the monitoring frequency of blooms and toxins as well as collecting more information on analytical methods involved in toxin analysis. This project is aimed at rectifying gaps in the current knowledge in the area of cyanobacterial hepatotoxin screening, and testing the feasibility of pro-

duction of the toxin standards necessary for continued research in this field. The study will also include the development and testing of an analytical method to screen for BMAA (beta /methyl amino alanine, a cyanobacterial neurotoxin suggested to have detrimental implications on human health.

Estimated cost: R250 000  
Expected term: 2006-2007

### *An investigation into the effects of atmospheric pollutants on surface water quality in the eastern regions of South Africa*

*Univ 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 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 (NOx and SOx). 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

**Programme 3:**  
**Integrated drought and flood management**

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

*Pegram & Associates*

**No 1683**

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

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

Estimated cost: R2 483 200

Expected term: 2006-1010

**Thrust 3**  
**Water Resource Protection**

**Programme 1:**  
**Groundwater protection**

*Sampling and monitoring protocol for radioactive elements*

*Univ of the Western Cape*

**No 1694**

The presence of radioactive constituents (uranium, thorium and associated daughter elements) in groundwater poses a health risk. Weathering and leaching of trace element-rich geological formations and also mining wastes result in high concentrations of these constituents in groundwater.

The National Radioactive Monitoring Programme (NRMP) of DWAF aims to monitor radioactive elements on a national scale. The focus of this study is to support the NRMP by implementing investigations around impacted sites for local monitoring programmes. Specific objectives are:

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

Estimated cost: R1 500 00

Expected term: 2006-2009

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

*CSIR*

**No 1696**

Extensive areas of land in South Africa are currently being cleared of invasive alien vegetation under the DWAF Working for Water Programme. Several of the invasive alien trees being targeted are legumes (e.g. *Acacia* spp. such as black wattle, rooikrans and Port Jackson willow), which fix nitrogen, thus a distinct risk that clearing alien vegetation may lead to nitrate contamination of groundwater and eutrophication of surface water bodies exists. The proposed study will be a systematic assessment, in two or three selected catchment areas in the Western Cape, of nitrogen stocks in soils under alien vegetation and nitrogen movement in soils,

subsoils, groundwater and surface water after clearing. Nearby areas with natural vegetation will serve to provide baseline data.

**The project aims to:**

- Quantify nitrogen accumulation in soils and sub-soils under invasive vegetation, using undisturbed natural vegetated areas as baseline
- Investigate the spatial distribution of nitrogen species (nitrate, ammonia, and organic nitrogen), within soil and sub-soil profiles and across catchment landscapes, as well as ground- and surface water
- Determine changes to the physical distribution and chemical speciation of nitrogen in catchment landscapes after clearing of alien vegetation and the impact on the quality of water resources.

Estimated cost: R 845 000

Expected term: 2006-2008

**Programme 2 :**  
**Protection and management of surface water quality**

*GIS based assessment of non-point source pollution in Kuils-Eerste River catchments, Cape Town*

*Univ of Western Cape*

**No 1692**

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

# KSA 1 (continued)

## Water Resource Management

Estimated cost: R713 000

Expected term: 2006-2009

### Programme 3:

#### Urban water resource management

*The history of Cape Town's river systems:*

*Using hindsight to guide the management of urban river systems in South Africa*

*Southern Waters Ecological Research and*

*Consulting*

**No 1691**

Historical urban water resource issues, encountered problems and how they were resolved, changes in the whole water resource environment including physical changes to the riverine and catchment areas are documented in a number of archived municipal material. In addition, satellite images and aerial photographs have also captured changes over time. An analysis of past events, water resource problems, the interventions undertaken and the associated ecological, economical and social implications will enable the provision of meaningful guidance on the future management of urban rivers.

This project will also aim to:

- Undertake a comprehensive review of the management of rivers in Cape Town in the 20th century
- Evaluate the options selected in the past to improve understanding of implications on social, ecological and economic costs and benefits
- Use the lessons learnt to inform a set of principles for future management of Cape Town's rivers in particular, and urban rivers in South Africa in general.

Estimated cost: R 642 200

Expected term: 2006-2008

### Programme 4:

#### Low flows and streamflow reduction activities

*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 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 the 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:

#### Policy Development and Institutional Arrangements for Water Resource Management

### Programme 3:

#### Institutional arrangements and processes for IWRM at catchment, WMA and national level

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

*Rhodes University*

**No 1688**

Institutional arrangements supporting the implementation of the National Water Act (No. 36 of 1998) and the Water Services Act (No. 108 of 1997) are devolved across all three tiers of government. At a regional level, water resource management [WRM] is currently being transferred from regional DWAF offices to catchment management agencies (CMAs), facilitated by water user associations [WUAs] with additional stakeholder input from catchment forums including local government. Water services authorities [WSAs] are to manage water

service provision [WSP]; local authorities can act as WSAs. Challenges to local government are therefore considerable, particularly where capacity and financial resources are limited. Added challenges are posed by municipal and water management area boundaries that do not coincide; the inattention to the linkages required for sustainable WRM to support WSP; and little guidance given to the links between WUAs, catchment forums and local government. This project emerges from the recent call for researchers' participation in the design of Integrated WRM (IWRM) institutional arrangements research programme. Local government needs to establish WSP within an IWRM, in an environmentally sustainable manner. In order for local governments to effectively contribute to catchment WRM, understanding point and non-point source management, with questions of water quality and quantity impacts on resource management, is essential.

Estimated cost: R 537 000

Expected term: 2006-2009

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

*Univ 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, alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R 390 400

Expected term: 2006-2009

### Programme 5:

#### Governance, law and regulation

*A philosophy and strategy enabling learning for good ecosystem governance*

*CSIR*

**No 1689**

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

Estimated cost: R 639 200

Expected term: 2006-2009

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# KSA 2 Water-Linked Ecosystems



**Dr Steve Mitchell: Director**

## Scope

Research undertaken within this KSA will continue to address the conservation of aquatic ecosystems in order to provide the knowledge for their sustainable functioning in terms of the national commitment to international conventions and the ongoing provision of goods and services which ecosystems deliver. In addition, the National Water Resource Strategy (NWRS) focuses on resource protection as one of its components. The research undertaken in this KSA provides knowledge for protection of the resource, and is therefore central to this aspect of the NWRS. No major changes in strategic direction are envisaged and the research portfolio as presented in the previous year's strategy was found to be sound and applicable. Deviations in programme focus or structure will be highlighted below.

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

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

## Objectives

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

- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems.
- Transfer the knowledge to appropriate end-users.
- 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. However, a new programme on impoundments has been introduced under the thrust addressing Ecosystem Processes. 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**

This thrust includes research addressing the biophysical processes, form and function of ecosystems. 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**

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

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

### **Thrust 3:** **Ecosystem Rehabilitation**

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 process, form and function. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore bio-diversity where possible. Capacity will be built to implement the research findings. This thrust includes research addressing the processes and functioning of ecosystems, dealing more specifically with the biophysical processes and form of ecosystems as well as the rehabilitation of these in eco-

systems. Knowledge generated by research within this thrust will be used to increase the national capability to sustainably manage ecosystems and the impact of people on it. Programmes include:

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

### *Research portfolio for 2006/07*

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

The proposed new projects will continue to develop knowledge to enhance the national capacity to ensure sustainable management and utilisation of ecosystems while maintaining diversity in the form and function of ecosystems.

Research will be solicited in the following areas during 2006/07 to start in 2007:

#### **The effect of temperature change on aquatic ecosystems:**

During the course of 2006/07 the scope and terms of reference (TOR) will be drawn up for a project investigating the effect of temperature and temperature change on aquatic ecosystems with the expectation

that this will be funded from the 2007/08 financial year. The effects of global warming are apparent in the temperate zones and becoming increasingly apparent in South Africa, and this research will indicate what we can anticipate and guide decisions that have to be taken in managing the effects where this is necessary.

#### **Impoundment management:**

A programme on the integrated management of the aquatic environment, with an emphasis on water quality in impoundments will be started in 2007. The long-term objective of this programme will be to reduce the negative impact of eutrophication.

#### **Development of an ecosystem health risk assessment model to determine the risk of endocrine disrupter chemicals in the water environment:**

EDCs have been included in the National Toxicant Monitoring Programme developed for DWAF. A risk assessment model has been developed for DWAF for the normal toxicants. EDCs do not have the same effect as toxicants on the ecosystems but have a detrimental effect on various systems of living organisms at very low detection limits. The EDCs were therefore not included in this risk assessment model. An EDC risk assessment model needs to be developed for ecosystem health. This project will aim to develop a model by which the risk may be determined when ecosystems are exposed to EDCs. The model will include all the different pathways of exposure and will address all the different effects of EDCs, such as effects on the reproductive system, nervous system, thyroid function and the immune system.

#### **National Wetland Research Programme Phase 3: Wise Use of Wetlands:**

The initial TOR as envisaged in 2002 will be updated during the early part of 2006 in time for the call for proposals. The study is becoming increasingly necessary as NDA are starting the process of drawing up new policy for agriculture in wetlands. There is also increasing interest in this topic internationally, with Wetlands International holding a workshop at St Lucia, KZN at the end of January 2006 and a resolution on this was discussed at the recent RAMSAR COP.

#### **Kruger National Park Rivers Research Programme: Phase 4:**

Technologies developed during Phases 1-3 were world-leading at the time and considerable effort was made to transfer these to the KNP management. This energy was put in at the level of scientist to scientist. During the 2005 drought the monitoring raised several of the red flags that the monitoring programme designed during Phases 2 and 3 was designed to raise, but no action was taken to remedy the situation. It was apparent that the buy-in generated during previous phases had not reached the upper echelons of management. It also became apparent that although Ecological Reserve had been determined for the Olifants River, DWAF lacked the political will to enforce this and SANParks did not have the necessary co-operative governance structures in place to be able to work with DWAF at a sufficiently high level to remedy the situation quickly enough to avert the river drying up with the ancillary problems.

Phase 4 will be aimed primarily at developing the governance structures that will enable the technologies to be implemented as necessary. Part of the outcome of this research will be the development of a generic protocol that can be applied in other situations, as the problem of implementing good technology has also been experienced in other spheres of WRC activity.

#### **Natural resource accounting:**

This is the augmentation of conventional measures of economic activity by accounting for the missing environmental values and integrating these into a unified framework for macro-economic and environmental management. The outcome of this research will contribute to decision making around the sustainable management of the resource. This project was initially planned to start in 2005/06.

#### **Non-solicited research:**

Projects researching ecosystem processes will be given prominence.

### *Budget for 2006/07*

The approved funding of the research portfolio for 2006/07 leads to a committed funding budget of R11 958 845 in 2006/07. The focus of this portfolio will continue along the current trends.

# KSA 2 (continued)

## Water-linked Ecosystems

### Core Strategy

The core strategy is fundamentally unchanged from 2006/07. Research funded from within this KSA will continue to address, within the mission and vision of the WRC, issues of sustainable use and the needs of the legislation and international conventions of South Africa.

### 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.

The research funded through this KSA provides knowledge for protection of the resource and biodiversity of aquatic ecosystems, thus addressing the commitment of international conventions as well as the needs of policy.

### The position of the WRC in funding research into ecosystems

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

To this end the WRC has funded research on ecosystems for approximately a decade and a half. The work funded has been a balance between the generation of knowledge needed to support resource management and the generation of understanding of the ecosystem processes to guide future resource management direction. Some examples of this from research funded during 2005/06 are the funding of research on the sustainable management of estuaries aimed at empowering local authorities to better manage their natural resources and research on the development of cross-sectoral policy on biodiversity conservation aimed at providing all tiers of government with the knowledge to protect South Africa's unique biodiversity without stifling development.

The WRC, with its mandate to improve the national capability to sustainably manage water in the country, has a specific role which differs from that of other research funders. Although in some cases there is an overlap, there is opportunity for synergy with other sources of funds, as the breadth of work funded by the WRC covers the short-term to longer-term strategic needs of the country, and ranges from more fundamental to highly applied work within the area defined by the mandate.

### Needs analysis

Identified in previous years is the urgent need for the generation of the ability to implement the new legislation such as the NWA. However, the need also exists, possibly more than ever, for strategic research for innovation, the lead for which may come from global trends not necessarily yet reflected as needs in South Africa. The need to implement legislation tends to distract attention from this long-term need, although this is handled proactively as far as possible within this KSA so that anticipated research products are available when needed. The capability to sustainably manage ecosystems is an overarching need which this KSA addresses. This was articulated at the World Summit on Sustainable Development (WSSD).

At the higher level, it is necessary to improve the interface between scientists on the one hand and managers and the public on the other. Without this the concept of sustainable management will remain in the realm of theory. An aspect of this will be a way to provide people, particularly rural communi-

ties, with a method of articulating their needs which will feed directly into the management of institutional arrangements. Another aspect is to generate the understanding that a healthy and sustainably managed environment is integral to a healthy and sustainable livelihood.

In addition, 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 last decade and a half, we are reaching the limits of current knowledge. More research needs to be initiated in selected areas of this to ensure that our knowledge remains ahead of the need to apply it.

At the operational level, in addition to the issues around the implementation of legislation, there is a need to provide knowledge on the mitigation of the effect of development (generally in the form of engineering interventions) on ecosystems

### Overview of technological trends related to needs

Several important new trends in inland water research have been emerging internationally, and these are briefly discussed below. These trends are being picked up into the medium- to long-term planning within the KSA where they are relevant to the country.

- Climate change. There is an increasing body of knowledge on the effects of climate change from the temperate latitudes, but this deals largely with increasing temperature. More relevant to Southern Africa is the predicted change in rainfall, with the dry west becoming drier. The ramifications of this for management of the resource could be substantial.
- Impoundment management. Toxic blue-green algal blooms resulting from the eutrophication of impoundments are a problem world-wide. Recent work internationally is addressing the possibility of managing the natural ecological processes within these impoundments in order to reduce the impact of these blooms. The ability to do this would not only protect the natural environment, but would also assist in keeping the cost of water treatment down.
- Conservation planning is being used increasingly internationally as a holistic and reliable tool for making decisions

on how to most effectively conserve representative ecosystems.

- Natural resource accounting is becoming widely accepted as a way to bring environmental values into the macro-economy of countries.
- In Europe there is a current surge of interest in the development of environmental water quality indices based on diatoms. These appear to be more successful than previous attempts at correlation as it appears that new methods of data analysis are being used.
- The successful implementation of all of the above hinges on thorough knowledge of ecosystem functions and processes as well as the will to implement.

**Portfolio planning:** As indicated in the previous years' business plans, national research drivers in ecosystem research continue to be aligned with international trends, although the emphasis is on the local situation. A series of consultative workshops were held in conjunction with KSA 1 early in the year during which stakeholders (researchers, managers and industry) were consulted to give input into the future research needs in water-linked ecosystems. Although a number of technological issues were identified, a number of drivers not specifically related to technologies and methods were also identified. These addressed areas of communication, awareness, public understanding of science and capacity and competence development. The effective management of resources, including existing knowledge, as well as the more effective transfer of technology also featured in the issues to be addressed. Thus, current research drivers include:

- Ecosystem processes and functions. Research into these aspects is important for the sustainable management of ecosystems and it is anticipated that this will remain a priority research driver for the foreseeable future. Research in this area provides the basic understanding on which management decisions may be based.
- The Ecological Reserve provides a tool which enables managers to balance resource use with sustainability. Version II of the Resource Directed Measures (RDM) Manual is in the early stages of development, and it is anticipated that the process to determine the Reserve will become a lot more stable once this is out. As this happens the need for

new research in this field should decline sharply. Projections for this research topic are that within 5 to 6 years it will require considerably less funding than it has at the moment, and in about 10 years it will be phased out. A possible exception to this may be wetlands, as methods for determining the Reserve in these complex systems have not yet been finalised.

- Co-operative environmental management and governance is being developed within the context of research programmes addressing estuaries, wetlands, the Ecological Reserve and other initiatives. This develops the capability to integrate ecosystem management with the social and economic requirements of the stakeholders.
- Within the current estuaries research programme much progress has been made in locating the management of estuaries within the institutional structures of the local authorities responsible for the estuaries.
- The current wetlands programme will be run in 3 phases. The first phase (rehabilitation) is underway, and a start has been made on the second phase (health and integrity). The third phase (wise use) will probably start between 2008 and 2010. It is anticipated that this programme (as currently envisaged) will be complete before 2015.
- Conservation planning is a tool for making decisions on how to most effectively conserve representative ecosystems. The WRC is co-funding a programme which is piloting this process on rivers (elsewhere it has only been used in terrestrial situations until now).
- Ecosystem health and environmental water quality provide knowledge to balance the use of the resource and the discharge of effluents with the ecological health and sustainability of the resource as well as human health related issues. It is anticipated that research into this topic will continue for the foreseeable future.
- Rehabilitation research in its present form has a finite duration. It is becoming linked to wetland rehabilitation within the Working for Water programme as well as within DWAF, and will probably cease to exist as a research initiative within 10 years.

- The research initiative into the need for and provision of fish-ways is going well and the current level of funding will probably be reduced substantially after 2008.
- Following the emphasis on the need for Communication, Education and Public Awareness (CEPA) which emerged from the consultative workshops held early in the year, increasing attention will be paid to this aspect of technology transfer. Some of the activities routinely taken within the KSA have proved successful, but it is necessary to hone these activities in order to ensure that this important link is managed as efficiently as possible.
- A number of research initiatives have been identified, some of which are being piloted. It is anticipated that some of these will become large programmes which will run for longer than a decade. Resource constraints prevent all of these from being initiated simultaneously. These are discussed briefly below: Knowledge of the socio-economic aspects of sustainable ecosystem management lags behind knowledge of the ecosystem functions and processes. Knowledge of this aspect needs to be improved if we are to ensure long-term sustainability of the resource. It is anticipated that research in this area will continue for the foreseeable future. Some work may be done within the KSA that addresses water resource management (KSA 1), but KSA 2 will make a substantial contribution to this topic. TOR will be developed early in the year for a solicited project on this topic.
- Groundwater-dependent ecosystems present a little-understood area where the over-use of resources can cause irreversible (on the time scale of a human life) change. The complexity, as perceived from the standpoint of present knowledge, indicates that this research area will be active for a long time to come. During current financial year Research has been initiated to indicate the needs in this area.
- Research has been initiated on the Reserve determination for non-perennial rivers. Perennial rivers are largely limited to the well-watered east and the main stems in the arid west of South Africa. However, many of the tributaries, even in the well-watered east, are non-perennial. Although this programme is planned to

# KSA 2 (continued)

## Water-linked Ecosystems

be complete by 2009, it is certain that a number of research questions will be raised during the research, and will require a decision as to which should be addressed in future research initiatives. A one-year study carried out during 2005/06 tested current methods as used for the determination of environmental water requirements on perennial rivers on non-perennial waters. This was done through desktop studies of three main case studies and the review of six other non-perennial systems on which DWAF has conducted Reserve studies. This process enabled the compilation of a research programme which addresses the areas of the current methodology most needing attention.

- Since the closure of the FRD Inland Water Ecosystems Programme in the mid-1980s there has been very little research done on impoundments, and this has been largely limited to that funded by the water boards to address their own pressing needs. Impoundments are integral to both South Africa's water resource management strategy and to the linear ecosystem corridors of the rivers that they impound. They also have specific characteristics of their own. For instance, they are the first part of the resource to be affected by eutrophication, they break the connectivity of the river which affects biodiversity, alter the sediment characteristics of the river and a number of other effects. There are new ideas emerging from elsewhere in the world that have the potential to improve our management of impoundments, and these need to be examined. It is anticipated that research in this area will continue for the foreseeable future. A consultancy was initiated with the brief to review the state of the art internationally and to guide the development of TOR for future research in South Africa.
- South Africa has a very rich history of diatomology. Recently developed indices using diatoms as indicators of water quality appear to be promising as both present indicators of water quality which are both robust and easy to use, but will also be able to give insight into historical water quality for areas where early collections exist. It appears that these indices may be successfully applied to both historical collections and to recently collected diatoms. New initiatives

through both the WRC and DWAF are investigating the potential of using diatoms as an indicator for wetland health as the conventional indicators have not come up to expectations in this complex environment.

- Conservation planning for aquatic ecosystems is a new area of research which is being piloted in South Africa through an initiative co-funded by DWAF, CSIR and the WRC. It offers a quantitative method for planning conservation and utilisation of the resource. While this initial phase may not last longer than 8 to 10 years, the needs identified during this phase will continue for the foreseeable future and are likely to address the management of biodiversity and the resource. In addition to the above initiative the WRC is one of the lead agents in the harmonisation of policy across government departments, the support of a national forum of stakeholders and will fund research into the socio-economic aspects of biodiversity conservation from 2006/07.
- Research into the management of biodiversity (in terms of the recent legislation) has started with a small project on fish biodiversity. It is likely that this field will expand substantially once the outcome of the conservation planning programme (above) becomes known. This initiative is being expanded to, inter alia, develop conservation.

There are a number of research areas which have not yet been addressed, and these need attention for the reasons given below. These are listed briefly:

- Climate variability and change. The effects of these on biota and the influence on long-term resource management need to be better understood if we are to plan successfully in the long term. Of particular importance to the Southern African situation is the predicted decrease in rainfall in the drier western parts of the country. The initial stage of addressing this is being undertaken by climatologists, and ecologists will be included this year.
- The contribution of river flow to the near-shore environment needs to be better understood. We estimate the contribution of estuaries to the marine commercial fishery (through species that either breed or spend part of their life cycle in estuaries) at R950 million

per year (1997 value; WRC Report No 756/2/03). We know qualitatively that the prawn fisheries off the Thukela River mouth, in the Maputo Bay and off the Zambezi River mouth improve after a season in which there have been good floods. We do not know the extent of the effect of management interventions on rivers on the near-shore marine environment, so are unable to include this effect in any natural resource accounting on new developments. Land-based developments may prove to be less economically attractive when viewed against the larger picture. A consultancy to provide initial insight into the contribution of river flow to the near shore environment is approaching conclusion, and this will provide insight into the importance of this and will outline future research needs.

- There is a need to develop the ability to effectively manage the integration of ecological, economic and sociological knowledge to enable IWRM. This will synergistically add value to the knowledge available in each of the disciplines. The work planned for natural resource accounting will feed into this.

### Key stakeholders (influencers)

The key stakeholders remain largely unchanged. They are the national government departments which have water under their jurisdiction (DWAF and DEAT), specifically at this time when they are implementing new legislation. Provincial and local government are also key stakeholders, and the anticipated needs of catchment management agencies (CMAs) are influencing research direction. Donor funding is available in this field, usually for specific tasks which satisfy the donors' mandate. The largest funder is the Global Environment Facility (GEF), funded by the World Bank, which has been instrumental in establishing large biosphere reserves as well as the Cape Action Plan for the Environment (CAPE) in South Africa. Both the IUCN and Wetlands International, (international NGOs) fund specific projects within their mandates in this field, and the latter is becoming increasingly active in Africa. Funding may also be available from industry for specific projects. The relationship between the WRC and the Secretariat of the RAMSAR Convention is becoming closer.

## Strategic Initiatives Undertaken During 2006/07

### National initiatives

- Assisted in the assessment of proposals to develop a generic estuary management plan for the CAPE Programme. – 8/08/06
- Member of the CAPNET team in Pretoria
- Member of NRF panel assessing proposals for the ecosystems programme – 23/10/06
- Presentation to the NSTF on the WRC – 23/11/06
- Plenary presentation at the NMMU annual symposium on research done through the year by staff and students – 30/11/06
- Organised the Science Exhibition at the University of Venda that WRC participated – 11 /08/2006
- Yellowfish Working Group annual meeting – 7-9/4
- Attended SASAqS conference – 18 – 23/6
- Participated in the Institutional Review of the WRC.
- Co-author of 'The Changing Water Resources Monitoring Environment in South Africa' presented at the SAEON summit and subsequently published in the S. Afr. J. Sci.
- The Effects Of Water Pollution On Fish And People – presentation to the Yellowfish Working Group, 4/06
- Attended the Climate Change Workshop held at the ARC, 5 July 2006
- Arranging a conference on environmental water requirements.

### National collaboration

Participation in national committees related to this KSA

- Steering Committee (National)
  - The River Health Programme. The WRC is one of three national custodians of this programme
  - Development of a planning tool for the systematic conservation of river biodiversity in South Africa – project steering group
  - South African Environmental Observation Network (SAEON) – Technical Committee
  - Researchers funded through this KSA were well represented and participated actively in the WRC Open Day held at the University of the Western Cape.

- Working for Wetlands Steering Committee
- Co-chair of FETWater (with DWAF)
- Leadership positions: (within South Africa)
  - Board of the National Community Water and Sanitation Institute, University of the North (Chairperson) (SA Mitchell)
  - Appointed member of the ARC Board 01/11/06 (MS Liphadzi)
  - Institute for Environmental and Coastal Management, UPE (vice-Chairperson) (SA Mitchell)
  - Institute of Water Research, Rhodes University (SA Mitchell)
  - National Science and Technology Foundation – Executive Committee representing the Science Council sector Chair NSTF Science Councils Sector meeting – 23 /11/06 (MS Liphadzi)
  - Consortium for Estuarine Research and Management (CERM) – Co-ordinate for the WRC – WRC the lead organisation (SA Mitchell).

### Strategic positioning

- Led a delegation to present the Annual Report to the Parliamentary Portfolio Committee – 9/5
- Participated in the ESASTAP workshop held at the Innovation Hub (Pretoria)- 18/08/06
- Made a presentation and participated in the DWAF-RDM strategic planning workshop in Midrand, JHB. – 30 /11/06
- Took part in the portfolio committee training in January 2007 Facilitated an IUCN workshop on Environmental Flows in the Mzingwane catchment, southern Zimbabwe. Workshop held in Bulawayo – 28 – 29/09/06
- Attended Joint African Union-Economic Commission for Africa Science, Technology and Innovation in Addis Ababa (23-30 January 2007)- NEPAD
- Chaired the IMWI steering committee meeting on wetland management in SADC countries

### International initiatives

- Appointed reviewer by Elsevier Publishing Co. to review research papers for their three international journals (Environmental Pollution, Hazardous Waste, and Chemosphere) – 02/08/06.

- Dr MS Liphadzi co-authored 3 journal papers with Prof. M.B. Kirkham of Kansas State University in the USA:
  - Auxin-enhanced root growth for phytoremediation of sewage sludge amended soil. Environmental Technology 27 695-704.
  - Chelate-Assisted heavy metal removal by sunflower to improve soil with sludge. Journal of Crop Improvement 16 151-170.
  - Availability and plant uptake of heavy metals in EDTA-assisted phytoremediation of soil and composted biosolids. South African Journal of Botany 72 391-397.
  - A further publication is in preparation.
- Presented a paper at the World Congress of Soil Science in Philadelphia, USA (7-14 July 2006) – Received a travel grant of R12 000 from the NRF to contribute to travel costs.

## Growing the Knowledge Base

### Capacity-building initiatives

Progress to date on ongoing projects indicates that the number of students undergoing post-graduate training at tertiary institutions under WRC-funded projects in this KSA was estimated as 120 in total, of which 49 students are from previously disadvantaged groupings.

The following table gives a breakdown of the students employed by each of the agencies with which KSA 2 has research contracts for the year 2006/07:

# KSA 2 (continued)

## Water-linked Ecosystems

Organisation	Previously disadvantaged students	Total number of students
Anchor Consultancy (linked to UCT)	2	12
CSIR Environmentek	2	4
DH Environmental Consultants		1
National Museum, Bloemfontein		1
Nelson Mandela Metropolitan University	2	4
Nepid Consultants	1	1
Pulles, Howard and de Lange (now Golders)		2
Rhodes University	4	5
SA Institute for Aquatic Biodiversity	8	15
University of Cape Town	5	20
University of the Free State		3
University of Johannesburg		5
University of KwaZulu-Natal Dbn & Pmb	18	27
University of Limpopo	2	2
University of the North West		2
University of Pretoria		3
University of Stellenbosch		2
University of the Western Cape	1	4
University of the Witwatersrand	4	7
<b>TOTAL STUDENTS</b>	<b>49</b>	<b>120</b>

### **Knowledge-sharing and leadership**

KSA staff contributed to and attended the Open Day at UWC as well as the launch of the *2005/06 Knowledge Review*

### **Scientific technical workshops**

The KSA led, participated in and/or supported 6 technical workshops so far this year as follows:-

- Workshop on Ecostatus conditions – reference conditions for fish
- Facilitate stakeholder workshop on developing policy for agriculture in wetlands for the DoA & ISCW
- International workshop on conservation planning in conjunction with the IUCN (Australia & USA) and the Nature Conservancy (USA), Kruger National Park. (~60% of delegates not South African)
- Workshop on Social Ecological Systems
- Wetland Specialist Workshop (facilitated)
- ToR workshop for the solicited project 'Framework and manual for the valuation of goods and services from aquatic ecosystems for the Resource Directed Measures (RDM)

### **Staff of the KSA attended the following conferences:**

- South African Society for Aquatic Sciences
- Attended WISA conference in Durban, KZN

## **Implementation Plan**

### **Research portfolio for 2006/07**

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.

This will continue to be achieved through the following:

1. Develop an understanding of the ecological processes underlying the delivery of goods and services.

2. Develop the knowledge to sustainably manage, protect, utilise and rehabilitate the aquatic ecosystem.
3. Transfer the knowledge to appropriate end-users.
4. Build capacity in both research and management to sustainably manage aquatic ecosystems.
5. Increased emphasis will be placed on points 3 and 4 above.

The research portfolio (broken down into thrusts and programmes) is presented in **Table 1**. A 6<sup>th</sup> programme (on **Socio-economic considerations**) and a 7<sup>th</sup> programme (on **Ecosystem governance**) has been added to Thrust 2, as there is a need for research on these.

### **Expected outcomes**

An additional programme on impoundments has been added to Thrust 1 to accommodate research scheduled to start during 2006/07.

In Thrust 2, two additional programmes will be developed in 2006/07. These will be socio-economic considerations and Governance

Each programme within each thrust is designed to deliver products which are needed by specific end-users in the short-, medium- and long-term. In the case of the thrusts on ecosystem management and utilisation as well as ecosystem rehabilitation the end-users will largely be managers and policy makers, while in the case of that on ecosystem processes the end users may be the same as above, the research will also provide the basis on which the more applied research would be based.

Each programme is designed with the input of the relevant stakeholders, taking global trends into account, and so is able specifically to address the needs expressed, and benefit the country.

Products are planned, as far as possible, to be ready before they are needed by the end-users, in this way effecting innovation.

Capacity building and competence development are central to the work funded in this KSA as, apart from natural attrition, the implementation of the NWA and all the changes that that implies to the management structures, requires that water management will be devolved to lower levels of government, requiring greater numbers of people able to fulfil the function.

The research portfolio for 2006/07 is presented in Table 1, which provides an overview and description of research thrusts and programmes.

# KSA 2 (continued)

## Water-linked Ecosystems

**Table 1**  
Overview and description of thrusts and programmes

Thrust 1: Ecosystem Processes	
<b>Scope:</b> This thrust includes research addressing the biophysical processes, form and function of ecosystems. The aim is to generate knowledge to inform policy and management. Current programmes are:	
Programme	Scope
<b>Programme 1</b> <i>Estuarine processes</i>	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.
<b>Programme 2</b> <i>Riverine processes</i>	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.
<b>Programme 3</b> <i>Wetland processes</i>	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.
<b>Programme 4</b> <i>Groundwater-dependent ecosystems</i>	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.
<b>Programme 5</b> <i>Impoundments</i>	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. 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.

<b>Programme 1</b> <i>Ecological Reserve</i>	Within this programme research will be conducted to develop and refine methods for determining and operationalising the Ecological Reserve as required by the National Water Act. The programme will address the more strategic issues such as the development of new and improved methods as well as the shorter term issues such as implementation of the Reserve. This programme is managed in close association with DWAF.
<b>Programme 2</b> <i>Estuary management</i>	Within this programme research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of government, communities) as management guidelines to inform them on how to manage estuaries sustainability. This programme is managed in close association with Marine and Coastal Management, DEAT.
<b>Programme 3</b> <i>Ecosystem health</i>	The River Health Programme (RHP: custodians are DWAF, WRC and DEAT) aims to implement nationally (at the level of provincial government and industry) a coherent bio-monitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and so are kept in the same programme. Research on the environmental health of wetlands, estuaries and impoundments is also included in this programme. This programme links with the crosscutting domain <b>Water and Health</b> and includes resource management actions which may affect human health.
<b>Programme 4</b> <i>Environmental water quality</i>	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 licenses 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 crosscutting domain <b>Water and Health</b> .
<b>Programme 5</b> <i>Endocrine disrupting compounds</i>	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 done in three phases, of which the first phase is already completed.
<b>Programme 6</b> <i>Socio-Economic Considerations</i>	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.
<b>Programme 7</b> <i>Ecosystem Governance</i>	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.

# KSA 2 (continued)

## Water-linked Ecosystems

Thrust 3: Ecosystem Rehabilitation	
<p><b>Scope:</b> 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. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore bio-diversity where possible. Capacity will be built to implement the research findings:</p>	
<p><b>Programme 1</b> <i>Wetland rehabilitation</i></p>	<p>Within this programme research will be conducted to develop methods to rehabilitate wetlands which will address both abiotic and biotic components, and seek to rehabilitate ecological processes and restore biodiversity as far as possible in degraded wetlands. This will be done in terms of both the international conventions to which South Africa is signatory as well as recent legislation from both DEAT and DWAF. The programme will also develop the competence to implement rehabilitation. Projects in this programme link closely with each other, and are managed as a unit</p>
<p><b>Programme 2</b> <i>River rehabilitation</i></p>	<p>The research conducted within this programme aims to provide protocols for the rehabilitation of rivers, with the emphasis on urban rivers, that have been degraded as a result of anthropogenic activities or invasive biota.</p>
<p><b>Programme 3</b> <i>Influence of instream-constructed barriers</i></p>	<p>This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems.</p>

### Research Projects for 2006/07

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2006 and 31 March 2007.

### Completed

#### Thrust 1: Ecosystem Processes

##### Programme 1:

##### Estuarine processes

*Freshwater requirements of the marine environment: A proposed predictive approach to assessment of potential impacts*  
Environmentek, CSIR  
No K8/509

The report considers the impact of altered fresh water flows on estuarine and inshore marine systems. Observations indicate that freshwater inputs have a strong influence on the abundance of many aquatic species of socio-economic importance which are supported by these marine environments. An Assessment Framework and methods to assess the potential impacts of the reduction in freshwater flow into South African marine en-

vironments, is proposed. Recommendations regarding continued research and predictive assessments are made, such as the need to differentiate between coastal ecosystems (from east to west). Guidelines are given for the extension of Resource Directed Measures (RDM) protocols to include potential freshwater requirements of the marine environment.

Cost: R200 000  
Term: 2004 – 2006

##### Programme 2:

##### Riverine processes

*Ecological impacts of reverse hydrograph water releases from Albert Falls Dam on in-stream processes*  
Umgeni Water  
No 1307

Impounded water is usually released at times of natural low flow. Most South African rivers are affected in this way, but there is little data on the impacts (positive or negative) of this. It was shown that while the ecosystem remained functional, the ecosystem structure was altered by 'reversing the hydrograph' on the river. This will enable guidelines to be developed on optimising environmental releases from impoundments within the management requirements of the system. This information will contribute to the development of operational rules for impoundments from

which releases are required in order to supply flow in terms of the Ecological Reserve.

Cost: R241 688.66  
Term: 2002 – 2006

##### Conservation planning for river biodiversity

Environmentek, CSIR  
No 1486

Conservation planning was developed for use on terrestrial systems. Using it on river biodiversity is a new application which started during the planning of the Greater Addo National Park. It worked well, but areas needing refinement were identified. This study formed a pilot study for a broader national initiative, which aimed to develop a policy and planning framework for systematic conservation of inland water biodiversity in South Africa. The pilot was undertaken in the Fish-to-Tsitsikamma Water Management Area, which aims to facilitate testing, refinement and demonstration of the river prioritization and selection tool at a sub-national scale, providing an example of the lessons learnt and best practice for use elsewhere in the country.

Cost: R545 966.79  
Term: 2004 – 2006

**Programme 3:**  
**Wetland processes**  
*Strategic overview of the research needs regarding wetlands health and integrity*  
Univ Cape Town  
K8/590

The wetlands research programme, when planned in 2002, saw the need for three phases of research, namely rehabilitation, health and integrity, and wise use. This consultancy was initiated primarily to ascertain what was being done both in South Africa and worldwide in the field of the assessment and management of wetland health and integrity. Two of the important outputs of the consultancy were a Terms of Reference for the research to be funded by the WRC during Phase 2 of the programme and to collate a bibliography of the topic of the assessment of wetland health and integrity.

Cost: R200 000  
Term: 2004-2005

**A biophysical framework for the sustainable management of wetlands in the Northern Province with Nylsvley as a reference model**  
*University of the North in conjunction with University of Johannesburg*  
No 1258

It has been estimated that 50% of South Africa's wetlands have been lost as a result of anthropogenic activities. However, wetlands provide a number of valuable goods and services amongst which are flood attenuation, improved water quality and agricultural potential. Many of South Africa's wetlands are small and on private ground and as such are vulnerable, and Nylsvley, the subject of this project, is no exception in that it is approximately 95% in private ownership although the nature reserve (approximately 5% of the total area) is a Ramsar Site. In addition, the Waterberg (the catchment for Nylsvley) is registered as a Biosphere Reserve, making it an important international and national conservation area. The research covers a range of the biophysical aspects of Nylsvley and its catchment in the Waterberg, and based on this the project developed a framework for the development and refinement of management plan. The framework centres

on monitoring for adaptive management, and includes aspects of water quality, plants, invertebrates, fish, amphibians and habitat.

Cost: R549 403.22  
Term: 2001 - 2005

**A wetland classification system**  
*Freshwater Consulting Group, Cape Town*  
K8/652

The national wetland inventory is based on the advanced wetlands layer of the National Land Cover initiative which provides the distribution and extent of wetlands cover. But the evaluation, management and conservation of wetlands requires that each wetland unit be described and classified according to its biophysical characteristics and functional attributes. Consequently, the development of a classification system to distinguish between different wetland types is fundamental to the compilation of a national wetland inventory that encompasses the full diversity of wetland types throughout South Africa. Through wide consultation and review of classification systems in use elsewhere, the report presents a hierarchical classification systems based firstly on hydro-geomorphic criteria and secondly on biological criteria.

Cost: R60 000  
Term: 2005 - 2006

**Programme 4:**  
**Groundwater-dependent ecosystems**  
**Groundwater-dependent ecosystems**  
*CSIR*  
No 1330

During this project a national scale summary of known and probable groundwater dependent ecosystems in South Africa was produced based on geohydrological-type settings. This overview provides scientists and managers with the understanding necessary to engage this new field of research, and is particularly relevant in terms of the resource-directed measures as required in the National Water Act. Guidelines have been drawn up to enable CMAs and DWAF to assess the importance and vulnerability of groundwater-dependent ecosystems and to test the application of the tools developed for measuring groundwater use and dependency.

Cost: R459 075.97  
Term: 2002 - 2006

**Thrust 2:**  
**Ecosystem Management and Utilisation**

**Programme 1: Ecological Reserve**  
*Assessment of the geomorphological reference condition: Application to resource-directed measures and the river health programme*  
*Department of Geography, Rhodes University*  
No 1306

In terms of the reference condition, the initial approach of this project was to classify river reaches in terms of their zonal gradient classes and assess whether channel morphology and dominant bed material could be accurately predicted using channel gradient. If common groupings could be found for undisturbed 'reference' sites, it would then be possible to gauge how far a 'disturbed' reach was removed from its reference condition. This did not work and it was necessary to adopt a different approach.

The approach used was a systems approach. A river is seen as a system, and relevant systems concepts are examined and defined. An important concept in this regard is that of self-organisation. This is a measure of the system's intrinsic adaptation to the current set of external drivers. It becomes necessary to understand the degree of self-organisation that a system exhibits, and the trajectory of self-organisation permits prediction of the end point of change. It is proposed that the degree of self-organisation is a better measure of ecosystem health than a measure that compares the present condition to a historic reference condition.

Cost: R356 428.18  
Term: 2002 - 2006

**Low-flow hydraulics in rivers for environmental applications**  
*Dept of Civil Engineering, University of the Witwatersrand*  
No 1405

# KSA 2 (continued)

## Water-linked Ecosystems

The science of hydraulics integrates the hydrology with the ecology. It has been shown that the conventional equations are unsuitable for the estimation of low flow, and it is critical that there are reliable methods for the estimation of low flows for use in the determination of environmental flows. This follow-on project will continue the development of appropriate methods for describing the hydraulic characteristics of South African rivers under conditions of low discharge, as well as the influence of vegetation on large bed roughness.

Cost: R1 052 365.20  
Term: 2003 – 2007

### **The determination of substrate maintenance flows in cobble- and boulder-bed rivers: Ecological and hydraulic considerations**

*Dept of Civil Engineering, University of Stellenbosch*  
**No 1411**

The science of hydraulics integrates the hydrology with the ecology. It has been shown that the conventional equations are unsuitable for the estimation of low flow, and it is critical that there are reliable methods for the estimation of low flows for use in the determination of environmental flows. This project defined and quantified the flows causing ecologically significant disturbance of substrate in cobble- and boulder-bed rivers, developed models to address the relationship between discharge and substrate disturbance and developed guidelines for the specification of substrate-maintenance flow components in these rivers.

Cost: R890 597.34  
Term: 2004 - 2007

### **Programme 2: Estuary management**

*Integrated development planning for estuaries*  
*Institute of Natural Resources, Rhodes University*  
**No 1485**

The Eastern Cape Estuaries research and management programme which was initiated in the late 1990s to empower the communities living beside these estuaries to manage the resource sustainably. The integration of

knowledge generated into the Integrated Development Planning (IDP) process is a necessary step towards sustainable management of estuaries and building the capacity in this will entrench this for the future. This sustainable management is also required in terms of existing legislation.

Like other ecosystems, estuaries offer a range of services and attributes that generate value and contribute to human welfare. A suit of methods have been developed to establish economic value and the application of these indicate that estuaries confer significant benefits to society. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas. The course contains modules on economic value, estuary functioning, impacts on estuaries, estuary management and enterprise opportunities that can be derived from estuaries.

Cost: R1 244 337.00  
Term: 2004 - 2007

### **Programme 4: Environmental water quality** *Development of a diatom protocol for river health assessment (continuation of K8/508)* *DH Environmental Consulting* **No 1588**

The main aim of this project was to develop a Diatom Protocol for River Health Assessment in South Africa, which was achieved through three project phases. The first phase was comprised of the development of a South African diatom taxonomic identification key using proven Lucid-based software technology, transfer of diatom images from the SA Diatom Collection into electronic format, and linkage to the taxonomic key; and development of a standard Diatom Assessment Protocol ("DAP") for subsequent field testing and calibration. Phase 2 covered the comprehensive testing of the DAP in parallel with SASS. Phase 3 involved continuing extraction of historical water quality and information on ecosystem condition from the SA Diatom Collection. The outcomes of this project provided the basis for field application of the DAP as an added value, second-level aquatic ecosystem assessment tool that augments the present use of invertebrate-based methodologies. Additionally, the project has provided a PC-based diatom identification

key for use in both the DAP and general diatom work. Finally the project has positioned the SA Diatom Collection as a vital source of historical water quality information.

Cost: R357 500.00  
Term: 2005 - 2006

### **Thrust 3: Ecosystem Rehabilitation**

#### **Programme 2: River rehabilitation** **The nature and rehabilitation of alien-invaded riparian zones** *Dept of Zoology, Freshwater Research Unit, University of Cape Town* **No 1407**

Riparian zones are vulnerable to invasion by alien plants and need active management in areas where such species occur. This project was designed to investigate the effects of woody alien invading tree species on the natural vegetation of Western Cape headwater riparian zones, and the recovery of the indigenous vegetation after aliens had been cleared. Six invaded and ten cleared sites were then compared to the reference condition to assess the impacts of invasion and clearance on a number of biotic characteristics. A small study of the possible allelopathic effects of alien invasives was also conducted. All the heavily-invaded areas investigated during this study supported a number of riparian scrub species beneath the dominant alien canopy. In most cases the wet bank was abundantly vegetated with indigenous species whilst the dry bank had a few isolated indigenous shrubs and small trees of either Afromontane forest riparia or scrub riparia affiliation. The results suggest that young alien saplings probably do not exert an interference effect on establishing indigenous seedlings.

Cost: R863 579.47  
Term: 2003 - 2006

#### **Development of management guidelines for controlling pest blackflies along the Orange River** *Nepid Environmental Consultants* **No 1558**

This project was the fourth in a series on the control of the blackfly in the Orange River. The overall objective of this project was to develop practical management guidelines for integrated blackfly control, based on a combination of chemical and biological control methods, as well as flow manipulation. It is clear that the Blackfly Control Programme is having a beneficial impact in this region, not only for sheep farmers, but also for the rest of the population. While cost-benefit analyses show significant benefits to the control programme, benefits could potentially be further increased through applying smaller volumes of larvicide in an optimized manner, which incorporates upstream residual amounts through downstream carry. The key recommendation arising from this study is to establish an active advisory committee for blackfly control in the middle and lower Orange River. The main objectives of the proposed committee are to ensure that the control programme is effective, efficient, safe, legally compliant and scientifically sound.

Cost: R348 334.31  
Term: 2004 - 2006

## Current

### Thrust 1: Ecosystem Processes

**Programme 2:**  
**Riverine processes**  
*Habitat, use and movement of freshwater fish species*  
*Freshwater Research Unit, UCT*  
**No 1483**

This project presents a unique opportunity to investigate the movements of large fish in an un-impounded river, the Doring River in the Western Cape. This is knowledge which cannot be obtained from elsewhere in the country as there are so few un-impounded rivers remaining. The two things making this opportunity unique are that the Doring River, which is one of the last un-impounded rivers in the country, will be impounded within the next decade or so, and that we have a researcher capable of the task. DWAF have asked for information on the movements of fish in a river system for use in their planning of fish-ways, and this research will comple-

ment the existing projects researching fish-ways by providing additional information that these projects will not be able to provide. This work has previously been funded as a consultancy, and progress has been made in both initial aims of the project, as well as in the sourcing of funds for the radio telemetry tracking of the fish.

Estimated cost: R688 000  
Expected term: 2004-2007

**Programme 3:**  
**Wetland processes**  
*National Wetland Rehabilitation Programme: Phase II - Wetland Health and Integrity*  
*University of Cape Town, Freshwater Research Unit*  
**No 1584**

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

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

**Programme 4:**  
**Groundwater-dependent ecosystems**  
*Framework development for the sampling, classification and geographical occurrences of stygobiont amphipods in South Africa*  
*University of North-West, Potchefstroom, Zoology Department*  
**No 1586**

97% of the world's freshwater is subterranean, and there is an increasing demand for the development of this resource to meet the increasing needs of the population. Little

is known about the stygobiont fauna or the interaction between underground and surface water. During this project the following aims will be addressed:

- Formulate a framework to characterize the geological occurrences and geographical distribution of the subterranean amphipods using GIS techniques
- Discussion on the applicability of the sampling protocol
- Identifying microbial composition in association with stygobiont amphipods
- Trace of inorganic macro-elements for water quality
- A primary framework development for the characterization of groundwater systems.

Estimated cost: R1 350 000  
Expected term: 2005 -2010

### Thrust 2: Ecosystem Management and Utilisation

**Programme 1:**  
**Ecological Reserve**  
*Environmental water requirements in non-perennial systems*  
*Centre for Environmental Management, University of the Free State*  
**No 1587**

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

Estimated cost: R 2 737 000  
Expected term: 2005 -2008

**Development, testing and installation of a real-time Ecological Reserve implementation method for the Thukela River**  
*Institute for Water Research, Rhodes University*  
**No 1582**

# KSA 2 (continued)

## Water-linked Ecosystems

Previous work on implementing the Reserve has identified the need for suitable hydrological triggers to be used to specify the Reserve flows required in real time. It has also identified some of the limitations of the Regional Offices of DWAF to deal with, and make use of, the Reserve information supplied by the DWAF RDM Office. During the recent Reserve determination on the Thukela River some concepts were developed on how this could be done.

During the project the researchers will develop and test a real time Reserve implementation method, and install the system in the KZN DWAF Regional Office, for application to the Thukela River. A manual for the method and training of KZN DWAF Regional Office staff will also be developed. The model will be based on a standard model for which initial calibrations are available for all the quaternary catchments country-wide, so the model will be widely applicable.

The development and application of a real-time Reserve implementation method will assist in the implementation of the NWA on the ground.

Estimated cost: R681 800  
Expected term: 2005-2008

**Programme 2:**  
**Estuary management Valuation of estuary services in South Africa**  
*Dept of Economics, Nelson Mandela Metropolitan University*  
**No 1413**

Estuaries are delicate systems that are not only in high demand for development, but also deliver important goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological processes and functions, but does not adequately account for the values placed on estuaries by people.

This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 170 000  
Expected term: 2004-2008

**The freshwater requirements of temporarily open / closed estuaries on the South Eastern and South Western Cape coasts**  
*South African Institute for Aquatic Biodiversity (SAIAB)*  
**No 1581**

This project is the result of recommendations of a CERM strategic planning meeting held in March 2004 and is a multi-faceted project in order to answer the generic questions routinely posed during DWAF RDM workshops.

The outcome of the research will deepen the knowledge on the functioning of temporarily open and closed estuaries. The results will be worked into estuary management as the work progresses as the team are involved with DWAF and MCM initiatives in estuary management, including determination of the Reserve.

Estimated cost: R1 753 000  
Expected term: 2005-2008

**Programme 3:**  
**Ecosystem health**  
**Evaluation of the fish assemblage integrity index to assess river health, and its refinement to ensure high levels of accuracy**  
*Ecosun*  
**No 1256**

Worldwide there is a trend towards bio-monitoring for the initial monitoring of water quality. Some of the reasons for this are that it would be virtually impossible to monitor chemically for all the substances released into the environment, and biomonitoring offers a cost-effective way of ascertaining the water quality and alerting authorities to the existence of problems. The South African River Health Programme, a biomonitoring programme using a suite of methods, has been piloted in Mpumalanga and is in the process of becoming institutionalised in several provinces in the country.

The prototype Fish Assemblage Integrity Index (FAII), one of the indices used in this programme, has been developed over a number of years in Mpumalanga and the Northern Province, and has been used elsewhere in the country. It has proved its

value within the River Health Programme, but its application has identified additional work that needs to be done to make it the robust and universally applicable tool that is required by the Programme. With this in mind, the aims of the project are to relate fish distribution to the eco-regions, evaluate the suitability of the FAII in assessing levels of site-specific impairment for rivers, to amend and standardise techniques used as part of the FAII to ensure acceptable levels of accuracy, precision and representivity and to develop guidelines for the use of the FAII to enable the evaluation of the levels of site-specific impairment.

Estimated cost: R593 000  
Expected term: 2001-2005

**Osmoregulation in freshwater invertebrates in response to salt pollution**  
*Institute for Water Research, Rhodes*  
**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 is 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: R2 01 160  
Expected term: 2005-2007

**The effects of streamflow manipulation on the intermediate hosts and vector populations of disease and the transmission of associated parasites**  
*Environmental Assessment and Reporting, Institute of Natural Resources*  
**No 1589**

An effect of manipulating the flow of a river is that the changes in habitat will result in changes in the occurrence, population dynamics and dominance of organisms in the ecosystem. While many of the effects brought about by these changes are known,

one effect which needs more attention is the influence of flow manipulation on the aquatic intermediate hosts / vectors of the diseases. The diseases caused by bilharzia, liver fluke and malaria are prevalent in certain areas of South Africa and within these areas are considered to have important economic consequences, which are manifest in sectors of the economy other than the water sector. The implication of the Reserve process determination on human health has hitherto not been realised or researched. The need to understand the relationships between the environmental Reserve and epidemiology is critical for community household health and regional economic growth. This project will define the intermediate hosts / vectors and routes of parasite transmission in the natural environment for bilharzia, liver flukes, and malaria; describe those streamflow interventions that enable or enhance the intermediate hosts /vector life cycle and parasite transmission; it will assess the low manipulation options for control of the Intermediate hosts / vectors and associated parasites. The project will develop the capability to predict the effect of flow manipulations on the intermediate hosts / vectors and associated parasites and will make recommendations on how stream flow manipulation could be used to manage the incidence of the identified diseases.

The project will be carried out mainly as a desktop study and available data from the regulated and unregulated rivers will be considered. Relevant case studies that illustrate the implications of stream flow regulation for regulation of intermediate host / vector populations and the transmission of associated diseases will be identified for use in this study.

Estimated cost: R400 000  
Expected term: 2006 -2008

**Programme 4:**  
**Environmental water quality**  
*Application of biosensors for eco-toxicity testing of water resources*  
Department of Microbiology, University of Durban-Westville  
**No 1286**

Microbial biosensors offer advantages over other methods of eco-toxicity testing by the rapid and sensitive response they provide, ease of culturing and maintenance, and the

possibility of selecting for an environmentally relevant micro-organism. The use of bioluminescence-based biosensors is gaining support as a sensitive method in microbial eco-toxicity assessment. The Microtox assay, which uses a naturally bioluminescent marine bacterium, has become widely adopted as a microbial biosensor. This assay is expensive and not appropriate for all environmental applications. The use of a marine micro-organism for the assessment of soil and freshwater samples presents a number of disadvantages because it requires pH and salinity conditions normally associated with the marine environment. The cloning of lux genes from marine vibrios into terrestrial bacteria offers the opportunity for bioluminescence-based toxicity testing using biosensors relevant to the environment being tested. The focus is to develop the tests and the capacity to use them in the country.

Estimated cost: R700 000  
Expected term: 2001-2004

**A programme for research into the application of aquatic toxicology to water resource management**  
*Institute for Water Research, Rhodes University and Ecosun*  
**No 1313**

This toxicology programme will investigate the application of aquatic toxicology to water resource management. The specific aims will be determined at a workshop to be held early in 2002 together with DWAF.

Estimated cost: R1 900 000  
Expected term: 2002-2005

**Application of chronic (sub-lethal) toxicity endpoints to the development of resource quality objectives**  
*Centre for Aquatic Toxicology, Rhodes University*  
**No 1484**

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

Estimated cost: R1 340 000  
Expected term: 2004-2007

**Programme 5:**  
**Endocrine disrupting compounds (EDC) in water sources**  
*WRC Programme for endocrine disrupting contaminants (EDC)*  
*Consortium Members: US; UFH; Technikon Free State; Tshwane University of Technology; SABS; CSIR Environmentek; ARC-PPRI; Consultant manager*  
**No 1402 (includes Projects 1469, 1470, 1471, 1472 and 1473)**

This Programme, which is the result of several preliminary studies, is intended to determine the present status of EDC pollution in South African waters. A wide variety of chemicals will be identified and techniques for their detection will be developed, where necessary, and tested. A battery of bio-assays and chemical analyses will be identified in order to monitor EDC pollution. Thereafter, training workshops involving local and international expertise are planned in order to transfer specific skills and build capacity at laboratories on a country-wide basis. This is a follow-up of the preliminary studies of the EDC programme. The Programme will focus on the present status of EDC pollution in the aquatic systems of the country and will address the wide variety of chemicals involved to determine those crucial for the SA environment and the special techniques and skills needed for the detection thereof. It will be a combined effort between laboratories country-wide with specific capabilities and skilled researchers to develop a battery of bio-assays and chemical analyses that could be used to determine the extent of the EDC pollutions in SA. Each laboratory will be expanding on their special capabilities and building capacity to form a centre of expertise, but not working in isolation, to the benefit of this research in SA.

Estimated cost: R3 000 000  
Expected term: 2002-2005

**An investigation into the occurrence of steroidal hormones (oestrogens) in sewage effluent using biological/ biochemical and chemical techniques**  
*CSIR Environmentek*  
**No 1555**

Chemicals with endocrine disrupting potential find their way into the environment via use and disposal. A large number of structurally diverse chemicals are suspected to act

# KSA 2 (continued)

## Water-linked Ecosystems

as endocrine disrupting chemicals (EDCs). One of the groups of EDC contaminants found in the environment is the steroidal hormones (oestrogens). Studies have shown that sewage effluent and surface waters contain the oestrogenic chemicals 17 $\beta$ -estradiol, estrone, estriol (metabolites of human hormones) and 17 $\alpha$ -ethynylestradiol (synthetic oestrogen). Several *in vivo* and *in vitro* biological/biochemical techniques have also demonstrated significant oestrogenic activity in South African sewage effluent and receiving surface waters. As oestrogens may pose a risk to human health and aquatic life, it is essential to screen local sewage effluent for oestrogens, to ensure useful results for risk assessment and management.

The objective of this project is to determine the oestrogenic activity (biological/biochemical tests) and oestrogen concentrations (chemical analysis) in the effluent of selected sewage treatment works.

Estimated cost: R120 000  
Estimated term: 2004-2005

**An investigation into the occurrence of endocrine disrupting chemicals - organochlorine pesticides and heavy metals (Cd, Zn, Ca and Pb) in surface waters of the Northern province**  
*University of Venda*  
No 1557

Organochlorine pesticides (OCPs) and cadmium (Cd), a heavy metal, have been implicated in endocrine disrupting activities. Lead (Pb) though not classified as endocrine disruptor is equally toxic. In malarious regions residual spraying of DDT for malaria control purposes is common and allowed by government. OCP residues could get into freshwater systems via storm water erosion (both urban and from agricultural lands). OCPs have been of great concern due to their persistent nature and chronic adverse effect on wildlife and humans. These substances including Cd may affect the normal function of the endocrine systems and can adversely affect the bio-diversity of ecosystem and also have serious implications for human health. Cadmium is also implicated in endocrine disrupting activities. Lead is also shown to be toxic. Zinc (Zn) and calcium (Ca) have synergistic and antagonistic interactions with Cd, respectively. Their presence in large amounts could affect the toxic effects of Cd one way or the other.

Water quality criteria for Cd, Zn and Ca, have been set, but have not been established for other EDCs. DDT was detected in streams and some at levels marginally higher than the WHO guideline levels. It is important to widen the scope of the study to get a clearer picture of the pollution profile of waters in the Venda Province.

The objectives of the project are to:

- Establish the use pattern of pesticides in the region
- Compile a list of endocrine disrupting pesticides in use and other potential EDCs and heavy metals (Cd)
- Determine the levels of OCPs and heavy metals - Cd, Pb, Zn, Ca (Ca & Zn because of their synergistic and antagonistic effects on Cd) in major freshwater systems in the region

Estimated cost: R60 000  
Estimated term: 2004-2005

**A seasonal study of the endocrine disruptors in effluent coming from the Kuils River Sewage Treatment Plant, Western Cape, South Africa**  
*University of the Western Cape*  
No 1590

Sewage effluents have a major impact on aquatic ecosystem health. Several xenobiotics occurring in the environment are known to interact with the development and functioning of endocrine systems in wildlife and humans. Many of these xenobiotics have been known to exhibit oestrogen-like activity in fish, amphibians, reptiles, birds and mammals. One of the most widely used approaches for assessing oestrogenic activity in non-mammalian oviparous species is the development of bioassays for detecting vitellogenin in the plasma of animals. *In vitro* assays have been developed using vitellogenin as biomarker. Vitellogenin induction by *Xenopus laevis* liver cultures and the recombinant yeast assay could be used to detect oestrogen activity in environmental waters. Recently ELISA kits that detect estrone, estradiol and estriol have become commercially available.

The aim of the study is to do a seasonal study to monitor EDCs (oestrogenic contaminants) in sewage treatment plant effluents ending up in the Eerste-Kuils River water catchment system by using the locally produced UniVtg kit for the detection of tissue culture

synthesised *Xenopus laevis* vitellogenin and this study will test its reproducibility and reliability for use with the *Xenopus* liver culture assay system.

Estimated cost: R200 000  
Estimated term: 2005-2006

### Thrust 3: Ecosystem Rehabilitation

**Programme 1:  
Wetland rehabilitation**  
*Wetland rehabilitation Consortium: School of Life and Environmental Sciences, University of KwaZulu-Natal (Lead agent)*  
No 1408

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.

Estimated cost: R4 000 000  
Expected term: 2003-2007

**Programme 2:  
River rehabilitation**  
**Integrated management of water hyacinth in South Africa**  
*School of Animal Plant & Environment Sciences, University of the Witwatersrand*  
No 1487

Water hyacinth is difficult to control and is a problem worldwide. Chemical control is expensive and ineffective in the long term. Biological control has provided a sustainable and cost-effective control in certain conditions, but the harsh South African winters are more detrimental to the control agents than the weed, allowing the weed to regenerate

in the spring of each year. This project will refine earlier work (WRC **Project No. K5/915**) to control this problem weed by low-dose levels of certain herbicides without unduly damaging the populations of the control agents.

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

**Programme 3:**  
***Influence of in-stream-constructed barriers***

*Facilitating the free passage of migratory aquatic biota in South African rivers*  
*Consortium: Pulles Howard & de Lange (lead agent)*  
**No 1409**

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 prioritising 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.

Estimated cost: R2 000 000  
Expected term: 2003-2007

Herewith a list of the new projects which commenced between 1 April 2006 and 31 March 2007.

## **New Projects**

### **Thrust 1:** ***Ecosystem processes***

**Programme 1:**  
***Estuarine processes***  
*Biochemical processes in a groundwater-fed inter-tidal ecosystem:*  
*Biogeochemical controls on the plant biodiversity within a salt-marsh ecosystem in the West Coast National Park: Impact of saltwater-groundwater interaction on pore water chemistry and vegetation*

*UCT (Dept. 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: R 397 400  
Expected term: 2006-2008

**Programme 2:**  
***Riverine processes***  
*Periphyton flow dynamics*  
*UCT 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 rendering 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, and 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: R 1 000 000  
Expected term: 2006-2009

**Programme 3:**  
***Wetland processes***  
*National Wetland Rehab Programme Phase II*  
*Wetland Health & Integrity*  
*UCT Zoology Department*  
**No 1584**

This solicited project is Phase 2 of the three-phase National Wetland Research Programme and it focuses on the development of methods to assess the health and integrity of wetlands. The assessment of wetland health and integrity lags behind that for rivers and estuaries and this poses a problem in the environmental water determination process. There is also growing recognition of the important role of the ecosystem services provided by wetlands. A suite of assessment techniques is required not only to assess the ecological condition of the wetland but also the state of the services delivered. To that end, research undertaken during this project will address the development of tools to assess the ecological condition as well as the state of the services delivered, and to develop a protocol to gauge the loss of wetland function through degradation. Training courses and a communication programme will be developed to assist in the transfer of the technologies developed.

Estimated cost: R 3 450 000  
Expected term: 2006-2010

# KSA 2 (continued)

## Water-linked Ecosystems

### 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 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 & utilisation

#### Programme 2:

**Estuary management**  
*CERM: East Kleinemonde Estuary modelling study*  
Anchor Environmental Consultants; UCT  
Zoology Department  
No 1679

This project will be closely linked to WRC Project No. K5/1581 (The freshwater requirements of temporarily open / closed estuaries on the South Eastern and South Western Cape coasts), where the objective of this study is to integrate the knowledge

generated in such a way as to provide the additional dimension of an economic evaluation of the estuarine services. In this way the knowledge generated will become more accessible to managers.

Estimated cost: R 644 500  
Expected term: 2006-2009

#### 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 for Natural Resources  
No 1589

Altering the flow of a water body will alter the environment. One of the effects of an altered environment is a change of the organisms that inhabit the environment. When making decisions on environmental flows, the status of disease vectors or intermediate hosts is not considered, and yet diseases such as malaria, bilharzia (in people) and fascioliasis (in livestock) have a substantial impact on the economy of areas where they prevail.

The overall objective of this study is to assess the impact on the economy and to investigate ways in which it can be ameliorated, either through management actions or through altering the behaviour of the population groups at risk.

Estimated cost: R400 000  
Expected term: 2006-2009

**Conservation model for threatened fish species**  
*Limpopo University, School of Agricultural & Environmental Sciences, Aquaculture Unit*  
No 1677

Freshwater ecosystems are recognised as the most threatened ecosystems world-wide, and in a n inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of habitat, are generally more sensitive to disturbance than invertebrates. The three main threats are from habitat loss, impact of aliens and exploitation.

The objective of this project is to develop a conservation model for threatened fish species using *Opsaridium peringueyi* as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170  
Expected term: 2006-2008

#### Programme 4:

**Environmental water quality**  
*Determine the applicability of Ecological Informatics Modelling Approaches for South African conditions with preliminary testing on algal blooms*  
University of the North-West (Potch) School for Environ Sciences  
No 1675

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

The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use based on the technologies used in Australia for use by water resource managers and water treatment works.

Estimated cost: R225 000  
Expected term: 2006-2007

#### Programme 5:

**Endocrine disrupting contaminants**  
*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: R 1 985 000  
Expected term: 2006-2008

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

*University of Stellenbosch (Dept 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 is 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: R 400 000  
Expected term: 2006-2008

***Programme 6: Socio-economic issues Enriching freshwater conservation planning and management CSIR Environmentek No 1678***

The pressures from social-economic aspirations have resulted in a progressive degradation of freshwater habitats in recent decades. As in other countries, this country's rivers have deteriorated faster than terrestrial habitats. *Ad hoc* conservation efforts are not effective in the face of this pressure, a strategic and systematic approach is needed if the initiative is to be effective.

This project is part of a suite of initiatives (funded by WRC, DWAF and CSIR) which include the development of cross-sectoral policy and planning tools for conservation planning, and aims to advance our understanding of the relationships between freshwater conservation planning and the socio-economic and political processes that govern freshwater conservation at international, national and sub-national levels. This will be done through engaging the broader socio-economic and political discourse to identify the issues that are important for the successful implementation of the conservation planning process, and incorporating these into the overall process. This will be tested in a specific geographic context.

Estimated cost: R 450 000  
Expected term: 2006-2008

***Framework and manual for the valuation of goods & services of aquatic ecosystems for resource directed measures Zeta Consulting CC No 1644***

The determination of the Ecological Reserve for a particular catchment area requires the integration of the catchment area's management class, the related Reserve and the resource quality objectives. In addition, benefit trade-offs with other water users also have to be considered. The NWRS recognises this by seeking to find a 'balance between protection and utilisation'. Therefore, in order to develop resource-directed measures (RDMs) that are technically sound, scientifically cred-

ible, practical and affordable, a framework and manual for the valuation of goods and services from aquatic ecosystems for the RDM are now required. The set of problems to be addressed here is therefore clear: in order to enable interpretation (and negotiation) of the likely consequences of changes in management class as embodied in the RDM procedures, the 'invaluable' aquatic ecosystem threshold must be determined, while trade-offs in ecological, social and economic benefits of the other management classes must be made transparent to users and other interested and affected parties.

This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R 750 000  
Expected term: 2006-2008

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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 the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors with the aim of improving productivity and supporting economic growth while minimising negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remains a continuous challenge. 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 our environment. The entire way we think about and use water is thus an important factor in determining our future. A changing institutional environment and the need for strong institutional capacity add to this challenge.

## Objectives

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

### The secondary objectives are to:

- Improve the management of water services in both rural and urban areas
- Develop appropriate technologies for improving the quality and quantity of our water supplies for both domestic use and industrial applications
- Develop new approaches to manage and enhance hygiene and sanitation practices
- Provide appropriate, innovative and integrated solutions to water and waste management in the industrial and mining sectors.
- Develop applications for improved treatment of wastewater and effluent and improve processes for enabling increased reuse thereof.
- Improve health, economic and environmental conditions while supporting the development of appropriate technologies and socially-focused management practices related to water and effluent management.

## Thrusts and programmes

This KSA focuses on a portfolio of five thrust areas, these being:

### 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 (storm water, 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**
- **Water Services Regulation.**

### 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: *Wastewater and Effluent Treatment and Reuse Technology*

**Scope:** With the continuous increase in wastewater and effluent flows, the challenge arises to better manage treatment, such that the effluent produced meets requirements and can be considered as a resource.

Research in this thrust aims to develop innovative treatment technologies and systems that would optimise treatment processes and infrastructure in the municipal, mining and industrial sectors.

**Current and new programmes to commence from 2006/07 are:**

- Biological sewage treatment processes
- Sludge characterisation, treatment, utilisation and disposal
- Treatment and recovery of organics from agro-industrial processing
- Treatment and recovery of inorganics (incl. sulphate and metals) in industrial and mining effluents
- Training in wastewater treatment plant operation
- Biotechnological co-treatment of industrial / mining effluents with sewage wastewaters
- Sewerage reticulation
- Stormwater
- Energy from waste.

**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 impact of waste on the water environment
- Minimising waste production
- Improved ability to predict and quantify effects.

**Thrust 5:**  
*Sanitation and Hygiene Education*

**Scope:** This is a new thrust that includes some programmes which were previously

under other thrusts. 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:**

- Health and hygiene education
- Peri-urban sanitation research
- Knowledge/information management and advocacy
- Institutional and management aspects of sanitation service delivery
- Technical sustainability of sanitation services
- Financial sustainability.

**Research portfolio for 2006/07**

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

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

Strategic initiatives of the previous years, together with the consolidation of research and project activities in the year 2005/06, has provided the path for strengthening the activities of the KSA related to strategic direction, technology transfer, project management and business processes, towards meeting the broader KSA and organisational goals. In the year 2005/06 the KSA introduced and prioritised three new programme areas in the Wastewater and Treatment Thrust to cover aspects related to stormwater and sewerage and water services and institutional issues to address quantifying the impacts of water and sanitation interventions, as well as a new thrust area dedicated to sanitation issues.

The plan for 2006/07 will put greater emphasis on technology transfer and consultations with the sector role players towards further identifying research needs and creating awareness of the strategic research portfolio for the KSA and its thrusts. It is planned that one new programme will be initiated in 2007/08 as follows:

- In the thrust area of **Wastewater Treatment and Reuse**, the thrust will establish the programme dealing with *Energy from Waste*. This programme and

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## Water Use and Waste Management

initiative supports national S&T strategy to start looking at alternative sources of renewable energy. Sewage sludge has the potential to be a renewable energy resource. This programme will start with scoping studies and grow into an important research activity area in the future.

- The programmes in the thrust area **Sanitation, Health and Hygiene Education** will be lowered to four instead of the current six programmes. These are *Programme 1: Advocacy, health and hygiene education*; *Programme 2: Peri-urban sanitation research*; *Programme 3: Institutional and management aspects of sanitation service delivery*; and *Programme 4: Technical sustainability of sanitation services*. In *Programme 1* emphasis will be placed on the role of HIV/AIDS on and in the sector

Eighteen (18) new projects have been accepted for funding, comprising 13 non-solicited and 5 solicited. An amount of R 516 320.00 has been set aside, called the reserve fund, to allow the KSA to respond to priority research issues requiring urgent attention which may emerge during the year.

### Budget for 2006/07

The approved funding of the research portfolio for 2006/07 leads to a committed funding budget of R 32 230 000. The focus of this portfolio will continue along the current trend.

### Core Strategy

#### Strategic context

No major changes with regard to water use have emerged over the past few years, except for the floods, 2004 Tsunamis and earthquakes that have raised greater importance of how to deal with disasters and its mitigation, as well coordinating strategies for restoring and rebuilding reliable water and sanitation provision.

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 been dramatic over

the last 20 to 30 years. Economic growth and development resulting in a greater demand for water and annual consumption continues to rise in most countries. Ensuring a reliable source of clean water and adequate treatment of wastes and wastewater for large urban populations and rural communities pose great challenges for many developing countries. South Africa is no exception to this situation and this has led the government to embark on major water-related infrastructure development projects and to introduce water conservation measures, the focus being on optimal utilisation of existing water resources, the upgrading of existing sources and conservation and protection of catchment areas.

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

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

Effluents from all of these sources arise either as point sources (e.g. piped effluents from factories or sewers) or as non-point sources (e.g. runoff from un-serviced high-density settlements and seepage from mine slimes dumps or mine workings).

Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as our environment. The entire way we think about and use water is thus an important aspect in determining our future.

When comparing water use against the GDP of South Africa, the example of Gauteng shows that for an estimated use of 11% of the total water used in South Africa (1 355 million m<sup>3</sup>/annum), Gauteng generates 38% of South Africa's GDP and 10% of Africa's GDP (DWAF 2004, Gauteng Water Summit).

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

The policies of the previous Government had left a legacy which has resulted in at least half the population of South Africa not having access to safe and reliable water services. The Government has made this the focus of attention since 1994 and great strides have been made in improving this situation. The radical policies and strategies that have been introduced to accelerate and achieve the goal of complete coverage, has in itself generated and posed a number of new challenges on the issue of sustainability of water services.

The costs of providing clean water and sanitation to a fast-expanding and growing economy will continue to escalate. In an environment of increasing resource and financial constraints, coupled with the vision of some for all and the need to redress past imbalances, efficient use of water for domestic, industrial and mining purposes, as well as improved sanitation, would be critical for improving public health, eradicating poverty and contributing to global competitiveness.

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

Over the past 30 years, the science of water supply and collecting, treating and beneficially using wastewater and storm water has grown significantly. As a nation we have gone from rudimentary treatment to complex systems involving multiple phases and types of treatment. We have also expanded considerably the infrastructure of collection systems feeding increasingly sophisticated treatment plants. However, much still needs to be done. As water and wastewater flows continue to increase, supply and treatment systems must be optimised for better management and efficiencies. This can be achieved not only by increasing infrastructure but by finding new and innovative technologies and processes that will enhance the performance of systems. An example is treatment processes that can target development of new media and increasing treatment flow through. New innovative and appropriate technologies will play a key role in the improved management and extension of our water resources.

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, is becoming incrementally scarce. Managing water use and the wastewater released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it.

With all the achievements and developments to date, it is clear that South Africa has a good knowledge base and the competencies required to face the future challenges. 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, impact

on the environment and resource base, institutional and management issues, minimisation of wastes and other emerging issues.

Against this background the challenges posed are medium to long term and require greater interdisciplinary solutions. In line with the strategic context presented in previous years, which has regularly undergone both internal and external reviews, there are no major changes, as shown above, but there is greater emphasis towards solving the water supply and sanitation problems, it is worthy to note that the importance of research and development has also been strongly emphasized. Any major emerging changes are incorporated and absorbed into the current context.

### Needs analysis

During 2005/06, the KSA in its endeavour towards identifying research needs, as well as developing and improving research strategies at the thrust level have continuously engaged at a strategic level both nationally and internationally; to identify any gaps and strengthen the portfolio of priority research topics and areas requiring attention. In this regard, a number of small consultancies were awarded and the outcomes will provide the following:

- The state of stormwater management in South Africa
- The state of sewerage in South Africa
- The state of ponding and small systems in South Africa.

Added to the above the following strategies were developed during 2006/07 that assisted to shape the KSA portfolio:

- Towards a research strategy and agenda to support sanitation delivery South Africa
- Strategy of the health domain will influence activities in the programmes related to drinking water quality and supply.

In reviewing the wealth of information generated through the various processes and some of the incidents such as the typhoid outbreak in Delmas (failure of many municipalities in providing basic services), it is clear that the key challenges facing the water sector in South Africa as identified last year remained unchanged and warranted greater emphasis and support. These being:

- In a changing and dynamic legislative and strategic environment many solutions

are required towards sustainable and affordable water services provision. Key focus over the next few years will be on strengthening the capacity of local government to function in this challenging environment, introduction of successful models of service delivery which enjoy the support of all stakeholders, tackling 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 water services environment has undergone dynamic change over the past few years. The newly published Strategic Framework for Water Services (DWAF, 2003), has set a new set of challenges and goals for the sector. It will be imperative that the success of this framework will help realize the ultimate goal of national water policy and local government legislation.
- The World Summit and World Water Forum 3 impetus on setting water and sanitation targets has generated a new urgency and priority to this area of activity. South African ambitious declaration of obtaining full coverage by 2010 has prompted greater importance to the provision of water and sanitation.
- Since 1994, greater emphasis has been placed on improving water supply coverage resulting in sanitation coverage lagging behind. Recent incidences of cholera outbreaks have highlighted the importance of sanitation and hygiene. 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 and hygiene education coverage. These two components are essential ingredients for sustainability and achieving public health objectives. Focus areas over the short term are to develop appropriate technical solutions, finding ways to cost-effectively provide high-impact hygiene education, finding acceptable and affordable service arrangements,

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## Water Use and Waste Management

models for sanitation delivery and O&M, improving the legislation and policies that contribute to an enabling environment and accelerating sanitation delivery.

- 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.
- 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 the water resource. 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, more and more complex wastewater streams are introduced. It is imperative that solutions are generated to manage these negative impacts. Further, there is growing recognition for more innovative approaches such as cleaner production and waste minimisation. This area requires 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 meeting 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 undertaken 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.
- Further, the infrastructure and associated resources are the assets of our country and contribute to improving the quality of life and this 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.
- HIV/AIDS is one of the emerging issues that need to be addressed in the sector. Through the WRC's involvement in forums of the DWAF and DoH it was realized that the WRC could play a role in addressing HIV/AIDS and its role in the sector. In future more research will be done in collaboration with the two departments and the HIV/AIDS mainstreaming core group. This action started with the WRC's

involvement in the DWAF workshop on the global HIV/AIDS day in 2006. The specific needs of these vulnerable groups including the families where children are the head of the family regarding water quality and the delivery of and/or kind of water supply and sanitation services needed urgent attention.

### Technological trends

At an international level there is a continuous move towards new approaches as to the provision of water services and adaptation of new approaches to improved domestic water quality and improve availability of water through alternative advance technologies. An emerging trend in developing countries is to decentralise the management of services to a local level or to a local government level, with the national authorities moving into a stronger regulatory environment. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries when there is the need of addressing 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. Outcomes from the WSSD have highlighted the slow pace of water and sanitation delivery, and specifically sanitation, which is lagging further behind and the World Summit and World Water Forum 3 impetus on setting water and sanitation targets, has generated a new urgency and priority to this area of activity. South African ambitious declaration of obtaining full coverage by 2010 has prompted greater importance to the provision of water and sanitation. 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. An example of some of the processes is that of the WASH campaign. It is essential that these concepts and ideas be translated at a local level thus requiring the need for developing improved strategies, policies and mechanisms that create a sustainable and enabling environment.

In water supply, the emphasis is on efficient use of water and managing demand, as well as looking at the contributory elements such as energy, pipe components and materials, water supply components and behavioural aspects. In terms of treatment technology the current international trends are toward the increased removal of more and more specific contaminants in the water. In addition, it is aimed at adding less and less chemicals to the treated water product (Improved source quality). The removal of pesticides, heavy metals, endocrine disruptors, disinfection by-products and other harmful organics is receiving attention. The removal of *Cryptosporidium* and *Giardia* and the use of membrane filtration in this regard are receiving much attention – especially in the USA. There is a strong trend towards improving determination techniques of these new emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues on breaking the transmission of water and faecal-oral related diseases, through understanding practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

In the developed world, there is greater attention and focus being put 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 being considered by some South African coastal cities. Further with 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 new promising technologies such as nano-technologies, 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 application of cleaner production and waste minimisation principles is a losing game ultimately costing

all the parties material and energy resources, i.e. money. The consequences are profound: co-regulation becomes a meaningful negotiation; value as co-product is extracted from 'wastes' before discharge, thereby further reducing the waste load requiring treatment; technologies for treatment aim at being 'cleaner', are more focused towards specific waste fractions or even constituents and include recovery and reuse where technically and economically justifiable; resource-efficient technologies are not only favoured but even their optimum deployment ('where' in the process stream) is critically examined, etc. These trends are predicted to not only continue but in fact to accelerate in the future.

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

The contribution of mining-related non-point sources to water quality degradation is increasingly appreciated and has given rise to a need for improved techniques with which to quantify their contribution and improved technologies to minimise their effect.

The effect of water quality on HIV/AIDS positive individuals are one of the emerging issues that needs to be addressed. This will have an effect on the current and planned water supply and sanitation schemes. Results of research done in these areas showed that more care must be taken in planning these schemes to the special needs of these families. Education will also play a strong role in addressing the issues.

## Key stakeholders

The following stakeholders continue to be of key importance and important to the WRC in general and this KSA in particular. They are divided into internal and external stakeholders. Over the years, our international partners and business partners have also proven valuable to us.

The internal stakeholders are the WRC personnel, Executive Management and the Board.

### The external stakeholders include:

- Government departments and the Ministers representing them (DWAF, DEAT, DPLG, DoH, Mineral and Energy, etc.)
- Advisory groups
- 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 services providers, catchment management agencies, water user associations
- Industrial sectors and industry-representative bodies (mining, forestry, water services, etc.)
- NGOs, CBOs and international aid agencies
- Private consultants
- Tertiary institutions, primary and secondary education institutions, science councils, professional bodies (WISA, SAICE, IMESA, etc.) media agencies
- The public
- International coalitions such as GWRC, WSSCC, WUP, ET, UNEP, IRC, WARFSA
- Business.

## 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.

# 3 KSA 3 (continued)

## Water Use and Waste Management

### Strategic Initiatives Undertaken During 2006/07

The following strategic initiatives were undertaken to achieve the objectives of this KSA:

#### National initiatives

- There is an ongoing process within the thrusts in updating and identifying research needs and strengthening the portfolio of strategic research needs to be addressed over the short- to medium-term (2 to 5 years). During the year the following progress has been made:
  - Studies are being concluded to determine the status of stormwater drainage and sewerage, and identify research needs. This area has been identified in many strategic exercises as requiring greater attention and priority.
  - KSA members continue to occupy key positions on a variety of strategic bodies and forums. Examples of these are the Steering Committee – Waste Minimisation, Water Sector Leadership Group, Water information Network, JASWIC, WISA, and ESETA.
  - KSA member functions as the Chair of the Minister's Water Advisory Committee and the National Benchmarking Initiative
  - KSA is a key partner and driver of the national component of the Global Review of Private and Public Sector Participation, which was formally launched in 2006/07 with secured funding for a two-year period
  - The KSA continues to facilitate the National Water Services Benchmarking Initiative in partnership between DWAF and SALGA and the second national conference was held in February 2007. Participation of local authorities during this year increased from 40 to 80.
  - On appointment by DWAF, the KSA undertook a study to determine the status of wastewater treatment plants in South Africa as well as the suggested intervention strategies
  - On a further appointment by DWAF, the KSA was commissioned to have a guideline drafted on the desalination of seawater along South Africa's

- coastline, aimed at both municipal managers and practitioners in the field
- A KSA-completed study on creation standards for water supply chemicals, gave effect to the development of a process to create National Standards. The WRC has been instrumental in facilitating his process with the SABS and DWAF.
- KSA members have made a number of presentations on live radio on subjects of priority. An area which enjoyed media attention during the year was that of drinking water quality
- In collaboration with DWAF/DST – established the National Sanitation Technical Advisory Group. The idea was developed and conceptualized by the WRC. It aims to support national policy with O&M challenges of basic sanitation provision. (New)
- A further presentation on drinking water quality was made to the Parliamentary Portfolio Committee for Water, which included a suggested strategy for improving the situation
- The KSA hosted 8 workshops. These are reported under the KPA Learning and innovation, and also form the basis for stakeholder consultation and national initiatives. Note must be taken of three key national workshops on developing action plans for setting up of water quality laboratories, people affected with HIV/AIDS, and strategy planning workshop on drinking water research requirements.
- The KSA has been in the forefront in developing a national laboratories framework for SA. This initiative is regarded as critical in meeting SA's drinking water quality monitoring. The first workshop was held during the WISA conference in Durban (New)
- The National Health and Hygiene Strategy implementation task team met on 5 June and the KSA contribution as Chair of the Research Task Team is to give guidance and recommendations for research needs for the implementation of the strategy.
- The KSA will play a key role in the HIV/AIDS mainstreaming core group in the identification and excreting research needed to address HIV/AIDS in the sector.

The element of customer/ stakeholder relationship is further enhanced by WRC and its staff representations on a number of important bodies and forums. The WRC and the KSA are represented on the following forums:

- DWAF's Policy Group and Project Steering Committee for the implementation of the Waste Discharge Charge System
- DWAF's Project Steering Committee concerning the development of Best Practice Guidelines for the Mining Industry
- Work Team of DWAF's Project Steering Committee for the implementation of the Waste Discharge Charge System to define approaches to deal with non-point source pollution
- DWAF's Project Steering Committee concerning the development of a Comprehensive Framework for Integrated Water Resource Management in the Mining Industry
- Chamber of Mine's Steering Committee to develop Guidelines for the Vegetation of Residue Deposits against Water and Wind Erosion
- Coaltech 2020's Surface Environment Committee
- DEAT's Steering Committee to Develop a National Strategy On Cleaner Production and Sustainable Consumption
- Management Committee of WISA's Mine Water Technical Committee
- Organising Committee of WISA Biennial Conference 2008
- Board of WISA
- NTMP Programme Steering Committee
- Management and Steering Committee of the National Benchmarking Initiative
- DWAF Water Services Regulations Steering Committee
- DWAF Water Services Asset Management Steering Committee
- DEAT National Strategy for Sustainable Development
- Advisory position on the DWAF - Sanitation Technical Advisory Group and The WC/DM Advisory Group
- Appointed by the Minister to the Advisory Committee of the Groot Marico Catchment Agency
- KSA member was elected chairperson of the WISA Portfolio Committee on Education, Training and Youth Development

- The WRC is also presented on the HIV/AIDS mainstreaming core group as well as on the Health and Hygiene Strategy Implementation steering committee
- The KSA in collaboration with WHO has funded a research project on the adequacy of water, sanitation and hygiene services in relation to home-based care services for HIV/AIDS infected individuals in rural and urban communities in South Africa. This extensive report will be included in a WHO report and the extensive report will be published as a WRC TT report.

Another new key initiative is the closer collaboration between the KSA and WIN-SA. During the year through a process of restructuring WIN-SA became the responsibility of this KSA. Progress and achievements to date through WIN-SA were:

- WIN-SA took over the support of the District Water Services Managers Network, which emanated from a WRC study
- WIN-SA produced a series of lessons learning and good practices booklets
- WIN-SA undertook an exploratory study to look at sharing of information and successes within the SADC region

### International initiatives

- Ten South African presentations on new emerging and innovative developments addressing drinking water were presented for the Biennial Emerging Technologies Forum held in Switzerland in April 2006. South Africa is one of the leading countries regarding new technologies. All 10 innovations are wholly or partly funded under KSA projects.
- The KSA participated in an EU – FP6 bid on a sanitation project led by the IRC and forming part of the African partner contingent. After the bid passed the first round qualification, it was unsuccessful.
- The KSA is a member of a successful bid for a WHO project looking at determining the impacts of Watsan interventions. Led by the University of Johannesburg, the project complements WRC initiatives on the subject.
- KSA is the coordinator for the South African contributions to a new European Union project - TECHHNEAU (technology

enabled universal access to safe water) EU project started in 2006. The project aims at rethinking current water supply options.

- KSA and the WRC is now a member of the WHO International Group for Small Community Water Supply Management
- KSA in collaboration with WISA assisted in the preparation for the SA bid to host 8th ICARD in 2009
- The KSA participated in the Development of a Global Guide to deal with AMD. Contributions included help to develop a guide about proposed content and appropriate SA publications.
- The KSA has been invited to present a special paper entitled 'Management of Wastewater Sludge in Southern Africa' as a representative of the WRC at the International Water Association Specialist Conference: Moving Forward, Wastewater Biosolids Sustainability: Technical, Managerial, and Public Synergy. Moncton, New Brunswick, Canada, 24-27 June 2007
- The WRC, represented by the KSA, joined the Global Alliance of key regional organisations active in the field of acid mine drainage (AMD), that engages with the International Network for Acid Prevention (INAP). INAP is an international grouping of mining companies that was established in 1998 to help meet the challenge of effectively dealing with the problem of acid mine drainage. It has since become a leader in mobilising international information and experience in research, technology transfer and networking.
- The GWRC partnership is bringing greater collaboration in research and benefits. To date the KSA's involvement has been rewarding and includes the following:
  - The KSA made presentations to the GWRC planning workshop on asset management in the water industry. A number of collaborative projects were discussed and agreed upon. The WRC will lead the study on International Best Practice in Asset Management, for which funding from the GWRC will be forthcoming.
  - Presented the South African status on Nanotechnology and Energy Research and Research Needs in the Water Field, GWRC Meeting, Cincinnati, USA, 8-9 Nov 2006

- The KSA contributed towards the State of Science report on water reuse under another participative project with the Global Water Research Coalition and provided information on water reuse in Southern Africa
- The KSA is contributing toward GWRC joint activities in endocrine disruptor and algal toxin research. Further GWRC initiatives include cooperation in a membrane bioreactor research strategy plan and in a water reuse project. The KSA also participated in the development of the GWRC International Research Strategy to Support Asset Management in the Water Services Sector. The KSA research programme will contribute and provide inputs into the GWRC projects.
- A very promising development was that the SA laboratories involved in the EDC toolkit project received samples from Frederic Leusch, the Australian project leader, for analyses and validation of the methods chosen for the EDC toolkit. Two of these methods used, were innovated and developed by the UP, through the WRC study.
- The SA Cyanobacteria Management Manual recently developed is one of the three manuals that are currently used to develop the Global Cyanobacterial Guideline Manual. Two of SA's researchers have been appointed to manage and compile two of the chapters in the GWRC manual.

### African leadership

- The WRC was invited by DEAT to assist with their programme 'Addressing Land-based Activities in the Western Indian Ocean' WIO-LaB. The KSA serves on the project's National Municipal Wastewater Task Force which feeds into the Regional Municipal Wastewater Task Force.
- The KSA played a key role in the organising of international events:
  - AfriWISA-2007
  - Dutch Technology Matchmaking Mission, Feb 2006

With regard to African and International Initiatives, the KSA will continue in line with the WRC key strategic issue of regional and international relationships, strongly position

# KSA 3 (continued)

## Water Use and Waste Management

itself globally and in Africa, with special emphasis on collaboration and sharing of water-centred knowledge. This will be achieved via co-operative agreements and partnerships that will also allow for leverage of funds and global recognition.

### Growing the Knowledge Base

#### Capacity-building initiatives

At the end of the year 2005/06, 39 projects were finalised resulting in 34 Masters Degrees and 10 Ph.D.s obtained through these projects. A further estimate of 50 undergraduate activities contributed to these projects. In terms of demographics 54 Black males, 26 Black females, 24 White males and 16 White females were involved.

Progress to date on ongoing projects 2006/07 indicates that the numbers of students undergoing post-graduate training at tertiary institutions under WRC-funded projects in this KSA was estimated as 189 in total. Of these, 151 students (about 80%) are from previously disadvantaged groups.

Of the 35 projects finalised to date, 38 research reports have been published, 31 popular articles, 89 presentations and 24 workshops. On the academic level 6 doctorates, 21 masters and 20 Honours have been achieved.

A total of around 32 institutions comprising consultants, research bodies, industry and academic centres are involved. The table below highlights the institutions which are actively involved in capacity building projects for 2006/07:

Organisation	Students from PD Background	Total No of students
African Water Institute (AWI)	2	2
Arcus Gibb (Pty) Ltd	2	2
Cape Peninsula University of technology	2	2
Chris Swartz Water Utilization Engineers	10	10
Coaltech 2020	2	2
Council for Geoscience	2	3
CSIR	9	9
Digby Wells and Associates	2	4
Durban Institute of Technology	2	2
Emanti Management (Pty) Ltd	2	3
Environmental Business Strategies cc	1	1
Golder Associates Africa (Pty) Ltd	5	8
Industrial and Urban Infrastructure (Pty) Ltd	2	2
Mvula Trust	2	2
Partners in Development cc	2	2
Pulles, Howard & de Lange Inc	3	3
Rand Water	8	14
Rhodes University	16	20
Sustainable Environmental Technologies	1	1
TBR Project	1	1
Tshwane University of Technology	3	3
Umgeni Water	8	10
University of Cape Town	9	15
University of Fort Hare	1	1
University of Johannesburg	5	6
University of KwaZulu- Natal	11	13
University of Pretoria	5	10
University of Stellenbosch	15	19
University of the North West	3	3
University of the Western Cape	6	7
University of the Witwatersrand	8	8
Zitholele Consulting (Pty) Ltd	1	1
<b>Total</b>	<b>151</b>	<b>189</b>

### Knowledge sharing and leadership

Internal learning, innovation and dissemination are paramount to the KSA meeting its goals. The following are some of the achievements to date:

- The majority of research results are published in the form of manuals with computer models, guidelines or standard reports. These are disseminated as widely as possible. The number of final reports published at the end of 2005/06 amounted to 46, out of 39 research contracts finalized. Progress made during 2005/06 on completed projects realised 6 popular articles, 67 scientific papers, publications and conference presentations were made.
- KSA related adverts were placed in the IMESA journal, and the South African Local Government Digest highlighting the WRC and its contribution to the local government sector
- KSA-specific exhibitions included :
  - WISA launch of the Water Treatment Manual - Durban
  - IMESA – Soweto
- The KSA hosted the following workshops:
  - The KSA arranged around 7 workshops related to ongoing and completed projects at the WISA Conference, Durban 2006.
  - Workshop held to develop ToRs for solicited project on sustainable tailings facilities
  - Strategy planning workshop on drinking water research requirements, Umgeni Water & DWAF, Durban, 20 Sept. 2006
  - Funded and arranged with WISA – 20 October 2006 – Workshop on challenges with small package treatment plants
  - New standards for chemicals used in potable water treatment in the thrust Water Treatment and Supply
  - Sanitation Workshop - Prof D Mara, May 2006
  - To inform stakeholders regarding the occurrence of the cyanobacterial neurotoxin beta-methyl amino alanine (BMAA) in raw potable and drinking water supplies in South Africa
  - GWRC global cyanobacterial guideline workshop
  - National Benchmarking Conference, Feb 2007
- In addition many research projects are increasingly building technology transfer activities as a key objective in their research methodology. These take form of popular articles, specialist workshops and web-related promotion activities.
- The following technology transfer actions were undertaken:
  - Interview on Radio East Coast on drinking and bottled water quality in SA, 15 June
  - Publications on the concept off franchising in:
    - Business Day
    - Top 300 Companies magazine
    - Engineering News
    - WASE
    - IMESA journal
  - KSA launched the Guideline on the Design and Operation of Water Treatment Plants at WISA, which gained significant popularity.
  - A one-hour 702 & East Coast Radio talk show with Lee Benny on bottled water and home water treatment devices
  - A special press pack for DWAF to effectively communicate the message related to the status of wastewater treatment plants in South Africa as well as the suggested intervention strategies.
  - Water Science & Technology (Volume 54 Number 5, 2006) edited by HG Snyman that contains selected papers from the International conference held in 2005: 'Sustainable Management of Residues from Water and Wastewater Treatment' was published in September 2006. The edition contains several papers from South African researchers supported by the WRC
  - A technical debate organized and sponsored by the KSA in association with WISA was held on 5 October 2006 at the CSIR. The technical debate theme was: 'Is Urine Diversion Feasible in the Urban Areas Served by Water-Borne Sewage Systems?' The debate was informed by the work done by Dr Jac Wilsenach (CSIR, Stellenbosch) on the treatment of source-separated urine and its effects on wastewater systems.
  - Presented a paper at the 3 day OR Tambo DM Water Services Summit, held at the Mzamba Wild Coast Sun Hotel, Eastern Cape (17-19 October 2006). The paper was entitled: 'Factors that affect the functionality of wastewater/sewage treatment plants'. Over 400 people from local government attended the summit and the DM indicated that they appreciated the WRC's involvement and presence
- The following papers have been presented by WRC staff at international and local conferences:
  - Presentation on Sanitation Options for Peri-Urban Areas, Eskom, 6 June 2006
  - Franchising of Water Services at the WISA conference 2006.
  - Advances in the Management of Water Supply Systems, ETXII, Rapperswil, May 2006
  - Future Concepts for the Urban Water Cycle, Rapperswil, May 2006
  - Franchising Water Supply and Sanitation, IWA Biennial Conference in China
  - First phase of the EDC research programme for SA, IWA Biennial Conference, China:
  - Status of Wastewater Treatment by Water Service - Providers in South Africa - A Visual Record of the Challenges, ESETA Conference, November 2006
  - Presentation made on the WRC project on Productive Use at the MUS Workshop held on 6 October 2006
  - Application of Cleaner Production Principles in Mining and Minerals Processing: Comparing South Africa to the World, Melrose Arch, Johannesburg
  - Presented the South African status on Nanotechnology and Energy Research and Research Needs in the Water Field, GWRC Meeting, Cincinnati, USA, 8-9 Nov 2006
  - 1 November 2006 – WISA Appropriate technologies – presented a paper on Low-Cost Sewerage Technologies
  - 29 November 2006 – Presented a paper at the Africa water conference on franchising of water
  - Developing Guidelines for Greywater Reuse for Small-scale Agriculture in South Africa – ICID Conference, Malaysia, September 2006
  - INAP's global initiatives to deal with acid mine drainage – WISA Mine Water Conference, October 2006

# 3 KSA 3 (continued)

## Water Use and Waste Management

The KSA contributed to WRC open day sessions in Cape Town and Pretoria.

- Presentations were made to the Parliamentary Portfolio Committee for Water on two occasions.
  - Presentation on Sanitation Technology Options
  - Presentation of the SA Water Quality Situation Seen from a WRC Perspective, 20 June

### WIN-SA

As highlighted, the activities of WIN-SA are very closely associated with that of the KSA, and closer collaboration on dissemination and other WIN-SA activities will be forged. WIN-SA will therefore strive to :

- Set in motion an incremental process to improve access to and use of information and knowledge
- Ensure that users have access to appropriate information, such that the water services sector can improve its performance
- Strengthen the culture of learning and sharing amongst sector stakeholders
- Strengthen and support provincial water services resource centres and maximize returns on the existing investment in information and knowledge initiatives.

In the year under review significant progress has been achieved by WIN-SA against its set objectives. All activities under its four core thrust areas have been established and many milestones have been achieved:

- **Core Thrust 1: Knowledge documentation:** Bringing in the Harvest Campaign - Lessons documented and disseminated widely; the Development of the WIN field notes; Analysis and reviews of key sector activities and processes as timely and needed for the sector
- **Core Thrust 2: Access to information and knowledge:** Portal established
- **Core Thrust 3: Strengthening a culture of learning and sharing:** Support to Sanitation lesson learning - A strategy to support Regional Sanitation lesson learning developed in partnership with DWAF; Tools and guidelines developed to enhance knowledge sharing practices in the sector.

- **Core Thrust 4: Creating the capacity to assimilate and understand knowledge:** Key champions trained and capacitated; Support to sector training initiatives to support accelerated water and Sanitation delivery ; KM tools utilised and evaluated on a continuous basis.
- **Core Thrust 5: Building the network:** Strengthening and growing the Network - WIN-SA's role as a value adding network for the WS sector entrenched.

It is planned that in the year 2007/08, initiatives started on the four thrust areas will be further strengthened. These include the *Bringing in the Harvest Campaign*, lessons learning, North-South lessons sharing and strengthening the network.

### Implementation Plan

#### Research portfolio for 2006/07

The KSA's continuous activities in light of the results of the strategic needs analysis and stakeholder engagement, with regard to its objectives and thrusts, have been well supported. Feedback from these exercises has ratified the KSA direction and many valuable inputs assisted in strengthening the portfolio. Thus the primary and secondary objectives of the KSA remain the same.

The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. To achieve these objectives, strong internal processes are necessary. Strengthening internal processes and capacity will therefore receive greater attention.

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

- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education

- More emphasis will be placed on water and sanitation related HIV/AIDS research
- 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 storm- water)
- 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.

Twenty two (22) new projects have been approved for funding, made up of 13 non-solicited and 9 solicited projects. Experience has shown that in this KSA, there is an emergence of new and critical issues requiring research. The KSA is reserving an amount of R516 320.00 (Reserve Fund), to put the KSA in a position to respond to these research issues.

The research portfolio for 2006/07 is presented in **Table 1** which provides an overview and description of research thrusts and programmes.

**Table 1**  
*Overview and explanation of thrusts and programmes*

<b>Thrust 1: Water Services - Institutional and Management Issues</b>	
<p><b>Scope:</b> <i>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 to the strengthening of water institutions (water services providers, water services authorities, water boards, national departments) in providing sustainable water services.</i></p>	
<p><b>Programme 1:</b>  <i>Cost recovery in water services</i></p>	<p>The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this program intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing of new approaches.</p>
<p><b>Programme 2:</b>  <i>Institutional and management issues - Water services</i></p>	<p>Relationships and partnerships between service providers, both external and internal, are a key to sustainable water service delivery. This program'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.</p>
<p><b>Programme 3:</b>  <i>Innovative management arrangements - Rural water supply</i></p>	<p>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.</p>
<p><b>Programme 4:</b>  <i>Regulation of water services</i></p>	<p>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. Further, 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.</p>
<p><b>Programme 5:</b>  <i>Impact of Water and Sanitation interventions</i></p>	<p>The programme will address aspects related to determining and quantify 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 billions of rand 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.</p>

# KSA 3 (continued)

## Water Use and Waste Management

<b>Thrust 2: Water Supply and Treatment Technology</b>	
<p><b>Scope:</b> <i>The provision and supply of affordable and reliable water of quality and quantity for drinking (domestic) and economic (industrial/commercial and mining) activities, remains 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.</i></p>	
<p><b>Programme 1:</b> <i>Drinking water treatment technology</i></p>	<p>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.</p>
<p><b>Programme 2:</b> <i>Water treatment for rural communities</i></p>	<p>This programme aims to provide, through research products, adequate quantity and quality water to rural communities on a sustainable basis. Expected outcomes required to achieve sustainable water services include community involvement, cost-recovery, effective operation and maintenance, affordability and willingness to pay for water services.</p>
<p><b>Programme 3:</b> <i>Drinking water quality</i></p>	<p>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.</p>
<p><b>Programme 4:</b> <i>Water distribution and distribution systems</i></p>	<p>The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated, potable water to the end-users thereof. The programme has the following expected outcomes: To develop reliable processes in the 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. To develop innovative methods, tools and processes that will improve system integrity and reliability.</p>

### Thrust 3: Wastewater and Effluent Treatment and Reuse Technology

**Scope:** The ongoing provision of sanitation services and expansion of industrial development, both of which are national developmental priorities, continually increase the need to better manage and treat the resultant wastewater and effluent flows, mitigated as far as possible by reduction-at-source measures, so that the effluent produced not only meets discharge requirements but can also be considered as a resource. Research in this thrust aims at developing technologies and systems that optimize the wastewater and waste management chain in the municipal (domestic), mining and industrial sectors, including also the institutional and infrastructural arrangements operative in these sectors. From the needs analysis carried out in 2003 and preliminary strategic research planning, the scope, definition and priorities of some of the programmes within Thrust 3 will alter from 2005/6, involving both the establishment of new programmes and the consolidation of some of the existing programmes.

<p><b>Programme 1:</b> <i>Biological sewage treatment processes</i></p>	<p>This programme addresses the ongoing development of new or modified processes and optimisation of established aerobic and anaerobic processes for biological sewage treatment systems. Expected outcomes are greater cost-effectiveness, technical and operational control, process efficiency, performance security, affordability and application.</p>
<p><b>Programme 2:</b> <i>Sludge characterisation, treatment, utilisation and disposal</i></p>	<p>This programme deals with the systematic characterisation, quantification and categorisation of sludge from domestic and industrial sources in the RSA. The overall expected outcome is a greater capability for the development of technically-secure, cost-effective, environmentally acceptable and sustainable treatment process technologies, utilisation strategies and disposal practices.</p>
<p><b>Programme 3:</b> <i>Treatment and recovery of organics from agro-industrial processing</i></p>	<p>Addresses the development and piloting through to full-scale implementation of treatment and/or conversion technologies for problematic organic effluents from agro-industry processing including forestry (pulp and paper) and livestock products, particularly in respect of organic components which are too concentrated, refractory, inhibitory or even toxic for the biological treatment processes normally available at municipal sewage works.</p>
<p><b>Programme 4:</b> <i>Treatment and recovery of inorganics (including sulphate, metals) in industrial and mining effluents</i></p>	<p>This programme aims to develop a range of processes for effective treatment and disposal of industrial and mining effluents containing components such as heavy metals and inorganic salts, which have deleterious bio-inhibitory or bio-toxic effects on the performance of sewage works, the fitness of treated wastewaters for reuse, the sludge quality produced and the aquatic environment in general. Expected outcomes include the potential recovery of materials and water for beneficial reuse and fundamental scientific/engineering support for process development.</p>
<p><b>Programme 5:</b> <i>Training in wastewater treatment plant operation</i></p>	<p>Aims at researching, developing and delivery of appropriate tools, course material, management systems and providing training for wastewater treatment plant operators. The purpose is to strengthen and enhance the skills base (competency and expertise) necessary for effective control and management of the diverse needs of the water industry in the RSA.</p>
<p><b>Programme 6:</b> <i>Biotechnological co-treatment of industrial / mining effluents with sewage wastewater</i></p>	<p>The programme objective is to exploit and further develop beneficial applications of biotechnological processes for co-treating saline and sewage wastewaters in the sustainable and integrated management of various water-related communities, industrial, agricultural and environmental needs.</p>
<p><b>Programme 7:</b> <i>Sewerage reticulation</i></p>	<p>This programme aims at addressing technical design, operational, maintenance, refurbishment and management aspects of sewerage reticulation systems, which have been identified as a concern in the sustainable provision and protection of asset infrastructure in the extended delivery of sanitation services as a national priority.</p>
<p><b>Programme 8:</b> <i>Stormwater management</i></p>	<p>This programme addresses strategic and technical aspects of managing stormwater flows and impacts in urban, peri-urban and rural contexts, with their different implications for water resources, community health, environmental impacts, etc.</p>
<p><b>Programme 9:</b> <i>Energy from waste</i></p>	<p>This programme is established to investigate sustainable methods and technologies for generating energy from domestic and industrial waste sources.</p>

# KSA 3 (continued)

## Water Use and Waste Management

<b>Thrust 4: Industrial and Mine-water Management</b>	
<p><b>Scope:</b> <i>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.</i></p>	
<p><b>Programme 1:</b> <i>Quantification of water use and waste production</i></p>	<p>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.</p>
<p><b>Programme 2:</b> <i>Regulatory mechanisms to improve industrial and mine-water management</i></p>	<p>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.</p>
<p><b>Programme 3:</b> <i>Minimising impact of waste on the water environment</i></p>	<p>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.</p>
<p><b>Programme 4:</b> <i>Minimising waste production</i></p>	<p>There exists a direct link 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 thus 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.</p>
<p><b>Programme 5:</b> <i>Improved ability to predict and quantify effects</i></p>	<p>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.</p>

### 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.

<b>Programme 1:</b> <i>Health and hygiene education</i>	The main objective of this programme is to support 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.
<b>Programme 2:</b> <i>Peri-urban sanitation research</i>	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 institutions needs.
<b>Programme 3:</b> <i>Knowledge/information management and advocacy</i>	The overall aim of research under this programme is to improve access to sanitation research information and to develop effective mechanisms for promoting implementation of best practice by the sector role-players. The focus would be on ensuring that <b>an enabling environment supports the process of sanitation</b> knowledge and its uptake, which in turn empowers decision makers in providing sustainable sanitation.
<b>Programme 4:</b> <i>Institutional and management aspects of sanitation service delivery</i>	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.
<b>Programme 5:</b> <i>Technical sustainability of sanitation services</i>	To develop tools, procedures and guidelines that will guide those responsible for implementing projects in their selection of appropriate sanitation technologies that are social, environmental and financial sustainable.
<b>Programme 6:</b> <i>Financial sustainability</i>	The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices.

# 3 KSA 3 (continued)

## Water Use and Waste Management

### Research Projects for 2006/07

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2006 and 31 March 2007.

### Completed

#### Thrust 1:

#### Water Services – Institutional and Management Issues

##### Programme 1:

##### Cost-recovery in water services

*A study of the sustainability of current WSA financial arrangements, including an analysis of how the equitable share is being applied to water services, and the impact of the transfer of water schemes on the viability of Water Service Authorities*

*Palmer Dev Group/Cape Town Office  
No 1609*

Due to changes in the water policy environment in recent years, there have been significant changes in responsibilities in the water sector. In some cases the responsibility for providing rural water services, including sanitation, has been allocated to municipalities, both district and local, which have no previous experience in the water services sector. These predominantly rural WSAs are characterised by high backlogs, high levels of poverty, small urban centres, and very limited ability to cross-subsidise between different water consumer types. The aim of this study was an investigation of the sustainability of current WSA subsidy arrangements.

The study focused on the challenges associated with both maintaining access and targeting the poor, as there is a tendency to postpone maintaining assets until the roll-out of infrastructure is complete. The study focused on how equitable share funds are currently being applied to water services, in the context of municipal finances and three WSAs were used as case studies. Findings from this exercise are as follows:

- **Current ES allocations to water services is insufficient**

Using powers and functions and the national ES formula as a guide, the current allocations to water services within municipalities are completely inadequate. Funds are being diverted away from water services to pay for general municipal overheads, and low-capacity municipalities divert funds from service delivery to general administration costs.

- **Higher ES subsidies for urban consumers**

Looking purely at ES funds, municipalities are all over-subsidising urban water consumers. While one case study municipality is currently providing a portion of the Equitable Share to cover energy and repair costs for rural schemes, the application of a more consistent allocation rule, either per poor household, or differentiated by service level, would result in a substantial shift of current water subsidy funds from urban to rural areas.

- **Insufficient subsidies being allocated to sanitation services**

Of the subsidy funds which are allocated to water services, too little of it is being allocated to sanitation services. Even with the inclusion of the WSOTS subsidy in the analysis, the findings indicate that there is an excess of subsidy funds for served water consumers, while sanitation subsidies remain inadequate. There are insufficient funds to subsidise higher service levels if adequate provision is made for health and hygiene education. The danger is that funds will only be allocated to the small number of urban poor households with flush sanitation. This will reduce the sustainability of the service in the longer-term.

Cost: R207 040  
Term: 2005 - 2006

##### Programme 2:

##### Institutional and management issues - Water services

*Sustainable development indicators for urban water systems: Case study evaluation of the Thohoyandou and Makhado (Louis Trichardt) municipalities (NS)*

*University of Venda  
No 1517*

This study aimed at applying the concepts and sustainable development indicators developed by the UN and check their relevance in a developing country context. 20 SDIs were proposed for urban water systems and categorized in terms of four environmental and technical systems: freshwater, drinking water, wastewater and sewage sludge. Twenty SDIs were tested for urban water systems in the Makhado and Thohoyandou municipalities and 16 were found to be useful for the current situation in the study area and were recommended for future studies. Some SDIs like raw water withdrawal, drinking water quality, drinking water consumption, drinking water quality, waste production loads to receiving waters, access to drinking water, sanitation and development indicators were easy to apply in the study areas as data were easily available. Some of the SDIs like access to water and sanitation, water quality and affordability of services (economic indicator) were similar to the key performance indicators of the South African Department of Water Affairs & Forestry. The current situation for many of the indicators studied for the water and wastewater systems is not moving towards sustainability and some improvements are necessary in the operation of the systems to make them sustainable.

Cost: R150 000  
Term: 2004 - 2006

#### *Case study of a district municipality water services authority experience of implementing local government and water services related policy initiatives. An action-oriented research support (NS)*

*Palmer Development Group  
No 1518*

As a motivation to the establishment of the Forum, it was noted that South African municipalities have been through a major transition over the last few years with the revised demarcation of municipal boundaries and the related creation of two tier local government. Further there had been rapid change in the policy environment with new legislation introduced governing municipal affairs (Municipal Structures Act, Municipal Systems Act, Municipal Finance Management Act), new funding policy (equitable share, municipal infrastructure grant) and new water

sector policy (The Strategic Framework for Water Services, free basic water, free basic sanitation). All this had presented considerable challenges to municipalities.

While there is considerable research in these various fields, much of it was not packaged in a way which was useful to district municipalities and those who work with them. Further there was no established way of sharing what learning was taking place. Therefore it was proposed that the WRC could have a major impact by supporting an action oriented research project aimed at gaining an understanding of what was needed by districts and then providing the necessary research support to them and ensuring that this information is shared.

Using funding from the WRC, the District Water Services Managers' Forum was established. The idea was for a relatively small group of high-level water services managers from district municipalities, who operate under the difficult circumstances outlined above, to get together with some fairly limited research support to have quick access to information which they could use to improve their planning and service delivery arrangements. It was believed that such an initiative would save the water services sector significant resources by improving efficiency in decision making and service delivery through minimising duplication in terms of funding similar investigations, bad decisions, and committing similar mistakes by different WSAs because of lack of information sharing.

The District Water Services Managers' Forum (the Forum) was formally established on 9<sup>th</sup> of June 2004. During this period, the Forum has proved to be a good platform for information sharing, learning and action research for managers.

The Forum provided an important platform for the managers to:

- Learn from each other through sharing of experiences when implementing policy and legislation;
- Identify research support needs that are of priority to them as they respond to the challenges facing them;
- Minimise duplication of effort and the likelihood of committing the same mistakes thereby improving overall efficiency in the use of public resources

- Consult and formulate shared perspectives on policy proposals and developments especially in as far as they affect service delivery in their environments

The Forum is proving to be an effective mechanism of knowledge sharing and lessons learning for DM WSAs. It has also grown in stature within the sector over the past year and it provides a platform for water services managers/ practitioners to input in key national sector initiatives.

Cost: R400 000  
Term: 2004 - 2006

#### **Case study on learning by technical water professionals and decision-makers for urban developmental service provision**

*M van Ryneveld*  
**No 1519**

The aim of this study was to determine and identify how dissemination and learning by water professionals in the sector is taking place and its impact on service provision. The study was a strategic attempt to understand uptake of water knowledge. It will provide good methodology for future impact studies and assist in planning appropriate dissemination activities. The scope of the project was **intentionally broad, focusing on breadth more than depth**. The findings were as follows:

- There *is* a lot of information readily available on the provision of water services within a developmental context. Much of it is of a technical nature, and therefore only partial. Nevertheless, the conventional literature is not in fact exclusively technical. Social and financial aspects, for example, are included. What appears to be weak or missing is a mechanism for the integration, resolution and translation into practice of these various elements.
- What is suggested by this research to be missing is the **combination of political and technical disciplines and functions** into a unified approach, suggested as 'developmental water services', and formalised in the workings of the bureaucracy. Developmental water services is suggested to consist of an

agglomeration of different disciplines, consisting of:

- (a) Implementation of services on the ground carried out by technical professionals (in different fields such as engineering, health, housing etc, often arranged institutionally into departments along those lines);
- (b) Decisions, trade-offs and resource allocations (within limited resources, to meet developmental objectives) carried out by politicians; and the institutionalisation of this, or translation into the bureaucracy.

- Decision making in the provision of water services requires three levels of methodical competence, namely, **numeracy, knowledgeable analysis and problem solving**. It is clear from the research that only technical professionals require high levels of problem solving. As a basic minimum, participants in the sector should at least be numerate. A lack of numeracy can have a significant impact on the quality of decision making. It appears that most decision makers in the water services sector are numerate. However, examples of decision makers not understanding why a water reservoir needs to be higher than the housing it serves are in evidence.

Cost: R180 000  
Term: 2004 - 2005

### **Thrust 2: Water Supply and Treatment Technology**

**Programme 1:  
Drinking water treatment technology  
Membrane fouling and visualisation studies**  
*Dept of Polymer Science, University of Stellenbosch*  
**No 1441**

The aim of the project was to develop non-interfering methods for the early detection, measurement, characterization and cleaning of fouling on membrane surfaces. The scope of the project included the further development and refining of an ultrasonic method developed earlier at the University of Stellenbosch, called Ultrasonic Time Domain Reflectometry (UTDR) hardware and

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## Water Use and Waste Management

software; the development of this technique on flat-sheet membranes and more complex shapes; characterization of fouling layers from high natural organic matter (NOM) synthetic and real waters; and following the effect of cleaning protocols in real time.

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

Cost: R 1 500 000  
Term: 2003 – 2006

**Programme 2:**  
**Water treatment for rural communities**  
*Full-scale investigation of the application of a simple chemical dosing system (CDS), and upflow roughing filtration in layers (URFL) and slow sand filtration (SSF) combination, in small and rural surface water treatment plants*  
Department of Building and Civil Engineering, Peninsula Technikon  
**No 1396**

The project aimed to develop and evaluate a simple, non-powered, constant-head gravity chemical dosing system and test its application in a combined roughing filter - slow sand filtration system. The system was designed and built in-house, and evaluated both on bench scale and on pilot scale in the field. The project succeeded in developing a gravity-fed, constant-dose coagulation system for rural water treatment plants. In parallel, design and operational parameters were established for a rural water filtration system, consisting of up-flow roughing filtra-

tion in layers, followed by slow sand filtration. Guidelines were lastly developed for the design, construction and integrated application of the chemical dosing system and the roughing filtration – slow sand filtration processes, thereby enhancing knowledge transfer and the application of these, very appropriate, processes in practice.

Cost: R380 000  
Term: 2002 - 2005

**Programme 3:**  
**Drinking water quality**  
*Inflammatory potential measurement as a supplement to health-related microbial water quality assessment*  
Technikon Witwatersrand  
**No 1444**

It became necessary to investigate supplementary water-assessment tools that can link the quality of water (for consumption) more directly to potential human health effects. The aim was to develop an assessment methodology that combines measurements of inflammatory potential of, as well as the potential occurrence of bacterial pathogens in, water that people consume in order to assess whether water has the potential to cause inflammatory reactions in humans.

Water samples were collected from the Nwanedi River Basin in the Vhembe district of Limpopo. In this area, substantial numbers of people in several villages still source untreated river water for domestic use; however, some villages have access to tap water of a good microbiological quality. The common risk factor among these villages was containers that people used for collecting water from whatever source they accessed and transporting it to their homes where it was stored and used over time.

This study showed that most of the waters tested were inflammatory. The team, however, failed to associate this with the potential bacterial pathogenesis of the test waters. This meant that there were some other constituents that caused the inflammatory reactivity.

Nevertheless, as a screen for the health-related quality of water, this test approach did show potential for use as a robust supplement to tests traditionally used for monitoring.

The team recommended that this test approach should be included as a supplement for health-related water-quality testing not only to test water for what is in it, but also to test such water for what it could cause in a consumer.

Cost: R424 400  
Term: 2003 - 2004

**Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers**  
Rand Water  
**No 1445**

The proliferation of algae and cyanobacteria in the source water causes problems such as ineffective coagulation, flocculation and sedimentation, penetration of sand filters, clogging of sand filters, increase of organic loading and the release of taste and odour compounds, as well as toxic compounds during the treatment of drinking water. Possible treatment options for the removal of cyanobacterial cells and toxins from source and drinking water are needed to guide water treatment plants when such problems occur.

The overall aim of the project was to develop a Generic Cyanobacterial Incident Management Framework (CIMF) to manage the supply of drinking water when toxic cyanobacteria blooms are present in the source water.

The Incident Management Framework provides operations managers and operators with easily understandable information that would enable them to make informed decisions regarding the basic requirements for monitoring and dealing with cyanobacteria in source water. This will minimise the risk of exposure by consumers of drinking water to cyanotoxins. The CIMFs accommodate drinking water utilities with different capacities and contribute to the knowledge base currently available in South Africa. Whereas knowledge on how to manage cyanobacteria and their associated toxins effectively during drinking water purification was previously confined to only a few drinking water utilities it is now also available to all the drinking water utilities.

Two easy-to-use posters were developed that could be used by the drinking water utilities for easy reference by the plant operators' laboratory personnel and managers. This document has been reviewed by international specialists and would be used by the GWRC cyanobacterial group to develop an international guideline for cyanobacterial management.

Cost: R236 300  
Term: 2003 -2004

***On-line real-time enzyme diagnostic system for the detection and monitoring of sewage levels in drinking water***  
*Dept of Biochemistry and Microbiology, Rhodes University*  
**No 1446**

Current tests to detect indicator micro-organisms for the potential presence of pathogens in water intended for drinking purposes are in place (i.e. total coliform tests, *E. coli*, etc.), but these require often laborious and time-consuming procedures. During the course of 2000 to 2002, unique enzymatic profiles present in primary sewage sludge were established by the team, one of the first studies of its kind in the world.

The ultimate aim of this work was to develop an on-line real-time enzyme diagnostic system for the detection and monitoring of sewage levels in drinking water, using suitable marker enzymes. Furthermore, proof of concept was established for the design of a suitable electrochemical biosensor for the rapid detection of faecal matter in water intended for drinking purpose. One of the most promising alternative approaches to faecal microbial detection (by performing direct assays for marker enzymes of these indicator micro-organisms) was selected. Detection via marker enzymes was successfully achieved within 24 h although the aim is to reduce this time to less than 9 hours.

A number of stages were involved in confirming that the concept of direct enzyme assays can indeed be applied to the direct *in situ* detection of faecal contamination in water samples. Attempts were made to concentrate the marker enzymes (originally present in very low concentrations) in order to facilitate bio-informatic profiling and identification of the source from which these mark-

ers enzymes had originated. Protein profiling and bioinformatics studies, supported by literature, confirmed the origin of GAL and GUD as being from *E. coli*, and not from plant or algal origin. After enzyme assay optimisation, a liquid bioprobe was established. Field evaluation of the bioprobe showed the same degree of sensitivity as conventional membrane filtration methods with a maximum detection time of 24 h.

To implement real-time assaying, electrochemical detection of the enzyme breakdown products was investigated and proof of concept was established.

Real time monitoring of faecal pollution proved promising though direct electrochemical detection and development of a sequential flow injection analysis (SFIA) system.

This design constitutes a high priority for future research and is based on the proof of concept that was established during the course of this study. At this point, a provisional patent is being applied for, based on results obtained in this and the follow-on study.

Cost: R 500 000  
Term: 2003 – 2006

***Programme 4:***  
***Water distribution and distribution systems***

*Factors influencing the friction loss in pipelines and the relationship between water quality, operating conditions and the performance of different liner systems and pipe material*  
*Department of Civil Engineering, University of Pretoria*  
**No 1269**

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. The better quantification and identification of these factors required investigation, reviewing the available literature, conducting

experimental investigations, perform field investigations and develop software that will assist designers in evaluating a pipeline system over its full life cycle. This study quantified the contributing factors altering the hydraulic capacity of pipelines and reflects the most appropriate pipe material selection and lining systems for different operating characteristics and water. Findings identified that the two main contributing factors of energy losses are:

- Inherent resistance against flow exerted by the fluid (i.e. viscosity)
- 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.

Findings from experimental work indicated roughness parameters as well as the annual rate of increase in roughness parameter were all significantly higher than that prescribed in theoretical references. Biofilm exists on all piping surfaces in a potable water distribution system and that there is an increase of biofilm with time. Biofilm has an effect on the hydraulic capacity of a pipe system but the quantification thereof is difficult due to the fluctuating growth pattern thereof. The roughness parameters that are normally quoted by manufacturers tend to be too low.

Cost: R746 000  
Term: 2001 – 2004

***Country-wide assessment of non-revenue water throughout South Africa using latest international water association methodology***  
*WRP Consulting*  
**No 1535**

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. The

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## Water Use and Waste Management

project in partnership with DWAF is the first project in which the water balance methodology has been used to estimate the magnitude of wastage from water reticulation systems throughout the whole of South Africa. While many problems have yet to be resolved, the results from the current study provide the first plausible estimate of the municipal water wastage occurring in South Africa using the standardised water balance methodology supported by the International Water Association (IWA). Based on the results obtained from the 62 water reticulation systems, the following conclusions were reached:

- The density of connections for the South African systems ranged from a maximum of approximately 135 connections/km mains to 18 connections/km mains. The expected density of connections for a typical first-world system is in the order of 50 connections per km mains.
- The average operating pressure for the South African systems ranged from a minimum of 24 m to 63m. It should be noted that this represents the weighted average pressure for the whole reticulation system and pockets of very high or very low pressure may still exist in various systems. These pressures are typical of most normal systems in first world conditions.
- The average ILI for the South African water reticulation systems was found to be 7.6 (1.0 being very good and greater than 10 being very poor). Excluding one or two small outlier systems, the ILI ranged from approximately 2 (very good) to more than 20 (very poor). The average ILI value places South Africa in the middle of the world data set and indicates that the real losses in the country are high with significant scope for improvement but lower than most other developing countries.

Unfortunately the information available from the various water reticulation systems in the country is either not available or of dubious quality in many cases with the result that any conclusions made regarding the water leakage for the country as a whole must be considered as preliminary estimates that will be revised in future as more reliable data become available.

The National Water Resources Strategy of DWAF states that South Africa's total urban

and rural water requirement for 2000 is 3 471 million m<sup>3</sup>/annum. If this value is extrapolated using an assumed growth of 3%, it suggests a total municipal water use in 2005 of approximately 4 000 million m<sup>3</sup>/annum. The total bulk system input volume figure obtained for the 62 systems analysed was 2 149 million m<sup>3</sup>/annum which represents approximately 54% of the total urban/rural water requirement of the country. Based on these figures and extrapolations, indications were that:

- The losses (real and apparent) for the 62 systems analysed were estimated to be 623 million m<sup>3</sup>/annum or 29% of the total water supplied
- Based on the above figures, the extrapolated water losses from water reticulation systems for the whole of South Africa are likely to be in the order of 1 150 million m<sup>3</sup>/annum (based on the 54% sample size)
- The potential savings that can be achieved from the 62 water reticulation systems analysed are estimated to be 266 million m<sup>3</sup>/annum based on the methodology discussed in this report which includes a combination of real and apparent losses
- If the above figure is extrapolated to the whole country (based on the 54% sample size), the potential savings are estimated to be almost 500 million m<sup>3</sup>/annum, which represents approximately 12.5% of the system input.

Cost: R650 000  
Term: 2004 - 2006

### Benchmarking of domestic water consumption in selected South African cities

#### Rand Water No 1536

The study aimed to determine water consumption per erf and to relate this to erf size, number of consumers, etc. Included is calculation of return flows. Forty eight municipal treasury databases were collected and extracted for archiving in this study. This includes four metropolitan municipalities (Johannesburg, Tshwane, Ekurhuleni and Cape Town) and 151 cities or towns. The total number of stands in the databases exceeds 2.5 million, of which 1.5 million are non-vacant stands. The number of records (i.e. water meter records) in the databases exceeds 2.7

million. In most cases, the data record includes actual water meter readings, reading dates and estimated monthly consumption figures for more than two years. Data for all types of users with metered consumption are included in the database, including domestic, commercial, industrial and educational users. To ensure the integrity of the data, two data cleaning phases were implemented. The main findings on domestic water demand were that:

- Inland stands use significantly more water than coastal stands
- Water demand is positively correlated with both stand value or income and stand size
- The current design guidelines underestimate the demand for small stands, and overestimate the demand for large stands
- Higher income users have both higher demand and larger variation between summer and winter demand. This is mainly due to garden irrigation.
- Townships and informal settlements have very little variation in their demands
- The average water consumption per suburb was calculated and compared to the current South African design guideline as. It was found that 39 % of the 1 188 suburbs fell below the lower and 8 % above the upper envelope curve of the guideline
- The return flow in the sewer system is only linked to indoor demand and thus does not have much seasonal variation
- The result is that the sewer return flow as a percentage of the water demand shows the reverse behaviour of the water demand pattern. The return percentage is highest for the lowest income groupings and lowest for the highest income groupings. The highest income grouping has the greatest variation in return flow percentage, and this percentage is highest during the winter months and lowest during the summer months. Garden irrigation is the main reason for this behaviour.
- 47 % of the average suburb demands fell inside the design envelope proposed by the South African design guidelines
- Inland water demand is significantly higher than coastal demand
- There is strong evidence that domestic water demand increases with both increasing stand area and stand value (or income).

Cost: R250 000  
Term: 2004 - 2005

**Development of a national water consumption archive**  
Rand Afrikaans University  
No 1605

Domestic water consumption is a function of various factors, including stand size, income, household size, climate, pressure and water price. However, the overriding problem with studying water consumption is that quality data are difficult to get hold of. In recent years, a unique software product called *SWIFT (Sewer and Water Interface from Treasury)* was developed, allowing access to municipal treasury databases to obtain demographic and water consumption information of large numbers of users. This is a very valuable source of information on the topic of water consumption both now and in the future. This project aimed to ensure that this valuable source of information is not lost. A procedure was developed to collect existing and future water demand data from the different municipalities in South Africa and installing the data in an archive that is accessible to researchers and other interested parties in South Africa. Forty eight municipal treasury databases were archived in this study. This includes four metros (Johannesburg, Tshwane, Ekurhuleni and Cape Town) and 151 cities or towns. The total number of stands in the databases exceeds 2.5 million, of which 1.5 million are non-vacant stands. The number of records (water meter records) in the databases exceeds 2.7 million. In most cases, the data for each non-vacant record include actual water meter readings, reading dates and estimated monthly consumption figures for more than two years. Data for all types of users with metered consumption are included in the database, including domestic, commercial, industrial and educational users. A method was developed and documented for the sustained archiving of future Swift databases. Methods for making the data accessible to researchers and other interested parties in South Africa were investigated. Because of the very detailed and sensitive nature of the data in the archive, legal opinion has expressed that used in the wrong way, the developers of the archives can be held responsible. It is therefore recommended that the archive be held by the University of Johannesburg and sent to applicants only on

request and after signing an indemnity form. Information on the archive and this report are available from the website [www.uj.ac.za/wrg/](http://www.uj.ac.za/wrg/).

Cost: R150 000  
Term: 2005 – 2006

**Thrust 3:  
Wastewater and Effluent Treatment and Reuse Technology**

**Programme 1:  
Biological sewage treatment processes  
PETRO™ process to provide for biological nutrient removal  
PGJ Meiring Konsult  
No 971**

The PETRO™ (Pond Enhanced Treatment and Operation) system is a wastewater treatment technology which combines waste stabilisation ponds as a primary stage and a polishing facility as a secondary stage. The upstream stabilization pond(s) treat up to 60 % of incoming organic load which decreases the size of a secondary facility. The standard PETRO process was typically not designed for biological phosphorus removal. This project aimed to establish the technological feasibility of biological phosphorus removal using the PETRO process. If this is feasible, existing municipal wastewater treatment plants which employ 'older' low-cost technologies, such as waste stabilisation ponds and bio-filter plants (incorporating ponds for maturation), could be adapted to remove phosphorus as well as meet the more stringent carbon and nitrogen requirements. Observations made at a number of full-scale plants strongly suggest that the primary pond used in a particular regime of operation is capable of the RBCOD production at the rates required for biological P removal. The recirculation rate appears to be at least one of the key factors in the enhancement of the RBCOD production. The tentative data obtained suggest that the enhancement is effected through inhibition of extremely oxygen-sensitive methanogens. High-rate recirculation appears to provide an opportunity to significantly increase RBCOD production in an open primary pond. Under these conditions a specific organic loading can be safely increased well beyond the value recommended for ponds without recirculation

(0.6 kg COD/m<sup>3</sup>-d). Process engineers, planners and controllers will find the report useful as it contains many practical observations and experimental results related to aspects such as sludge production rates, factors that increased and decreased RBCOD production, appropriate recycle rates, sludge settleability issues and operational parameters.

Cost: R889 000  
Term: 1998 - 2001

**Characterisation of wastewater from low income - high density housing schemes with full water-borne sewerage and off-site disposal into conventional wastewater treatment works  
Ninham Shand  
No 1449**

The characteristics of municipal wastewater originating from catchments with industrial and middle- to high-income residential areas could be different from areas with a high percentage of Low Income High Density (LIHD) developments. This study aimed to provide new knowledge on characteristics of wastewater from South African LIHD housing schemes with full water-borne sewer reticulation and the social aspects that affect the characteristics of these wastewaters. The study focused on two LIHD areas near Cape Town with full water-borne sewer reticulation. The extent of the study was not sufficient to determine any relationship between social circumstances and wastewater characteristics apart from volume estimates. Daily samples were analysed for various parameters and the various COD fractions determined. This short-term study demonstrated that the wastewater compositions and characteristics from LIHD residential areas gave wastewater characteristics that fall within the range (although on the upper end) of typical domestic wastewaters (middle- to high-income areas) in South Africa. The un-biodegradable particulate COD fraction could not be accurately estimated. The research results are not sufficient to serve as a national guideline on the wastewater characteristics in LIHD residential areas, and follow-up research is required especially on flow-compensated composite samples.

Cost: R 500 000  
Term: 2003 – 2005

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## Water Use and Waste Management

### *Evaluation of sewage treatment package plants for rural, peri-urban and community use*

*Umgeni Water*  
**No 1539**

Localised prefabricated small-scale sewage treatment plants, or package plants, are used widely as an alternative to conventional centralized wastewater treatment plants. The study was commissioned to gain an understanding of sewage package plant technologies and to test the performance of the selected technologies under controlled conditions. The study identified two major shortcomings: the inability of plants to nitrify to remove ammonia and disinfect the final effluent. Being a global problem, failure can be attributed to poor design and construction, lack of maintenance and mechanical breakdowns. The project team concluded that addressing the issues of the legislative framework and technology development may assist in managing the problems relating to dispersed sewage treatment in South Africa. The application of such plants is a contentious issue and the WRC added value to the study outcomes by facilitating dialogue among the manufacturers, practitioners and municipalities via a series of workshops and seminars.

Cost: R380 000  
Term: 2004 - 2006

### *Programme 2: Sludge characterisation, treatment, utilisation and disposal*

*Scoping assessment for land disposal of sludges from potable water treatment*  
*University of KwaZulu-Natal/ Pietermaritzburg*  
**No 1601**

It is estimated that over 5 million m<sup>3</sup>/a of wet water treatment sludge (WTS) are produced in South Africa. Traditionally, WTS disposal has been to landfill. An option gaining acceptance internationally is application of WTS directly to land wherein the physical, chemical and biological properties of the soil are used to digest the applied waste without creating negative effects on soil quality, groundwater or plant growth. This study found that although few guidelines on the topic exist internationally, land application is generally viewed in a positive light.

The available South African and international data on the different properties of WTS were sourced to get an indication of the constituents of concern that may be present in WTS. Nine receptors were identified that could be impacted by the application of WTS to land. The nine receptors could be impacted through 36 different pathways ranging from direct impact to there being multiple barriers between the WTS and the end receptor. A risk ranking matrix was developed to systematically evaluate the significance of different aspects and identify matters that will need to be managed through guidelines. This process also highlighted knowledge gaps which would make it difficult to develop appropriate guidelines for land disposal/treatment of WTS at present.

Cost: R250 000  
Term: 2005 - 2006

### *Programme 3: Treatment and recovery of organics from agro-industrial processing* *Co-digestion of high-strength / toxic organic effluents in anaerobic digesters at a wastewater treatment works* *Department of Chemical Engineering, University of KwaZulu-Natal* **No 1074**

A need was identified for a method to assess whether an industrial effluent can be safely treated in an anaerobic digester; or whether it requires mixing with another readily biodegradable effluent in order to be simultaneously digested (co-digestion); or else whether it is not amenable to be anaerobically digested at all. A screening protocol was established investigating two quick simple reliable analytical and technical methods that are relatively inexpensive so that it is affordable to small companies.

The researchers studied the serum bottle method which is based on the determination of the volume of gas produced in a sealed vial, as a measure of the activity of the anaerobic sludge. Two assays, originally developed to separately address the toxicity and the biodegradability have been combined in a single test termed AAT (Anaerobic Activity Test), which enables the simultaneous assessment of the inhibitory effect on the methanogenic biomass and the biodegradability of the test material as well as the ability of

the biomass to adapt to the test material and therefore to overcome the initial inhibition. A second method that was considered is the pH-stat titrimetric method that consists of compensating the change in pH caused by a physico-chemical or biological process within a suspension, by the controlled addition of an appropriate solution which neutralises the excess acidity or alkalinity produced or consumed.

Toxicity and biodegradability tests on the landfill leachates and textile effluents were conducted. The quality of the experimental data was only sufficient to draw qualitative conclusions to develop an improved experimental protocol that was applied in the several tests.

Cost: R1 260 000  
Term: 2000 - 2006

### *Hydrophilisation of hydrophobic ultrafiltration membranes* *Institute for Polymer Science, University of Stellenbosch* **No 1268**

Membranes foul as result of the filtration operation and by nature of the membrane material of construction. The greatest barrier to increased use of membranes is this tendency toward fouling. Polysulphone (PSU) is the material of choice for the manufacture of various types of ultrafiltration (UF) membranes because of its robustness and chemical stability. Unfortunately PSU is a hydrophobic material, which is vulnerable to fouling. In order to capitalize on the usefulness of PSU membranes in filtration operations, chemical modification of this material to make it less hydrophobic and fouling was at the core of this study. The methodology followed was to impart a more permanent hydrophilic, non-fouling character to the membranes by synthesizing a polymeric compound which is compatible with the membrane polymer in solution, but which is not soluble in water.

Synthesis of a suitable material, a copolymer of poly (ethylene oxide) (PEO) and polysulphone (PSU) was accomplished with success. The PEO segments of the polymer are polar and impart hydrophilicity to the membrane. All analytical techniques used to study treated membranes showed greater hydrophilicity compared to control membranes that did

not contain the modifying material. Scale-up of the synthesis reaction was also successful and quantities of up to 5kg were synthesized at a time. In this project, the first concept of a new, high-flux capillary UF membrane was developed. Although further optimization studies are still required, it is clear that the membrane developed will have merit for use in drinking water applications and in protein separation.

Cost: R650 000  
Term: 2001 – 2005

***Dual-stage ceramic membrane bioreactor for the treatment of high-strength industrial wastewaters***  
*School of Environmental Sciences and Development, UP for CHE*  
**No 1371**

The project entailed a new approach to the operation of solid-liquid separation bioreactors for the treatment of effluents containing recalcitrant pollutants. This involved the use of a dual-stage membrane bioreactor, which uses ceramic membranes for cell recycle. It was found that the dual-stage hybrid membrane bioreactor enabled the intermittent transfer of acclimated retained biofilm developed in a seeding reactor to a hydrolysis reactor. This facilitated significant improvements in the enhancement of microbial population adaptability and performance efficiency as well as drastically decreasing the usual acclimation time necessary by 75% when compared with activated sludge wastewater treatment processes. The system of solid-liquid retention membrane bioreactors was shown to be a highly efficient application for the treatment of high-strength industrial effluents containing recalcitrant pollutants. In comparison to activated sludge systems, the long-term operation of this membrane bioreactor process treating high-strength effluents was characterised by more stable microbial populations, significantly less susceptible to deleterious shifts in the community dynamics, resulting in enhanced process efficiency due to less process variability. This, membrane-based system could therefore present a viable alternative to an activated sludge process in the treatment of 'difficult' industrial effluents.

Cost: R885 000  
Term: 2002 - 2005

***Development of a combined activated carbon / microfiltration (ACMF) process for the treatment of industrial effluents***  
*Department of Chemical Engineering, Durban Institute of Technology*  
**No 1374**

This project concerned the development of a novel combined activated carbon/microfiltration (ACMF) process that can remove all suspended and colloidal solids as well as significantly reduce the organic content of an effluent in a single step. The ACMF process is a very promising one-step process for organics reduction and the removal of suspended solids. The performance is superior to a micro-filter without a pre-coat or a micro-filter with an 'inactive' pre-coat, both from the point of view of rejection and permeate fluxes. The removal of organics is seemingly superior to conventional PAC processes, due to the formation of a secondary dynamic separation layer. As such, the process holds great potential in the treatment/pretreatment of 'difficult' industrial effluents. This project developed the ACMF process further, evaluated it on selected industrial effluents, and determined the overall economics of the process.

Cost: R397 000  
Term: 2002 – 2005

***Programme 4: Treatment and recovery of inorganics (including sulphate and metals) in industrial and mining effluents***  
*Development and piloting of the integrated bio-desalination process for sulphate and heavy metal removal from mine drainage water incorporating co-disposal of industrial and domestic effluents*  
*Department of Biochemistry & Microbiology, Rhodes University*  
**No 1078**

The development of suitable biological treatment processes for acid mine drainage (AMD) has to date been constrained by reactor design appropriate to the large volume flows and the availability of cost-effective carbon sources. The Rhodes BioSURE® process uses sewage solids as the carbon source for sulphate reduction and algal activity for precipitating heavy metals and neutralising acidic drainage streams. A pilot plant was constructed and commissioned at Grootvlei

Mine in a collaborative research venture involving the WRC (**Project No. 869**), ERWAT and Grootvlei Mine, with detailed study of the basic process mechanisms being undertaken in WRC **Project No.972**.

In **Project No. 1078** the outstanding components of the pilot plant were constructed to enable evaluation of the complete integrated process over an appropriate time period. Specific aims were to complete pilot-scale evaluation of sewage as an example of a complex carbon source used as an electron donor in the integrated biodesalination process; to complete construction, operational development and optimisation of the integrated BioSURE® pilot plant at Grootvlei Mine; and to operate the final configuration as a demonstration plant for an appropriate period for technology transfer, for process decision-making relating to the full-scale engineering of the process and to provide specialist support to WRC research partners in their implementation of process scale-up. The final report on this **Project No. 1078**, along with the final report on **Project No. 1336** (not yet finalised), is to be published as **Report 11** in the series *Salinity, Sanitation and Sustainability* (ISBN series 1-86845-853-9, **Volume 4**, Part 3 *Sulphur Production and Metal Removal Unit Operations*). The report will include early results from the full-scale plant currently being built and commissioned at Ancor Sewage Works.

Cost: R1 700 000  
Term: 999 – 2002

***Heavy metal removal from water with electrosorption using zeolite adsorbents made from co-disposal residues***  
*University of the Western Cape*  
**No 1546**

This project aimed to develop adsorbents for toxic element removal, develop a method to synthesise zeolites from the solid waste residues that is produced during the neutralization of acid mine drainage with fly ash and to demonstrate the feasibility of using this synthesised material with or without electrosorption for removal of toxic elements from contaminated water. The results demonstrated the opportunity to use zeolites prepared at both high and low temperatures from solid waste residues to treat and remove toxic elements from neutral mine waters or brines

# 3 KSA 3 (continued)

## Water Use and Waste Management

containing high levels of mono and divalent cations. Zeolites prepared at low temperature was somewhat less effective at toxic element removal than those synthesized at high temperatures, but generally performed equivalent to commercial faujasite (zeolite mineral of the sodalite group). Overall, better removal was achieved using the synthesized zeolites than standard commercial resins for most contaminants. A partial benefit was observed in the application of adsorbents in an electrosorption system under an applied electric field. Removal of toxic elements was enhanced slightly in the case of a few specific elements. However, the additional partial benefit of an electrosorption system was outweighed by its energy costs and by the observed leaching that may derive from components of the electrosorption system during the application of an electrical field.

Cost: R300 000  
Term: 2004 - 2006

### Thrust 4: Industrial and Mine-water Management

**Programme 2:**  
*Regulatory mechanisms to improve industrial and mine-water management*  
*Development of guidelines and recommendation towards the classification, rating and disposal of common industrial hazardous waste streams for the purpose of general authorisation for waste disposal*  
*Environmental Business Strategies*  
**No 1548**

It is estimated that approximately 90% of hazardous waste streams (by number) are common to most industries. Instead of every waste generator performing a separate waste classification for these common waste streams, this project aimed to develop a generic classification for them. Having obtained more detailed information on the common waste streams, the generator would be able to concentrate resources on their specific waste streams, which typically constitute more than 80% of the total waste (by mass) produced by the generator. The study developed a user-friendly guidance document and recommendations for the classification and disposal of 20 common industrial hazardous wastes. In addition to the guidance documents of each waste stream, further

information is provided on the legal requirements, waste management principles and best practices in South Africa for the handling, storage, transportation and disposal of wastes. The guidance document contains information on the following topics:

- Waste generation processes / industrial application
- Background information
- Classification and rating
- Environmental and health concerns
- Unacceptable disposal options
- Acceptable disposal options
- Industry trends and other information
- Illustrative pictures.

Cost: R325 000  
Term: 2004 - 2006

**Programme 3:**  
*Minimising the impact of waste on the water environment*  
*Improving the performance of covers for the rehabilitation of coal-mine residues*  
*Golder Associates Africa (Pty) Ltd*  
**No 1350**

A previous joint WRC-Coaltech project utilising an experimental set-up built by DWAF in KwaZulu-Natal, proved that soil cover design, and specifically cover thickness, had a major effect on limiting the flow of water through the cover (thereby reducing the volume of potential acid mine drainage – AMD). Soil cover also had a major effect on the ingress of air, thereby limiting one of the essential elements for the formation of AMD. Most of the rehabilitated coal discard dumps in Mpumalanga that were assessed during the current study were found to exhibit erosion, indicating that the covers are becoming progressively thinner with time. Future covers will thus need to be designed to prevent erosion by means other than vegetation. The current study also illustrated the importance of selecting soils with the appropriate characteristics in terms of moisture retention and volumetric stability. Lightly compacted soil was found to provide better storage capacity and less through-flow than better compacted soil of the same type. The simulation of a range of cover configurations based on laboratory-derived parameters showed that a cover thickness of between 0.5m and 1.0m will be optimum for the Mpumalanga coal-fields region. Laboratory tests also indicated that cracking of soil increases the amount of water that infiltrates into the soil cover. The research

supports the proposition that soils available in Mpumalanga may be used for store-and-re-lease covers and that the results of the experimental work conducted in KwaZulu-Natal can be used to calibrate designs conducted for other soil types and climatic regions.

Cost: R667 100  
Term: 2002 - 2005

**Stability and neutralisation capacity of potential mine backfill material formed by co-disposal of fly ash and acid mine drainage**  
*Coaltech 2020*  
**No 1458**

WRC **Project No. 1242** demonstrated the feasibility of using fly-ash (FA) to neutralise acid mine drainage (AMD) and to produce zeolites. This follow-on project evaluated the feasibility of the process on a bigger scale and for a larger range of FA-AMD combinations, and also investigated other applications for FA and the residual solids that remain after the FA-AMD reaction. Much attention was devoted to develop a better understanding of the chemistry involved in the neutralisation of AMD with FA. The feasibility of using FA as mine backfill was evaluated in simulated passive and active treatment systems. AMD water quality significantly improved during permeation through FA, and changed the FA mineralogy. Experiments were conducted to determine how the different backfill materials would behave when pumped and placed in simulated mine environments. Tests aimed to determine mixtures with appropriate slurry densities, strength development, slurry flow and density parameters. Solid residues performed similarly to residual solid/fly ash combinations and considerably better than the Portland cement amended blend. However, none of the materials were able to neutralise AMD over the long term. This study further demonstrated the potential to use FA in ash walling and to neutralise AMD and the use of the residual residue (or FA itself) to prepare highly adsorbent zeolites, or as backfill in underground mines. The feasibility of these applications needs to be further investigated at pilot scale, as part of an integrated waste management approach.

Cost: R 420 000  
Term: 2003 - 2005

***Impact of microbiology on fly ash/acid mine drainage (AMD) co-disposal and remediation systems***

*University of the Western Cape  
No 1549*

The use of FA as a more economic alternative for the neutralization of AMD is under active consideration, both within SA and internationally. Studies conducted at the UWC were sufficiently positive that a pilot-scale neutralization system is under consideration. The main aim with this project was to investigate the possibility of microbial community development in solids derived from the admixture of AMD and FA. As expected, they found fresh FA to be sterile and fresh AMD to contain a substantial and diverse population of acidophilic micro-organisms. During the process of mixing, microbial viability is lost within a matter of minutes, almost certainly due to the rapid rise in pH of the system. While the development of microbial communities in mixtures of the FA-AMD solid phase and soil was slow, no microbial activity was observed in the uncontaminated incubated solid phase during the 6-month period of the experiment. In the context of ash-walling or back-filling processes (where neutralization solids may be used undiluted), it is thus expected that the development of microbial communities would be limited. Although the short-term toxicity of neutralisation solids was found to be low, the possible long-term toxicity of such solids suggests that caution must be exercised in use of this material for the amendment of agricultural soils.

Cost: R559 000  
Term: 2004 - 2006

***Programme 4:  
Minimising waste production***  
*Environmental life-cycle impact assessment of water use in selected industrial areas of South Africa*  
*University of Pretoria*  
*No 1552*

This life cycle assessment (LCA) study was undertaken to identify key environmental aspects that should be considered where water is used in the South African manufacturing sector, and to identify possible shortcomings in the LCA tool. The study has compiled a comprehensive life cycle inventory of water supply to the Rosslyn industrial area, north of Pretoria in the Tswane metropolitan

area. The life cycle impact assessment (LCIA) framework for South Africa has been used to determine the extent of different environmental impacts. It was concluded that the extraction of the required water from nature to supply potable water is the most important consideration, while water losses in the supply system must receive attention, especially in the municipal-controlled part. Water quality impacts and electricity generation are also important. The boosting requirements (pumping) contribute most to the electricity dependency of the life cycle system. A number of data gaps were identified and recommendations were made to improve such future studies in South Africa. This study thus identified key environmental aspects that should be considered where water is used in the manufacturing sector, and identified specific shortcomings in the present LCIA methodology that needs further development for the specific conditions encountered in South Africa. These are often different to the conditions in Northern Hemisphere countries where the LCIA methodology was developed

Cost: R160 000  
Term: 2004 – 2005

***Thrust 5:  
Sanitation and Hygiene Education***

***Programme 1: Rural sanitation and hygiene education***  
*Increasing the pace of sanitation delivery by methodologically integrating health, sanitation and income generation*  
*Mvula Trust*  
*No 1380*

The study explored the hypothesis that a methodical approach to health and hygiene implementation on rural sanitation projects can potentially address current gaps in methods of health and hygiene delivery by sanitation service providers. It also began a preliminary exploration of the hypothesis that a livelihoods approach to water and sanitation delivery can potentially enhance the direct and indirect impact of water and sanitation on livelihoods and the recipient communities' ability to pay, thus ultimately increasing the pace of services delivery. The study developed a Community Based Health and Hygiene Model (CBHMM) with an attendant implementation kit and evaluated methods

used by service providers on rural sanitation projects in the Eastern Cape and Limpopo Provinces in relation to the developed model. An integrated livelihood and Knowledge Attitude and Practices (KAP) assessment was also carried out in Lushinton, a rural community in the Eastern Cape Province of South Africa and a report produced.

The study findings indicate that there are significant impacts reducing gaps at all stages of the health and hygiene programmes as currently carried out by the 12 service providers. The study results indicate that health and hygiene budgets are only 2% of sanitation project budgets (the house-to-house method of health and hygiene promotion is used in only 33.9% of cases) and community-based workers (CBWs) are paid R80 per toilet whilst project agents and consultants earn R273 and R172/hour respectively.

Relatively fewer consultants measured the impact of health and hygiene programmes when compared to those that carried out pre intervention surveys (8 or 66.7% ; 11 or 91.7% respectively), and less money was spent on post intervention surveys in comparison with pre-intervention surveys R34, 231.65 and R101, 347.02 respectively.

Recommendations are made to policy makers for the use of livelihood approaches in community water and sanitation delivery to ensure that projects are better able to identify, target and impact maximally on the livelihoods of the poor and vulnerable, thus ultimately increasing their ability to pay for services and enhancing the sustainability of such projects. There is a critical need to institutionalize and promote the CBHMM. Pertinent stakeholders should fund projects which make use of the CBHMM on sanitation projects in a bid to demonstrate the strengths of the model.

Cost: R204 694  
Term: 2002 – 2003

***Development of a child-centred course for teachers to promote basic health and hygiene awareness in rural communities***  
*Lenehan Engineering and Environmental Consulting*  
*No 1400C*

# 3 KSA 3 (continued)

## Water Use and Waste Management

Children have the capacity to actively promote health and hygiene campaigns within their communities. With this in view, it would seem that any programmes which target children as change agents in rural communities must involve schools and the community at large.

This research project aimed to facilitate the development and implementation of health and hygiene programmes on a local level in rural communities and included the development of child centred course materials that can be re-used by educators and adapted for other rural schools. The creation of these resources is necessary as they are often scarce in rural areas and they may also lack local context.

The Health and Hygiene Awareness Programme developed in this research project is based on the lesson plan format and is ready for use for by rural school educators. It consists of 10 lesson plans and is designed for learners aged from 6-8 years. The aims of these lesson plans are to provide an appropriate format for successful health and hygiene programme for lower primary school learners.

The chosen resources to support the lessons are typically available in rural schools or relatively easy to substitute, acquire or replicate (e.g. paper, pencils, crayons, plastic bottles). The resource sheet *Germ*s was designed to be easily photocopied and intentionally included images acquired in the internet public domain to avoid copyright infringement.

Cost: R 167 000  
Term: 2003-2004

*An identification and review of the factors in rural water services that facilitate and impact on local economic development in the Eastern Cape Rural Support Services*  
No 1437

There has been ongoing debate in the water and sanitation sector regarding the importance of viewing water services projects as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. One of the main issues related to this is the importance of, and ongoing need for local economic development in rural areas. This is an aspect

which should be addressed in both the planning and implementation stages of any project with the full participation of community members. However, the current framework for delivery does not allow for the facilitation and promotion of economic development. This is particularly problematic given the current context of unemployment and poverty in rural areas. This study endeavoured to identify the factors that both facilitate and impact on local economic development (LED) both during and after the implementation of water services projects, in an attempt to address poverty and underdevelopment in rural areas.

The term 'local economic development' generally refers to a process of creating wealth through the mobilisation of human, financial, social, physical and natural resources or capitals. The core issue in LED is about the creation of wealth and jobs. The aim of local economic development ultimately is to produce higher standards of living, improve the quality of life, alleviate poverty, create more and better jobs, advance skills and build capacity for sustained development in the future.

An analysis of both the desk research and the field research has revealed a number of factors that both facilitate and impact on LED in water services. The facilitating factors identified relate primarily to an understanding of the concept of LED, supportive and accountable local government and access to sufficient water, land and credit. The main factors that impact on LED are the lack of understanding of the concept of LED, and the fact that there are no linkages between water related institutions and LED institutions both within and outside the community. Clearly, the lack of access to land, water and credit are also factors that impact on LED in water services.

The findings from this research project reinforce a number of the key issues raised in the literature and provide further information in support of the positive impacts that can be expected if water services projects were viewed as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. Improved water supplies can lead to both direct and indirect opportunities for improved productivity. More water, of better quality and provided more reliably, can provide the water needed for productive activities such

as irrigation of a backyard or community vegetable garden or for micro-enterprises such as hair salons or brick manufacture. Indirect gains may sometimes be even more important than direct benefits in that they can apply to both water-based and non-water-based activities where saved time and money can be invested in activities that bring positive returns to capital or labour. It is clear that without specific training being provided to rural communities on LED there is unlikely to be a significant shift in the understanding of LED and the improvement of rural economies. It is recommended that community members are exposed to awareness raising and training on the importance and meaning of LED. In addition, community members should be capacitated to understand the IDP process and their roles and responsibilities in relation to the development of the IDP.

Cost: R 300 000  
Term: 2003 – 2005

*Involving traditional healers and myths and stories in hand-washing/hygiene education / sanitation promotion initiatives*  
Sigodi Marah Martin  
No 1521

In South Africa nearly 80% of the population rely on the services of Traditional Health Practitioners (THPs) in matters of health and well-being, often prior to engaging the formal health service sector, making them potentially a key partner and stakeholder in community health education. Despite this being the case there seemed little evidence of the potential role that THPs could play in sanitation, health and hygiene being explored or promoted.

The specific objectives of this project were:

- To investigate if there are myths or traditional practices that can assist with encouraging positive hand-washing behaviour and how can these be practically incorporated into hand-washing promotion, hygiene and sanitation education and sanitation promotion initiatives
- What is the potential for engaging traditional healers in South Africa to assist with carrying messages related to this?
- Could a similar model be used as was utilised for involving them in initiatives to combat HIV/AIDS?

The results showed that there is definitely potential for THPs to be involved in HH&S promotion due to their definitive influence on the daily life of communities in South Africa. In order to maximise this potential role there are a number of challenges that need to be addressed. These include, but are not limited to, the paradigmatic differences between the biomedical and traditional health disciplines as well as the historical relationship of THPs to the legislative context and formal health care infrastructure.

In terms of specific recommendations the research findings point out that there should be active encouragement of the participation of THPs in any HH&S initiative. A participatory approach will be most effective when engaging THPs and the development of specific materials about engaging THPs in HH&S issues should build on those utilised in this research project and others in the water services sector. Deliberate strategies are also required to create processes that allow for new paradigmatic health services to emerge which will integrate the strengths of the disciplines of biomedical and traditional health. From the literature review, it also became clear that taking into account traditional values and integrating them in efforts geared towards HH&S promotion initiatives is imperative in a cultural context. It is therefore important to explore how this integration of traditional and cultural ways of thinking and living can happen at a level which practically impacts the way that communities live.

Cost: R326 000  
Term: 2004 - 2006

***Molecular relatedness of enteric pathogens isolated from water sources and HIV/AIDS patients with diarrhoea in rural communities in the Limpopo and Eastern Cape Provinces***

*Univen*  
**No 1633**

Water services are limited in communities with high prevalence of HIV/AIDS. Immune systems of HIV positive individuals are prone to a wider range of common illnesses and diseases than individuals whose immune systems are not compromised by HIV/AIDS. HIV infected individuals therefore have greater requirements for potable water than un-infected individuals.

The aims of the project were to isolate and identify bacterial enteropathogens from stool samples of HIV positive individuals with and without diarrhoea and controls and to establish any epidemiologic linkage between bacterial enteropathogens from HIV/AIDS patients with diarrhoea and their household drinking water and to determine the antimicrobial susceptibility profiles of enteric isolates from water in comparison with diarrhoeagenic pathogens

The findings of the team were the following:

- The high rate of isolation of various enteric pathogens from HIV positive individuals with diarrhoea strongly incriminated them in the aetiology of diarrhoeal diseases in HIV/AIDS patients. Age and sex distributions of HIV seropositive individuals accentuate the feminization of the epidemic. The presence of enteric bacterial pathogens and the high rates of multiple antibiotic resistances of isolates from stool and water samples could be potential public health threats.
- The study also revealed the usefulness of some antibiotics such as meropenem, imipenem, gentamicin, ciprofloxacin, piperacillin-tazobactam, amikacin and nalidixic acid in the empiric management of diarrhoeal cases. The demonstrated correlation of enteric bacterial pathogens from HIV-positive individuals and their household drinking water by polymerase chain reaction unravelled the impact of water quality on HIV/AIDS and warrant some risk assessment studies. The most prevalent enteropathogens were *Salmonella*, *Campylobacter*, *E. coli* and *Aeromonas* species.

The team recommended that intervention studies should be undertaken including strategies to ensure the sustainability of water quality in child headed households, institutionalised orphanages and home based care settings.

Cost: R300 000  
Term: 2005-2007

***Programme 2:  
Peri-urban sanitation research  
Strategy for the furtherance of knowledge and good practice of ecological sanitation (Ecosan) technology in South Africa***  
*Boutek, CSIR*  
**No 1439**

VIP toilets, correctly engineered and implemented, are a good means of providing a dry sanitation service, but these systems are not without their problems. 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 ecological sanitation (Ecosan) systems address the above problems. They 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. Not enough is currently understood about the processes taking place inside the faeces vault, and there is still disagreement on safe retention periods and stability of the final product. The roles of dryness, pH, temperature and time in pathogen destruction need to be further clarified. Furthermore, institutional aspects associated with widespread implementation and management of Ecosan are largely un-researched in South Africa, and this will be a handicap to large-scale implementation unless efforts are made to address the matter.

A need was identified to create further competence in this area of sanitation in South Africa, and to increase knowledge concerning the technology. Ecosan technology is still at a conceptual and development stage, yet all indications are that it has the potential to provide benefits in the provision of sanitation. 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 which provide fundamental answers in the sustainable management of this technology.

Cost: R 820 000  
Term: 2003 - 2006

# 3 KSA 3 (continued)

## Water Use and Waste Management

### *Understanding the disposal and use of grey-water in the non-sewered areas in South Africa*

University of Cape Town  
No 1524

There is a strong drive from the South African government to attain basic water and sanitation coverage. The level of service to meet this requirement being applied by the majority of authorities in urban and rural areas relate in most cases to on-site dry latrines (VIPs or equivalent) and 25 ℓ/cap-d of drinking water. As water and sanitation services are attained and improved, the potential for problems related to the disposal and management of grey-water will emerge. Solutions are required to circumvent or minimise these problems. The study aims to undertake a complete scoping exercise to identify current and historic grey-water management initiatives in urban and rural areas, and to identify problem areas / challenges. Determine and assess existing management and disposal practices within South Africa.

There is currently a strong drive from the South African government to attain adequate water and sanitation coverage throughout the country and the basic level of service to meet this requirement being applied to the majority of authorities in urban and rural areas relates in most cases to on-site dry latrines (VIPs or similar) and 25 litres of potable water per capita per day (ℓ/cap-d) within 200m cartage distance. The connection of low-income settlements to municipal water sources has subsequently occurred on a massive scale, **frequently without giving adequate attention to greywater management** in those areas that are non-sewered. In the absence of suitable conveyance systems, greywater is generally disposed of onto the ground outside the dwellings and the resulting total pollution load, particularly from densely populated settlements, has the potential to create a host of environmental and health impacts. It is likely that the problems related to the disposal and management of greywater will increase as basic water and sanitation services are attained and improved, and solutions are therefore required to manage these impacts.

This study found that the total volume of greywater currently being generated in the non-sewered areas of South Africa has been estimated ranging between 65% and 85%, to

the amount of water consumed per household. The total volume of greywater that is generated on a daily basis in the non-sewered areas of SA (based on an average 75% return factor) can therefore be estimated at just over 500 000m<sup>3</sup>/d. This amounts to approximately 185 million m<sup>3</sup>/year – equivalent in volume to a medium-sized dam such as Voëlvlei near Cape Town, or approximately 50% of the current water demand of that city. These figures highlight the fact that grey-water disposal in dense non-sewered areas is likely to result in significant health and environmental impacts, particularly in dense urban environments where large volumes of greywater are generated.

This study has provided a general overview of the large variety of conditions that occur in the non-sewered settlements in SA, and has highlighted the implications of certain settlement characteristics (specifically settlement density) on greywater management in these areas. In addressing the original objectives of this research the following conclusions have been made:

- There is a noticeable gap between Government policy on water provision and the long-term sustainable water management challenges for the country – whilst the water supply interventions are aimed at improving the health of individuals, no attention has been given to the resultant longer-term impacts on environmental health in non-sewered areas. At a local government level there is still debate as to whether greywater is a stormwater (drainage) or a sanitation issue. Further National policies and programmes do very little to promote greywater management in water and sanitation improvements.
- Social dynamics and behavioural patterns have a significant impact on the way that communities deal with water supply and wastewater management issues, particularly with respect to greywater disposal. These behavioural patterns (and the drivers associated with them) must be taken into account when assessing specific greywater management options for individual settlements. This is particularly relevant when considering greywater use options in certain areas where potable water resources are limited.
- The quality of greywater in non-sewered areas differs significantly to the

greywater that is generated in higher-income seweried areas in that there is a greater variation in the concentration of the various pollutants and at its most concentrated it should be considered hazardous. There is therefore significant risk involved with the on-site disposal of greywater in non-sewered areas.

Cost: R800 000  
Term: 2004 - 2006

### Current

#### *Thrust 1: Water Services – Institutional and Management Issues*

*Programme 1: Cost-recovery in water services*  
*The development of models to facilitate financial sustainability of water services provision by Water Services Authorities in rural areas, based on an investigation of full costs and income*  
Mvula Trust  
No 1614

This project aims to establish the real costs and income for providing water services in rural areas, using learning and applied research methodology of engaging and mentoring five WSAs. The identification of the costs and the model will further assist with good budgeting from all tiers in government and will contribute to some standardization.

Estimated cost: R370 000  
Expected term: 2005 – 2007

*Programme 2: Institutional and management issues – Water services*  
*Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas*  
Umgeni Water  
No 1610

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and

proven, which would then allow piloting and implementation much more attractive. The concepts will contribute to wider participation of small scale entrepreneurs in the management of water services

Estimated cost: R600 000  
Expected term: 2005 – 2007

### ***Interactive mechanisms for WRC research to support municipal water services knowledge management***

*Sigodi Marah Martin*  
**No 1611**

The project aims to assess the extent to which WSAs access, integrate and apply knowledge to determine the current capacity of WSAs to access, integrate and apply information. The aim is to establish a roadmap for customer driven dimension to knowledge transfer and management at WSA level. This project is fresh and innovative, and tackles the subject of what is the uptake and level of transfer of knowledge at LG level.

Estimated cost: R622 000  
Expected term: 2005 – 2007

### ***Programme 3: Innovative management arrangements - Rural water supply***

*Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector*  
*Council for Geoscience*  
**No 1612**

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made. This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralization of services. Are these new arrangements supporting gender mainstreaming? This is what the study will be highlighting.

Estimated cost: R600 000  
Expected term: 2005 – 2007

### ***The state of community consultation in the provision of water services***

*Sigodi Marah Martin*  
**No 1616**

It is imperative that in a changing institutional environment the concepts of community involvement are not lost. As water services authorities take the helm of service delivery, it needs to be ensured that the community aspects are not lost. This study will look at the level and status of community consultation on a range of water services issues. It will aim to identify typical problems areas and successes and come up with recommendation for improving community participation in the sector. This will be of importance to the sustainability of projects, but also to the regulation of water services. This study will undertake a qualitative and quantitative survey to determine the level or status of community consultation.

Estimated cost: R700 000  
Expected term: 2005 – 2007

## ***Thrust 2: Water Supply and Treatment Technology***

***Programme 1:  
Drinking water treatment technology  
Evaluating the potential for upgrading existing SA filtration plants to high-rate filters***  
*Umgeni Water*  
**No 1395**

International experience indicates that gravity sand filters can be operated at filtration rates of up to 30 m/h. Standard practice in South Africa has been to design and operate filters at filtration rates of between 7 and 10 m/h. These are conservative filtration rates and are based on historical English and French design criteria.

The maximum filtration rate achievable in a filter is determined by its hydraulic design. However, the maximum rate which can be achieved before deterioration of filtrate quality or unacceptably short run times occur depends on the floc strength and filter media design (size and depth). High-rate filtration typically requires deeper beds and coarser media sizes than conventional rapid filtration and filter aid is often required to meet filtrate

turbidity standards. However, in some cases it is found that existing filters operating at conventional rates can tolerate higher rates without any upgrades or changes in chemical pretreatment.

Sand filters contribute a substantial part of the total capital costs of water treatment plants. Upgrading existing filters to high-rate filtration as opposed to building new filters could potentially minimise or totally eliminate the need for capital expenditure on upgrading existing plant capacity. This in turn would have a direct impact on the water tariff being paid by the consumer. Once the maximum feasible filtration rate for various filters designs is determined, the potential for and costs of upgrading existing conventional filters to high-rate filters can be assessed.

Estimated cost: R208 000  
Expected term: 2002 - 2004

***An investigation into alternative methods to clean filter media in rapid gravity sand filters to ensure optimal performance and quality of the filtrate***  
*Umgeni Water*  
**No 1525**

The project will establish a reliable procedure and protocol to measure cleanliness of the filter media, the behaviour of filter media, changes in head-loss, air and water scour rates and filtrate quality. The nature of deposits on the media will be determined in order to identify the mechanisms that cause media deterioration and extra-cellular microbial compounds present in the deposit on the filter media rendering the media sticky and difficult to clean will be determined. During the project, a representative survey of the SA water treatment plants will be conducted to benchmark the efficiency of backwash procedures and media cleanliness, to determine the leading causes of media deterioration. It will also be attempted to quantify the potential savings that could be made by implementing the multi-cycle sequential and chemical filter cleaning procedures.

Estimated cost: R413 000  
Expected term: 2004 - 2005

***Biological filtration of iron and manganese from groundwater***  
*Umgeni Water*  
**No 1526**

# KSA 3 (continued)

## Water Use and Waste Management

It is aimed to develop criteria for the design of biological filtration systems that will remove iron and manganese from ground-water 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 - 2007

### *Development of enhanced floating media separation for drinking water production and pretreatment 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 - 2007

### *Polyelectrolyte determination in drinking water*

*Umgeni Water*  
**No 1528**

The project aims to develop a new analytical technique, or improve on the existing technique, for the determination of residual polyelectrolyte levels remaining in drinking water after treatment of the water.

Estimated cost: R300 000  
Expected term: 2004 - 2006

### *The defouling of membranes by moving magnetic dipole polymer beads, containing nano magnetic particles, in a scouring motion across the membrane using external magnetic fields*

*University of Stellenbosch*  
**No 1592**

Fouling of membranes remains the main problem preventing the large-scale and economic use of membranes in more applications internationally. Various chemical, hydraulic and ultrasonic membrane-defouling methods have been investigated, with varying success. This project aims to investigate nano-technology for the *in situ* defouling of membranes. Nano-magnets will be incorporated into small polymer beads and the magnetic fields in all of the nano-magnets inside the beads will be aligned. Movement of the polymer beads on the surface of the membrane will then be induced in order to scour the surface, which will hopefully clean and prevent fouling on the membrane surface. The resulting system will be evaluated on a typical coloured surface water purification application.

Estimated cost: R794 000  
Expected term: 2005 - 2008

### *Development of improved local anti-fouling spiral wrap membranes*

*University of Stellenbosch*  
**No 1593**

This work will build onto the ongoing research in innovative defouling methods investigated at the Institute for Polymer Research at the University of Stellenbosch. These local innovations, as well as appropriate international developments, will be incorporated into a locally manufactured spiral wrap membrane. A number of trial membranes will be produced and bench-marked against existing membranes. Guidelines for the manufacture of these improved spiral membranes will be provided to the South African membrane industry.

Estimated cost: R720 000  
Expected term: 2005 - 2008

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

*RG Batson*  
**No 1594**

The project entails the further development and assessment of an improved limestone reactor for the treatment and stabilisation of coloured surface water. A fluidised bed reactor is required when using limestone, since colour and metals in surface water tend to coat the surface of limestone particles, rendering the reactor inefficient after a relatively short operating time. This patented system aims to overcome the disadvantage of fluidised bed reactors in terms of unacceptably high energy consumption, while still ensuring the required scouring action of the limestone particles in order to keep them from becoming coated. The technology will be evaluated and demonstrated on a typical soft, corrosive, Cape Province coloured water.

Estimated cost: R390 000  
Expected term: 2005 - 2007

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

*Umgeni Water*  
**No 1596**

The aim of this project is to study the factors that affect ozone demand with a view to optimise ozone dose and determine the impact of ozone on downstream processes and downstream water quality. Suitable determinants will be used to optimise ozone dose on three chosen full-scale plants currently using ozone treatment. An analytical test kit for optimizing ozone dose will then be tested in each of the three plants with a view of adapting the procedure for each of the three situations. Control strategies for ozone dose optimization for changing raw water qualities including flows and other operational issues will be developed so that it can be integrated into the general waterworks control system.

Estimated cost: R651 500  
Expected term: 2005 - 2007

**Programme 2:**  
**Water treatment for rural communities**  
*Technical and social acceptance evaluation of a novel microfiltration and ultrafiltration membrane system for potable water supply to rural and remote communities*  
*Chris Swartz Water Utilization Engineers*  
**No 1227**

The project entails the evaluation of locally developed membrane systems for the production of potable water for small communities from a variety of surface water qualities found in South Africa. The evaluation will be performed using both ultrafiltration and microfiltration mobile treatment systems. Guidelines for the application of these membrane systems to specific surface water qualities will be drafted. The project scope includes operational guidelines for potential users as well as the establishment of social acceptance factors of the technology with rural communities.

Estimated cost: R556 000  
Expected term: 2001 - 2004

**Development of appropriate brine electrolyzers for disinfection of rural water supplies**  
*Dept of Chemistry, University of the Western Cape*  
**No 1442**

Chlorine disinfection is required for rural water treatment since it has residual disinfecting powers after water has been carried into the homes. This project will further develop a novel system for the generation of chlorine from common table salt. The unit to be developed will not produce toxic chlorates as side-products – as can easily happen when employing currently available salt chlorinators. The unit will further allow pH control of the dosed chlorine liquid, allowing much more efficient disinfection and is a main advantage over the current systems.

Estimated cost: R 480 000  
Expected term: 2003 - 2005

**The evaluation and selection of small water treatment systems for potable water supply**  
*Chris Swartz Water Utilisation Engineers*  
**No 1443**

A large number of small water treatment systems supply water to small and rural communities from surface- and groundwater sources. The decision maker selecting a small water treatment plant has a large number of local and international designs and systems to choose from. The project aims are to identify new and suitable small water treatment systems being marketed for application to small communities and to provide technical and socio-economic guidelines to assist with the selection of such small systems. Promising new systems which have not been used locally yet will be evaluated on pilot scale if required. The guidelines document will incorporate a database on technical and economic information on these small systems, as well as an operation manual for each system.

Estimated cost: R 1 200 000  
Expected term: 2003 – 2006

**The testing of a membrane technology unit for the removal of nitrate, chloride, phosphate and sulphate pollutants from groundwater (NS)**  
*University of the North West*  
**No 1529**

The project aims to evaluate a number of different membranes for the removal of salts and specific pollutants from groundwater sources in the Northwest Province. The project also aims to assist in the training of local people (technicians) to operate and maintain the water processing installation and monitor impurities on-site with field testing equipment. The consumers' understanding of the implementation of a water purification system through examining the following:

- The knowledge of consumers regarding purified water and the purification system
- Their attitudes towards purified water and a purification system will further be determined.

Such membrane systems established in the rural areas will contribute to a healthier life, especially for people living in high nitrate groundwater areas.

Estimated cost: R499 600  
Expected term: 2004 - 2006

**Enabling water fluoridation in small drinking water treatment plants**  
*Umgeni Water*  
**No 1530**

The project aims to investigate and suggest ways to ensure that the implementation and operation of fluoridation in small and rural plants may be done in a safe and sustainable fashion. Available equipment and instrumentation will be evaluated and guidelines provided for the choice and operation of suitable equipment. Suggestions will be made on the optimal ways to install and operate such equipment and instrumentation. Innovative ways will further be suggested in which to implement and operate such equipment and instrumentation in order to ensure safe and sustainable fluoridation on small and rural water treatment plants.

Estimated cost: R1 200 000  
Expected term: 2004 - 2007

**Improving the efficiency of disinfection in small drinking water treatment plants**  
*University of Fort Hare*  
**No 1531**

Inefficient disinfection was shown to be a major weak point in the provision of safe water on small and rural drinking water treatment plants. The project aims to investigate the reasons for these existing problems and suggest both technical and social remedies to overcome the problems and to ensure the provision of efficiently disinfected and safe drinking water to these communities.

Estimated cost: R1 000 000  
Expected term: 2004 - 2006

**Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof**  
*Emanti Management*  
**No 1597**

Small water service providers are having problems in proactively managing drinking water quality within their distribution networks. This project aims to analyse the

# KSA 3 (continued)

## Water Use and Waste Management

relatively high percentage of water quality failure in two provinces of South Africa and in particular contrast the water quality at the water treatment plant with that at point of use. Guidelines will then be developed for the management of drinking-water quality in non-metropolitan distribution systems. The guidelines will include legislative compliance requirements, technical inputs (e.g. optimum free chlorine residual levels), best practices (e.g. pro-active maintenance requirements), monitoring and management protocols and reporting protocols to consumers, provincial and national government. These guidelines will then be used in a 'road show' to make the appropriate officials aware of the need for effective monitoring and management.

Estimated cost: R452 300  
Expected term: 2005 – 2007

### *The development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters*

*Durban Institute of Technology*  
**No 1598**

This proposed project will focus on developing the local woven fibre immersed membrane micro-filter into systems for the pretreatment of high turbidity surface waters as well as the gravity-fed treatment of water in remote regions. The project will complement and enhance the applicability of other local technological developments in rural water treatment, e.g. the locally developed capillary ultrafiltration system. The project will develop a standard membrane pack for immersed microfiltration membrane applications. Different configurations and operating protocols will be evaluated so as to minimize fouling and maximize ease of cleaning. A simple, gravity fed water treatment system for water provision in remote areas will be demonstrated.

Estimated cost: R765 000  
Expected term: 2005 – 2008

### *A manual and training aids for operation and maintenance on small water treatment plants*

*CD Swartz*  
**No 1599**

In a study of 20 small water treatment plants (WRC *Report No. 738/1/00* entitled

*Guidelines for the Upgrading of Small Water Treatment Plants*) it was found that most local small water treatment plants experience problems in operating on a sustainable basis. This was due to a number of both technical and human factors. However, due to the wide and encompassing nature of this investigation, it was not possible to identify and characterise the operation and maintenance-related problems fully. This project, therefore, aims to survey current management practices, determine optimal small plant operation and management methodologies for South Africa and compile a user friendly operation and maintenance manual. Based on the manual, training aids will be developed and this knowledge will be disseminated by means of a 'road show', demonstrating the training aids.

Estimated cost: R1 500 000  
Expected term: 2005 – 2008

### *Programme 3: Drinking water quality Occurrence and fate of EDCs in drinking water CSIR*

**No 1532**

It is of high priority that the fate of EDCs be determined to minimize the effect thereof on humans and animals. The project aims to investigate the occurrence and fate of EDCs in raw and treated drinking water using biological/biochemical techniques and chemical tests. Recommendations will be made on the most effective water treatment technologies for the removal of EDCs and the most appropriate combination of tests for the detection of EDCs in drinking water.

Estimated cost: R830 000  
Expected term: 2004 - 2006

### *Methods manual for monitoring phytoplankton and cyanobacteria Rand Water*

**No 1533**

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.

Estimated cost: R403 600  
Expected term: 2004 - 2006

### *New detection methods for EDCs*

*University of Stellenbosch*  
**No 1534**

The project will aim to produce and test an endocrine disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand binding domain (LBDER) into a suitable yeast (*Pichia pastoris*) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotinylation of LBDER and preparation of biotinylated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialised polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection.

Estimated cost: R647 500  
Expected term: 2004 - 2007

### *National standards for water and wastewater treatment chemicals*

*Umgeni Water*  
**No 1600**

The national standards for many water treatment chemicals in everyday use are outdated and describe analytical procedures which are in some cases obsolete and very time consuming. In addition to this, there are many water treatment chemicals for which no national standards exist, in spite of the fact that some of these are used extensively in the water and wastewater treatment industry. Therefore, this project aims to evaluate current South African standards and international standards for water and wastewater treatment chemicals; assess the needs of the industry in terms of national standards for water and wastewater treatment chemicals; and produce a report containing recommendations which will serve as the basis for

the up-dating and re-issuing of current standards and for the creation of new standards where these do not currently exist.

Estimated cost: R241 800  
Expected term: 2005 – 2007

***Determination of the specific origin of contaminating bacteria in drinking water of rural households by elucidating the contamination pathway using amplified fragment length polymorphism (AFLP)***

CSIR  
No 1602

Method development at the DNA level has made the identification of the exact origin of specific contaminating and other organisms possible. This ability may have a profound impact on our understanding of exactly where contaminating organisms originate from and where in the contamination pathway introduction of these organisms into drinking water supplies takes place. Understanding the latter will in turn allow identification of the specific human behaviours and practices that contribute to contamination of drinking water. The information will enable the design of preventative measures aimed at the very core of the problem and in doing so minimize health impacts and direct resources optimally. Using the amplified fragment length polymorphism (AFLP) methodology, the project therefore aims to identify those human behavioural factors and practices that are directly associated with the identified contamination pathway and identify the exact point where bacterial contamination of drinking water takes place in rural households without access to in-house piped water. Recommendations will be made that would address those behaviours or practices associated with the identified pathway so that contamination can be prevented or minimized in future

Estimated cost: R371 320  
Expected term: 2005 – 2007

***On-line real-time enzymatic biosensor system for the rapid detection of faecal contamination of water intended for drinking purposes***

Rhodes University  
No 1603

The unique enzymatic profiles present in primary sewage sludge during were investigated in 2000/03, one of the first studies of its kind in the world and results from this study have already been presented and accepted in internationally peer-reviewed journals. Subsequently, another two-year project was funded for the establishment of a suitable bio-probe and biosensor system for the rapid enzymatic detection and enumeration of indicators of faecal contamination in water. This project is a follow-up and the key outputs of the current study will be the design of a suitable bio-probe strip for the rapid detection of faecal contamination. A provisional patent is currently being secured to protect this innovation. Results from the current study have shown proof of concept, paving the way for the finalisation of the improved development and construction of a novel enzyme based biosensor for the rapid detection of faecal contamination via the presence of indicator micro-organisms and their metabolic enzymes.

Estimated cost: R700 000  
Expected term: 2005-2007

***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 SA 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: R 736 300  
Expected term: 2003 - 2006

***The status and use of drinking water conservation and savings devices in the domestic and commercial environments in South Africa***

Partners in Development  
No 1606

South African water legislation supports and recommends the use of water conservation and savings devices, towards meeting future goals of water assurance. Yet, in the seven years of existence of the new Act and despite the development of water conservation strategies, very little progress has been made in term of a water responsibility ethic amongst water users and providers. There are number of areas that may inhibit the promotion of water conservation ethics. These include lack of implementation of policy, lack of commitment by service providers and the lack of use and availability of affordable technologies. The study intends to investigate the *status quo* on the use of efficient devices in the domestic and commercial (schools, churches, sports fields, garages, hotels, restaurants, terminuses, etc.) environments through auditing exercises. Recommendations and strategies to enhance the use of water-efficient devices at domestic and commercial level will be developed and a financial cost assigned to introducing water savings and the concomitant benefits.

Estimated cost: R700 000  
Expected term: 2005 – 2007

***Thrust 3:  
Wastewater and Effluent Treatment and Reuse Technology***

***Programme 1:  
Biological sewage treatment processes***

***Practical implementation of external nitrification in biological nutrient removal activated sludge systems***

Division of Water Quality Engineering,  
University of Cape Town  
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

# KSA 3 (continued)

## Water Use and Waste Management

by others (excluding contributions in kind) amount to about 40% of the total budget.

Estimated cost: R1 280 000

Expected term: 2001 - 2005

***Biofloc modifications for sludge settleability improvements from selected BNR process conditions and configurations, pilot- and full-scale based settling behaviour evaluations for final clarification enhancement***

*ERWAT*

**No 1340**

Recent new DWAF legislative standards include lower permissible suspended solids and nitrate concentrations in effluents. Limited research has been done to determine the optimum levels of aeration necessary to keep solids in aerated suspension and produce the required flocculation. Alongside this, current biomass settling models are empirically based, the mechanisms postulated are not supported by representative plant data, and the settling process is very sensitive to variable process conditions and environmental factors. In this project a pilot plant will be operated to generate benchmark data which will be used to configure a comprehensive mathematical model describing both sludge settleability and settling behaviour. The pilot-scale tests will be conducted in parallel with full-scale verification trials at various ERWAT wastewater works.

Estimated cost: R298 330

Expected term: 2002 - 2004

***The production of aerobic granular activated sludge for enhanced settling in sewage treatment***

*BKS (Pty) Ltd*

**No 1451**

Building on previous work carried out by the group on a synthetic (acetate) substrate, this project aims at the systematic selection of granulated aerobic sludge in a sequencing batch reactor process treating sewage. If successful, the overall process efficiency would be significantly enhanced by improving the sludge settleability. Some similar work has been carried out overseas and the innovation level is relatively modest but equally the risk is reduced.

Estimated cost: R 327 800

Expected term: 2003 - 2006

***To investigate the performance and kinetics of biological nitrogen and phosphorus removal with ultrafiltration membranes for solid-liquid separation***

*University Cape Town*

**No 1537**

This project is a follow-on to WRC

**Consultancy No. 514** which was specifically commissioned as a one-year feasibility study in 2003 to test whether nutrient removal could be accomplished in this type of robust, low-cost sewage treatment system which is independent of the sludge bulking problems which in turn often compromise the effective performance of activated sludge processes. The low pressure-drop ultrafiltration (UF) membranes being used are supplied and funded for this purpose by the suppliers (MembraTech, UK). Recent information (November 2003) indicates that the process is operating satisfactorily. On the basis that the preliminary promise has been delivered, a fuller investigation is therefore required to provide a rigorous and definitive examination of this type of system. A parallel 'next step', which is already in hand, will be to investigate whether UF membranes of similar or superior performance can be locally sourced, and/or designed and manufactured.

Estimated cost: R1 132 400

Expected term: 2004 - 2006

***Development of a commercially viable implementation model for anaerobic co-digestion of toxic and high strength organic waters***

*University of KwaZulu-Natal*

**No 1538**

This project builds on two previous WRC projects, namely **No. 762** which assessed the viability of using anaerobic digestion to treat refractory textile wastewater and **No. 1074** which investigated co-digestion of these wastes with domestic sewage on a regional basis. The outcomes of these base studies were positive and the present project seeks to extend the technical success achieved into a practical technology-application scheme. In collaboration with Durban Metro (Water and Waste), a commercially-oriented survey will be carried out to quantify spe-

cific industrial sources, loads, sewage works capacity and costs (capital and running) for operating the scheme. These results will be drawn together into a multi-stakeholder business plan aimed at meeting the needs of industry, regulators and sewage treatment plant operators. It is significant that previous WRC research, regulator buy-in and progress made with industry with regard to cleaner production have come together to create this window of opportunity.

Estimated cost: R150 000

Expected term: 2004 - 2005

***IAPS algal biomass and treated effluent utilisation as a key strategy in sustainable and low-cost sanitation***

*Rhodes University (Centre for*

*Entrepreneurship in collaboration with*

*Sustainable Environmental Technologies)*

**No 1619**

Historically, the focus in sewage treatment in the RSA (in line with much of the 'developed' world) has been to seek 'efficient' end-of-pipe processes for converting the organic and inorganic residuals of human diets to end-products that are (superficially) more environmentally neutral - carbon to CO<sub>2</sub>/CH<sub>4</sub>, nutrients (e.g. N & P) to non-eutrophying compounds, etc.). Simultaneously, as global food demands increase, these same compounds constitute valuable agricultural resources. This project targets this strategic niche, by firstly capturing sewage nutrient-values in algal form and then applying the product as a fertilizer for food production. This approach creates a barrier between sewage treatment and crop production to control the potential health risk (the major problem with direct reuse of sewage wastewaters), but without seeking to 'destroy' the nutrient) values in the wastewater stream. The specific aims of the project are to investigate uses of algal biomass from integrated algal ponding systems (IAPS) in value-chain crop production and horticultural applications, to determine the role and mechanisms of IAPS algae in plant growth stimulation, to evaluate different methods for efficient harvesting and recovery of algal biomass from IAPS, and to carry out a preliminary economic feasibility study and business plan development for implementation of such schemes at IAPS treatment works. The project thus also has strong elements of interventions for effective and practical poverty alleviation.

Estimated cost: R395 200  
Expected term: 2005 – 2007

**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 – 2007

**Programme 2:**  
**Sludge characterisation, treatment, utilisation and disposal**  
*Scale-up development of the Rhodes BioSURE™ process for sewage sludge solubilisation and disposal*  
*Department of Biochemistry, Microbiology and Biotechnology, Rhodes University*  
**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 es-

tablished at Ancor Sewage Works (Springs) will be operated, monitored and optimised, and the facility will be extended to include sulphide bio-oxidation and sulphur recovery. A smaller pilot plant at Makana Sewage Works (Grahamstown) will be operated and monitored to study process variables in finer detail, to identify and investigate areas of sulphidogenic sewage sludge solubilisation that require further development for scale-up.

Estimated cost: R1 510 900  
Expected term: 2002 - 2005

**Survey and methodology for analysing organic pollutants in South African sewage sludges**  
*School of Chemical and Physical Sciences, University of KwaZulu-Natal*  
**No 1339**

Sewage sludges are contaminated with a wide array of organic compounds. Out of the 127 compounds listed by the United States Environmental Protection Agency as having the greatest potential to harm human health or to be detrimental to the environment, 111 are organic compounds. While the **South African Sludge Guidelines** of 1991 stipulated limits for organic pollutants, no mention is made of why these compounds were selected and how the recommended limits were arrived at. The limits of the same compounds were revised in 1997. The new limits were once again not tested for compliance or the *status quo* in South Africa. The maximum concentration limits as stipulated in the document are based on LC<sub>50</sub> calculations and not on experimental values. This project will determine and quantify the composition of organic pollutants in sewage sludges. The investigation will also test and suggest the best method(s) of handling and determining these pollutants, so that uniformity can be introduced among the various producers and government laboratories. It is intended to use the same sludge samples that are being used in WRC **Project No 1283** so as to reduce cost.

Estimated cost: R580 000  
Expected term: 2002 - 2005

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

This project aims to determine the influence of sludge conditioners used during sewage treatment processes on the soil conditioning properties of sewage sludge.

Estimated cost: R101 000  
Expected term: 2004 - 2006

**Development of the South African wastewater sludge disposal guidelines dealing with land and ocean disposal, beneficial use, use in commercial products and thermal treatment**  
*Zitholele Consulting (Pty) Ltd*  
**No 1622**

Soon after the publication of the 1st edition of the guidelines on the Permissible Utilisation and Disposal of Sewage Sludge in 1997, the WRC embarked on a process to revise these guidelines. A research programme was initiated to characterise South African wastewater sludge and better understand sludge disposal practices in order to develop a local knowledge base and a better appreciation of the issues that should form the basis for a comprehensive revision of the 1997 Guidelines. An Addendum to the 1997 Guidelines was published in 2001 to clarify and elaborate on certain issues where this was required. A start with the development of the 2nd edition of the South African Sludge Guidelines was made in 2003. This initiative saw the publication of the first two volumes (a general overview document and guidelines for beneficial agricultural use) of the new guidelines in 2006. The current project, which is being co-funded by DWAF, will complete the process and produce a further three documents, which will give guidance for:

- The non-beneficial disposal of wastewater sludge by employing options such as dedicated land disposal, landfills, lagoons and ocean discharge
- The beneficial use of wastewater sludge at high loading rates in agriculturally related practices, such as mine tailing rehabilitation, nursery growth material and landfill capping
- The production of commercial products such as bricks, cement and fertilisers as well as thermal treatment of wastewater sludge.

Estimated cost: R1 428 800  
Expected term: 2005 – 2008

# KSA 3 (continued)

## Water Use and Waste Management

### Programme 3:

#### **Treatment and recovery of organics from agro-industrial processing**

*Assessment of a baffled (compartmentalised) anaerobic digester for the treatment of high-strength and toxic organic industrial effluents*  
Pollution Research Group, University of KwaZulu-Natal  
**No 853**

Organic effluents from the agro-industrial sector are generally problematic in terms of their concentrated, variable, intermittent and sometimes toxic nature. Many streams would be amenable to treatment by anaerobic digestion if the toxicities of particular components are identified at an early stage so that the microbial populations in a suitable reactor can be acclimated to the constituents concerned. The anaerobic baffled reactor (ABR) offers good separation between hydraulic and solids retention times, good solids retention, and the potential for selecting acclimated microbial biomass fractions in a series configuration. This project aims to develop and apply an ABR for treating dyeing effluents from the textile industry.

Estimated cost: R1 218 000  
Expected term: 1998 – 2001

#### **Development of a hybrid immersed-membrane bioreactor**

*Institute for Polymer Science, University of Stellenbosch*  
**No 1369**

The project is aimed at producing an innovative immersed membrane bioreactor for potential use in the treatment of wastewaters as well as for potable water production from dirty surface water sources. This technology has particular potential for smaller systems. This project will take development to prototype stage. The product will combine the advantages of the newly developed immersed membranes with a novel cleaning, biofilm control and oxygen supply method. This technology has great potential in South Africa and elsewhere in the world, because it is expected to improve significantly on the current immersed membrane efficiencies, coupled with a lower potential for fouling and lower maintenance and general attention requirements.

Estimated cost: R990 000  
Expected term: 2002 – 2005

#### **To investigate and commercialise production of a cocktail of hydrolytic enzymes from anaerobic sulphidogenic bioreactor fed with sulphate reducing bacteria and municipal sewage sludge for the treatment of biological and industrial wastewater**

*Rhodes University*  
**No 1541**

This project for creating enzyme 'cocktails', based initially on a sulphidogenic system and applied then to the treatment of domestic and industrial wastewaters, has novel aspects of technical interest. The concept of generating enzymes to treat wastes is not new but is a relatively fresh approach compared to the conventional biological reactor.

Estimated cost: R216 000  
Expected term: 2004 – 2005

#### **The removal of reactive dyes from dye liquor for the reuse of salt, water and energy**

*Pollution Research Group, University of KwaZulu-Natal*  
**No 1542**

The textile industry needs cost effective, low environmental-impact processes to remove colour and salt from their effluent. The project is for the treatment of concentrated reactive dye effluents from the textile processing industry at source using activated carbon. The high salt concentration shifts the equilibrium towards the carbon, resulting in very high removal efficiencies. The project will combine life cycle assessment (LCA), chemistry and process engineering considerations to develop an important recycle technique for the textile industry, in order to recover and recycle chemicals and consequently reduce the waste loads generated. This is a good reduction-at-source approach towards developing a solution to the problem.

Estimated cost: R272 600  
Expected term: 2004 – 2006

#### **Industrial wastewater remediation via wet air oxidation using immobilised transition metal catalysts**

*University of the Western Cape*  
**No 1543**

Aqueous effluents from the chemical and related industries contain various organic pollutants which are toxic and refractory and occur in concentrations too low for economical recovery but too high for conventional biological treatment. This project aims to investigate and develop catalytic wet air oxidation as a technology for treating such effluents.

Estimated cost: R600 000  
Expected term: 2004 – 2006

#### **Integrated research to identify indigenous flora and microflora for use in constructed wetlands for agro-industry effluent treatment, especially winery wastewater**

*University of Cape Town*  
**No 1544**

The wine industry generates problematic wastewaters from cellars and distilleries, particularly when these occur in rural and semi-rural locations. Wetlands are known to be of value and to work, but not particularly well for the high-strength organic wastes. The research programme is to design a constructed wetland for winery effluent treatment based on existing constructed wetland mathematical modelling but optimised by using indigenous effluent-tolerant plants and optimum soil profiles to enhance desirable microbial activity. This application of phylogenetic classification and evaluation of indigenous species for wetlands construction and optimization has innovative aspects.

Estimated cost: R500 000  
Expected term: 2004 – 2006

### Programme 4:

#### **Treatment and recovery of inorganics (including sulphate and metals) in industrial and mining effluents**

*Investigation into sulphur chemistry with specific application to biological sulphate removal processes*

*Department of Civil Engineering, University of Cape Town*  
**No 1079**

This project complements current WRC research efforts into biological processes for treating acid mine drainage and other metalliferous sulphate-containing effluents. The aims are to apply fundamental aqueous chemistry to model metal precipitation and recovery, simulate the effects of pH and temperature on sulphur speciation and solubility along with active stripping of hydrogen sulphide (H<sub>2</sub>S), and explore the extent of conversion, reaction kinetics and control of a process to recover elemental sulphur by chemical oxidation of soluble sulphides.

Estimated cost: R280 000  
Expected term: 1999 - 2000

***Investigation and development of the biotechnology of sulphur biofilms in the beneficiation and treatment of wastewaters***

*University Rhodes  
No 1545*

The WRC has made a substantial investment in sulphur systems biotechnology for the treatment (active and passive) of acid mine drainage AMD and certain industrial wastewaters. Biodesalination of these wastewaters requires that sulphur-derived TDS be finally removed from the treated stream, but effective sulphur removal remains a technological bottleneck in these processes. This project seeks to further develop a sulphur-removal system based on sulphide bio-oxidation carried out in floating biofilms. This is a core technology in overall AMD bio-treatment processes and the project supports and extends current work being carried out in **Project No. 1456.**

Estimated cost: R924 810  
Expected term: 2004 - 2006

***Development of sustainable low-cost management for saline sewage and saline mine drainage wastewaters using integrated algal ponding systems***

*Rhodes University (Environmental Biotechnology Research Unit)  
No 1621*

The WRC has invested substantially in the development of sustainable management technologies for saline wastewaters from a range of sources including industry and mining. One specific innovation involves the use of ponding systems for the treatment of mine drainage wastewaters in the ***Algal Sulphate Reducing Ponding Process for Acidic Metal Wastewater Treatment (ASPAM®)*** which was preliminarily investigated at bench-scale and reported on (***Report No. TT 192/02***). The mining industry has identified the importance of the general approach and has requested evaluation of the process at pilot-scale with a view towards full-scale implementation. The aims of this project are accordingly to undertake pilot-scale process development of the WRC-patented ASPAM® system using algal ponding for low-cost sustainable treatment of metal-contaminated acidic sulphate-saline wastewaters, including investigating factors relating to the linkage and integration of the various unit operations of the process, determining kinetic values and design parameters required for full-scale implementation, undertaking a fundamental investigation of the algal proton-absorption capacity of the ASPAM® system underpinning the metal precipitation and neutralisation unit, characterising fundamentally the sulphur biofilm formation operation, and developing a descriptive model for the system.

Estimated cost: R1 139 700  
Expected term: 2005 - 2007

***Continued evaluation of the integrated managed passive water treatment system (IMPI), long-term monitoring of VCC passive treatment plant and three-dimensional characterisation of decommissioned sulphate reducing units***

*Pulles, Howard and de Lange Inc.  
No 1623*

In the RSA a sustained 9-year research programme with a 2004 value of around R21m. (from various funding sources) has aimed at developing passive water treatment technology that can reliably remove sulphates, acidity and metals from AMD waters. This research effort has resulted in the development of a

**degrading packed bed reactor** that is a world leader in volumetric sulphate removal rates from mine-waters, by almost an order of magnitude compared to other international technologies. A key feature of the technology is that it will generally be required to operate for a number of years, typically decades, and continue to perform in accordance with its specified duty. A strategic concern of the mining industry and the regulatory authorities relates to the confidence that can be placed in the long-term performance of such units and their eventual fate. As a logical final stage in developing and evaluating passive treatment processes, this project will extend and intensify the monitoring of existing passive AMD treatment plants while at the same time de-commissioning and autopsying other similar long-running units.

Estimated cost: R400 000  
Expected term: 2005 - 2006

***Programme 5: Training in wastewater treatment plant operation***

***Development of a diagnostics-based knowledge management system for the efficient operation and training of staff associated with municipal sewage treatment facilities***

*Department of Biochemistry and Microbiology, Rhodes University  
No 1337*

Pressures of rapid urbanisation and the provision of sanitation services have resulted in sewage treatment plants operating sub-optimally for a variety of reasons including not only installed hardware capacity but also insufficient operator training and expertise for consistent management of the facilities. This project aims to support and strengthen the human resource base by generating a knowledge management database for capturing the experience of operators and engineers in running sewage treatment facilities; developing and applying a system for implementation of the database; and testing the system initially at a sewage treatment facility in the Port Elizabeth Municipality.

Estimated cost: R329 200  
Expected term: 2002 - 2004

# KSA 3 (continued)

## Water Use and Waste Management

### **Thrust 3:** **Wastewater and Effluent Treatment and Reuse Technology**

#### **Programme 6:** **Biotechnological co-treatment of saline and sewage wastewaters**

*Biotechnological co-treatment of saline and sewage wastewaters with integrated recovery and reuse of water and organic and inorganic components for sustainable development:*

- Part 1:** Saline sewage treatment
- Part 2:** Biosulphidogenic sewage treatment
- Part 3:** Hybrid systems for treating acid mine drainage
- Part 4:** Integrated community benefit  
Dept of Biochemistry and Microbiology, Rhodes University  
**No 1456**

The overall objective is to exploit and further develop beneficial applications of biotechnological processes for co-treating saline and sewage wastewaters in the sustainable and integrated management of various water-related community, industrial, agricultural and environmental needs. The specific research objectives are to determine the economic, social, technical and technological feasibility of a biological process for treating sewage reticulated in saline water, including nutrient removal and disinfection, for urban and rural communities (the 'Saline Sewage Treatment' component); develop, test and demonstrate processes for biological treatment of effluents from the bio-sulphidogenic co-treatment of mine-water and sewage sludge to standards suitable for a range of subsequent beneficial uses, and biotechnological oxidation and recovery of sulphur from such systems (the 'Bio-sulphidogenic Sewage Treatment' component); develop, test and demonstrate hybrid active-passive systems for sustainable treatment of acid mine drainage before and after mine-closure (the 'Hybrid Systems for Treating Acid Mine Drainage' component) and develop integrated social responsibility / community components for employment opportunities, job creation, and other community upliftment benefits derived from the biotechnological applications envisaged (the 'Integrated Community Benefit' component).

Estimated cost: R 3 000 000  
Expected term: 2003 – 2005

### **Thrust 4:** **Industrial and Mine-water Management**

#### **Programme 1:** **Quantification of water use and waste production**

*A first-order inventory of water use and waste production by the South African industrial, mining and power generation sectors*  
Arcus Gibb  
**No 1547**

The aim with this project is to compile a first-order inventory of the amount of water used and waste produced by the South African industrial, mining and power generation sectors, and to assess the impact these have on water quality. Information in this regard is required to judge whether the present investment in research has the right mix and to provide strategic direction to research initiatives. The investigation will make optimal use of existing information such as the NATSURV investigation that provides a benchmark for water use and waste production by major South African industries, the COMRO report on water use by gold-mines, a WRC report on water use by coal-mines, a CSIR report on national waste production and DWAF's Water Resource Strategy on water requirements by different sectors. The available information will where necessary be supplemented by targeted field investigations and compiled into a consolidated overview that presents the total picture. The data on water use and waste production will furthermore be interpreted for the effect they can be expected to have on receiving water quality. In order to ensure credibility of the findings, they will be verified through a workshop with practitioners.

Estimated cost: R600 000  
Expected term: 2004 - 2005

*A first order assessment of the quantity and quality of non-point sources of pollution associated with the industrial, mining and power generation sectors*  
Pulles, Howard and de Lange  
**No 1627**

It is increasingly recognised that non-point source (NPS) pollution plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore, increasingly accepted that it is not feasible to properly manage water quality without addressing the contribution from non-point sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. This project will determine at a scoping level, the quantity and quality of NPS pollution that originate from the mining, industrial and power generation sectors. This information will *inter alia* be used at a strategic level, to determine whether the present investment in research in this KSA and more specifically the thrust on industrial and mine-water management, reflect the need in this regard.

Estimated cost: R 1 000 000  
Expected term: 2005 – 2007

**Programme 2:**  
**Regulatory mechanisms to improve industrial and mine-water management**  
*Valuing water for South African industries: A production function approach*  
Environmentek, CSIR  
**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 water '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 assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge.

Estimated cost: R549 600  
Expected term: 2002 - 2005

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

Each environmental risk assessment (ERA) study is faced with questions regarding the location, number, size and type of samples that need to be collected for a proper assessment. Answers to these questions are partially dependent on the predictions that need to be made, the available material and costs. This project will establish a methodology to guide users of an ERA process to quantify the uncertainty associated with pre-

dicted mine drainage quality as a function of sample representivity. Existing mineralogical and geochemical data for the Wits Basin, that are available from previous studies, will be used to demonstrate the application of the methodology that will be developed.

Estimated cost: R 562 000  
Expected term: 2005 - 2008

***Programme 3:***  
***Minimising the impact of waste on the water environment***  
***Closure planning in the minerals extraction industry: The role of effective waste characterisation and water-related impact predictions for solid mineral wastes***  
*University of Cape Town*  
**No 1550**

The mineral extraction industry is renowned for the contaminants that can emanate from their operations. Despite the fact that the quantitative prediction of environmental impacts associated with solid mineral wastes has been researched over the years, the bounds of uncertainty associated with currently available impact prediction methodologies remain high, and the ultimate fate of contaminants following waste disposal is still largely unknown. This project aims to assist with closure planning for the mineral processing industry by enhancing our ability to predict water related impacts associated with solid mineral waste and integrating that ability with decision making processes concerning water resource management. It is anticipated that a better understanding of the physico-chemical compositions, as well as the kinetic and metabolic behaviour of constituent components, will allow for more effective waste characterisation procedures, better assessment of the time-dependent leachate generation behaviour of waste materials, and ultimately in more realistic quantitative impact predictions.

Estimated cost: R655 000  
Expected term: 2004 - 2006

***Development of a first-order decision support system for the sustainable design, operation and closure of metalliferous tailings disposal facilities (S)***  
*Golder Associates Africa (Pty) Ltd*  
**No 1551**

The mining of South Africa's gold, platinum and base metal resources gave rise to hundreds of tailings disposal facilities covering an area of more than 200 km<sup>2</sup>. These tailings contain significant proportions of sulphide minerals, which upon weathering give rise to a range of potential pollutants. Seepage to ground- or surface water gives rise to various levels of water pollution over large tracts of land. In addition to their potential to degrade water quality chemically, tailings disposal facilities are often physically unstable and susceptible to collapse and erosion. They thus represent a long-term liability to the country. This project will provide a first order decision making tool that can be used by regulators, industry and consultants for the design and construction of tailings facilities that have 'surfaces that last' and where the potential for contamination of surface and groundwater resources are practically eliminated. The envisaged decision support system (DSS) will cater for the life cycle of tailings facilities and thus be applicable not only to Greenfield developments but also to the large legacy of existing operational and non-operational tailings facilities. Gaps in our present knowledge base will be identified for potential follow-on projects.

Estimated cost: R600 000  
Expected term: 2004 - 2006

***Programme 4:***  
***Minimising waste production***  
***Promotion of biodegradable chemicals in the textile industry using the score system: Phase 1 - Pilot study***  
*School of Chemical Engineering, University of KwaZulu-Natal*  
**No 1363**

The score system is a management tool, developed in Europe, for monitoring the environmental pollution potential of a company based on the characteristics of the chemicals used and which could report to the effluent. The parameters assessed are the amount of substance used and its biodegradability, bio-accumulability and toxicity, each of which is given a logarithmic score of between 1 (low environmental burden) and 4 (substantial negative environmental impact) to derive a composite 'score'. In this project the system is being tested for its applicability to the RSA, using textile companies as the initial pilot study. The objective is to reduce the environmental impact of a company, as measured

# KSA 3 (continued)

## Water Use and Waste Management

by its 'score', by minimisation of the chemicals used and/or their substitution in favour of less environmentally aggressive choices. If successful, the concept could be advanced for other industrial sectors as a generic environmental management protocol.

Estimated cost: R700 000  
Expected term: 2002 - 2005

### *Water conservation through energy conservation*

*Pollution Research Group, University of KwaZulu-Natal  
No 1368*

To meet the needs for increased thermal efficiency (because of firstly the first 'energy crisis' in the 1970s and subsequently the global warming/carbon dioxide issues of the 1990s) and for reduced water consumption (initially as water intake in water-rich regions), two separate but similar process integration techniques (thermal pinch and water pinch) were developed to optimise the thermal/energy and water efficiencies in industrial complexes (improved thermal/energy efficiency also implies reduced water use at the power-generating stage). Thermal pinch is a mature technique, while water pinch is evolving rapidly. This research group has successfully applied and adapted water-pinch techniques to the water-scarce situation in South Africa. This project aims to combine these two techniques and apply them to South African industry.

Estimated cost: R740 000  
Expected term: 2002 - 2004

### *Characterisation of microbial populations and identification of dominant micro-organisms in different paper mill water systems*

*Dept of Microbial, Biochemical and Food Biotechnology, University of the Free State  
No 1459*

The water quality in a paper mill deteriorates as the overall water consumption of the mill decreases. This is due to an increasing amount of recycling of the water and less purging of contaminants. The water quality can deteriorate to the extent that paper making becomes ineffective and paper quality suffers. Odours can also develop and the water can become threatening to the health

of workers. Management of the water system thus becomes one of the most important constraints to reducing water consumption in a paper mill. This project aims to develop understanding of which organisms develop under different conditions in a paper machine water system that will play a major role in the development of better management systems and, thereby, enable a reduction in water consumption and the release of waste products.

Estimated cost: R 686 050  
Expected term: 2003 - 2006

### *The introduction of cleaner production technologies in the mining industry*

*Digby Wells & Associates  
No 1553*

While the mining industry has played a major role in the development of South Africa (and is still continuing to do so) it has also been identified as the largest producer of waste and as a major contributor to water quality degradation in many of our important catchments. It is recognised that the long-term solution to waste management is to minimise waste production and introduce cleaner production technologies. An analysis of the WRC's past and present project portfolio indicated that most of the research effort to address water and waste management in the mining industry was devoted to minimizing the impact of waste on the environment, to improve our ability to predict and quantify effects and to develop technologies to treat polluted waters. No projects devoted specifically to waste minimization and cleaner production technologies were undertaken. Although cleaner production is an essential backdrop against which to do environmental management and the mining industry has launched initiatives such as the mining, minerals and sustainable development project, it does not appear as if the industry has embraced cleaner production, as yet. This project is aimed at introducing cleaner production to the mining industry and entrench its concepts where it is already being practiced. For this purpose multi-faceted initiatives will be undertaken to raise the awareness of the mining industry concerning the benefits and need for adopting cleaner production approaches. The project will start by assessing the level of awareness in the industry and identifying threats that could be

alleviated by cleaner production technologies. Opportunities will be created to implement these and establish cleaner production forums (waste minimization clubs) so that success stories can be generated which, in turn, can be used in an awareness campaign.

Estimated cost: R3 295 000  
Expected term: 2004 - 2007

### *Development of a complete process integration framework for wastewater minimisation in multipurpose batch plants*

*University of Pretoria  
No 1625*

This project aims to minimize the wastewater production and pollution emanating from batch processes where equipment is shared in the production of high value / low volume specialty chemicals. For this purpose a mathematical optimization model that operates on a continuous timing interval, will be developed and tested by using the General Algebraic Modelling System (GAMS) software. The model will be designed to optimize for both maximum profits and minimum effluent. The development of this product is important because of the extremely high toxicity of effluents produced by these processes and the ever tightening environmental requirements.

Estimated cost: R 198 000  
Expected term: 2005 - 2006

### *Cleaner production evaluation system and optimization 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: R 492 000  
Expected term: 2005 - 2007

**Programme 5:**  
**Improved ability to predict and quantify effects**

*Evaluation and validation of geochemical prediction techniques for underground coal-mines in the Witbank / Highveld region*  
Pulles, Howard & de Lange  
No 1249

The Witbank/Highveld coal-field in Mpumalanga is the most important coal-mining area in South Africa. While this coal-field makes a significant contribution to the economic development of the country it is also the source of potentially the most serious water quality problem facing the region over the longer term. There is thus an urgent need to develop and test tools with which to predict the progression of acid mine drainage (AMD) over time, and to develop, test and apply management options that will alleviate the situation. This project, together with **Project Nos. 1263** and **1264** will investigate the management of groundwater flow in collieries at various stages of closure with an aim to minimise the salt load emanating from them, evaluate alternative geochemical prediction techniques to use in the longer term, comparison of alternative management options, and the mapping of modal proportions of primary and secondary minerals. The contribution of this project will be to evaluate alternative geochemical prediction techniques for the prediction of water quality at underground coal-mines, based on on-site investigations and predictions, and to develop the ability to provide a long-term prediction of water quality and the effect of alternative management strategies on this water quality.

Estimated cost: R1 416 100  
Expected term: 2001 – 2003

**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 and de Lange*  
No 1460

The area covered by slimes dams is in the order of 400 km<sup>2</sup>. Previous research has indicated a varying but significant potential for pollution underneath these dumps. The overall water balance of a dump is the main driving force behind this pollution. The water

balance of tailings and rock dump facilities is not very well understood at present, both locally and internationally. This seriously limits our ability to make reliable predictions of post-closure pollution potential and to properly evaluate environmental management / rehabilitation strategies. This project aims to develop a procedure and methodology that can be used in developing water balances for gold-mine waste residue deposits. These water balances play a critical role in geochemical modelling of such deposits.

Estimated cost: R 913 500  
Expected term: 2003 – 2006

**Study of the kinetic development of oxidation zones of tailings dams with specific reference to the Witwatersrand gold mine tailings dams**

*Pulles Howard & de Lange*  
No 1554

**(Project No. 1347)** aimed to determine and predict the depth and rate of weathering on gold tailings dams, and to develop rapid procedures to assess the risk for a specific tailings dam to produce AMD. This project will complement and extend the earlier investigation by building on its findings and extending them. The large-scale reclamation of dams, ranging from 10 to 100 years in age, provides a perfect opportunity to study tailings dam profiles and characterise their oxidation profiles. The project aims to advance our knowledge and ability to practically implement improved prediction capacity in the following areas:

- Establishment of validated kinetic variation of oxidation zones
- Increasing the accuracy of predicting the depth of oxidation zones
- Increasing the accuracy of predicting the phreatic surface
- Applications to any other similar environment, e.g. platinum group metals (PGM) and copper mine tailings

Estimated cost: R360 000  
Expected term: 2004 – 2005

**Prediction of how different management options will affect drainage water quality and quantity in the Mpumalanga coal mines up to 2040**  
*Golder Associates Africa (Pty) Ltd*  
No 1628

Coal-mining in the Mpumalanga coal-field is a mature activity. Many mines have already closed and several more are heading for closure during the next 20 years. The acid mine drainage (AMD) that emanates from closed and operating mines have a huge impact on the water quality of the area. Because of the lag effect, it is likely that this impact will increase in future. Several investigations over the last decade were aimed at obtaining an improved understanding of how different management options would affect the quantity and quality of AMD emanating from mines. This project will build on mainly available information to predict how the quantity and quality of acid mine drainage emanating from coal mines in the Mpumalanga Highveld will change over the next 40 years for a range of different management scenarios.

Estimated cost: R1 500 000  
Expected term: 2005 – 2007

**Thrust 5:**  
**Sanitation and Hygiene Education**

**Programme 1:**  
**Rural sanitation and hygiene education Education, awareness and behaviour change requirements to improve safe water practices**  
*Human Sciences Research Council*  
No 1522

The main aim of this study is to determine or identify the water handling practices and behaviours which have a negative impact on users. Then use this as the basis to develop a framework for action and guidelines on improving hygiene behaviour. The study could break new ground and lead to new approaches which will lead to benefits in better health and hygiene promotion.

Estimated cost: R1 266 000  
Expected term: 2004 – 2007

**Health and hygiene education**  
*Mvula Trust*  
No 1634

The main objective of this programme is to support 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.

# KSA 3 (continued)

## Water Use and Waste Management

The following research topics will be addressed under this programme:

- Investigation of the linkage between poor sanitation and HIV/AIDS and also possible linkage between the high incidence of cholera outbreaks and prevalence of HIV/AIDS infection
- Investigate modes for the spread of cholera in South Africa and recurrence of cholera outbreaks
- Development of indicators for measuring health improvement and assessing the use of proxy indicators; this should include evaluation of the impact of health and hygiene in the creation of a demand for sanitation
- Guideline: **Education and Awareness Building on the Detrimental Effects of Pollution**

Estimated cost: R 800 000  
Expected term: 2005 –2007

**Programme 2:**  
**Peri-urban sanitation research**  
*Drainage in rural and peri-urban townships*  
*Water Systems Research Group, University of the Witwatersrand*  
**No 1440**

It is well known that drainage in low-income areas is lacking, leading to increased risks of flooding and environmental health. South Africa suffers from a backlog and inadequacy in drainage services, particularly in peri-urban and rural areas. The differentiation between sewage, grey water or sullage and stormwater is often unclear. In fact, in low-income areas, the paths are often merged. Sewage and solid waste enter surface drains, and pose health threats, are not aesthetic and degrade the environment. In high density, informal settlements, these services are often non-existent or at the most are inadequate and dangerous. Stormwater runoff from low cost townships is polluted by waste and overflows from toilets and goes untreated to watercourses. In some cases, the water is re-used posing a health hazard. There is no separate disposal mechanism for sullage. Even where pit latrines or chemical closets are provided, the sullage is discharged onto the surface. This study aims to investigate and pilot alternative methods of drainage systems for low-income areas. The output will be a user guide and software that would assist decision makers in the field.

Estimated cost: R 520 000  
Expected term: 2003 – 2005

**Programme 3:**  
**Knowledge/information management and advocacy**  
*Knowledge/information management and advocacy*  
*Hlathi Development cc.*  
**No 1635**

The overall aim of this programme is to improve access to sanitation research information and to develop effective mechanisms for promoting implementation of best practice by the sector role-players. The study will investigate:

- Development of a sanitation knowledge/information dissemination strategy including appropriate distribution channels, for example, the concept of sanitation resource centres
- Preparation of sanitation best practice guidelines

Development of a strategy for promoting application of research, this research should address the whole process from research topic identification to dissemination, advocacy, and the integration of new knowledge into human resource development initiatives within the sanitation sector.

Estimated cost: R 300 000  
Expected term: 2005 –2006

**Programme 5:**  
**Technical sustainability of sanitation services**  
*Research into urine diversion toilets in eThekweni*  
*University of KwaZulu-Natal*  
**No 1629**

The study aims to provide a scientific basis for the design and operation of urine diversion (UD) toilets, evaluate their effectiveness and determine the fate of *Ascaris* eggs in the toilets. The study puts forward a problem that is emerging around service delivery issues related to the use of urine diversion toilets. Ethekeweni has taken on the championing of the technology and has modified its design. Success of Ethekeweni's initiative will be of relevance to the rest of the country in the use of the technology. This research is a direct outcome of a strategy workshop

hosted by Ethekeweni and WRC. The fate of pathogens in UD toilets is not clear, that is what happens to pathogens in a dehydration process that is the basis of the operation of UD systems. This lack of understanding is an inhibitory factor in the use of pit contents, as well safe handling of faecal sludge. Thus, the management and operation of the UD provide greater challenges than just the sanitation convenience. The study intends to find answers to these challenges which would make the option of UD more acceptable and improve the management aspects.

Estimated cost: R 600 000  
Expected term: 2005 –2007

**Scientific support for the design and operation of ventilated improved pit-latrines (VIPs)**  
*University of KwaZulu-Natal*  
**No 1630**

The project aims to investigate and determine the fate of different pit-latrines additives and their performance, using newly developed testing procedures in wastewater treatment. The project is very important in light of previous attempts by the WRC to evaluate pit additives that did not live up to promise. The sector is continuously in demand for this information.

Estimated cost: R 600 000  
Expected term: 2005 –2007

**Programme 6:**  
**Financial sustainability of sanitation services**  
*Financial sustainability of sanitation services*  
*Partners in Development*  
**No 1632**

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices:

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall cost strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best-practice case studies
- Exploration of credit finance options for household sanitation improvement programmes

Estimated cost: R 600 000  
 Expected term: 2005 –2007

Herewith a list of the new projects which commenced between 1 April 2006 and 31 March 2007.

## New Projects

### Thrust 1: Water Services – Institutional and Management Issues

**Programme 3:**  
*Innovative management arrangements- Rural water supply*  
*Productive use of domestic water for sustainable livelihoods*  
*Nemai Consulting*  
**No 1666**

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional sources to improved water supplies and the requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor these additional requirements of water for poor communities to be able to sustain their livelihood. Further the general approach and thinking to productive uses is limited to small-scale agriculture; however in many cases domestic

water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities and establish the levels of supply that will be adequate. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems

Estimated cost: R700 000  
 Expected term: 2006-2008

**Programme 4:**  
*Regulation in the water services sector*  
*Review of regulatory aspects of the water services sector*  
*AWI*  
**No 1667**

The changing water services institutional and legislative environment in South Africa has indicated the need for a strong and competent regulatory component to oversee the activities of the sector, such that objectives of sustainability, equity and efficiency are achieved and maintained. There had been many debates and discussions on this topic area, as to whether the regulatory function should be an independent function or whether the sector can afford a regulatory function and who will finance such an initiative, etc. DWAF has commissioned a number of studies in this regard, to address many of these queries and questions which have emerged. However, the subject area is very new to the sector and there is a great deal of information requirements to support decision making and input to support this regulatory function. The area also poses many challenges in its implementation. The study aims to support and build on national initiatives to find optimum models and mechanisms for effective regulation of the water services sector. The study will cover:

- Review of international models for water services sector regulation and highlight pros and cons of the different regulatory models
- Assessment of institutional and human capacity required to implement sector regulation
- Evaluation of the cost implication of sector regulation on municipalities

- Exploration of the feasibility of using incentives to regulate the water services sector
- Investigate international best practice on proper regulation, identifying institutional, financial and operating procedures of relevance to South Africa
- Investigating and evaluating case studies of independent regulation and central regulation, capturing lessons and experiences of relevance to the South African situation
- Investigate water sector and consumer opinion on independent vs. central regulation and aspects that should be addressed
- Determine the scope of water services regulation and the linkage/integration with water resource management
- Identify the capacity and competency requirements to facilitate regulation across the sector
- Evaluation of the cost implication of water sector regulation and its impact on tariffs/ chain of costs
- Exploration of the feasibility of using incentives to regulate the water services sector.

Estimated cost: R 800 000  
 Expected term: 2006-2008

**Programme 5:**  
*Impact of water and sanitation interventions*  
*Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa*  
*Johannesburg University of Technology*  
**No 1700**

Over the years, the government has spent billions of rand to meet the backlogs 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

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## Water Use and Waste Management

to quantify the benefits (social, technical, health, economic and environmental). Thus, the time is most appropriate for a study of this nature.

Estimated cost: R 1 200 000  
Expected term: 2006-2008

### Thrust 2: Water Supply and Treatment Technology

**Programme 2:**  
*Water treatment for rural communities  
Compliance of non-metropolitan South  
African potable water providers with  
accepted drinking water quality and  
management guidelines and norms*  
University of Fort Hare  
No 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other, operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers that are preventing compliance to these guidelines and norms, and communicate these solutions to the municipal management authorities. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000  
Expected term: 2006-2009

*Investigate the state of plumbing used  
in South Africa*  
University of the Witwatersrand  
No 1701

The project will investigate the state of plumbing used in South Africa and provide guidelines for the appropriate use of plumbing and components to ensure correct application and optimum cost-benefit values, also in the long term. The investigation will include the effect of not using plumbing material components complying with minimum national standards, nor installed according to installation and design codes of practice;

product performance standards for showers, aerators, flow restrictors, dual flush toilets, low flush systems, etc.; condition of retrofitted products and the effect and suitability of high-pressure domestic plumbing systems on product life performance and system life, water wastage and system performance.

Estimated cost: R 600 000  
Expected term: 2006-2008

*Assessment of the feasibility of using  
a dual water reticulation system in  
South Africa*  
University of Johannesburg  
No 1702

The option of dual reticulation, that is supply of different qualities of water, for drinking and flushing/gardening, continues to receive a great deal of queries from a high political level to a local level. Much work has been done on this subject at an international level, and at a local level the option has been investigated in the past. The verdict was that it was not a favourable option due to costs and management constraints. However, the technology has evolved since then and great strides have been made on the subject. With the current and future challenges facing South Africa the opportunity exists to revisit the subject area and determine the state of knowledge and its applicability to South Africa.

Estimated cost: R 600 000  
Expected term: 2006-2008

### Thrust 3: Wastewater and Effluent Treatment Reuse Technology

**Programme 1:**  
*Biological sewage treatment processes  
A status quo assessment of the effectiveness  
of wastewater pond systems for containment  
and treatment of wastewaters, and the  
development of practical operating  
guidelines*  
Emanti Management (Pty) Ltd  
No 1657

In various parts of the RSA, algal ponding systems constitute a significant proportion of the installed capacity for sewage treatment

and have generally been effective in limiting environmental pollution and associated health impacts. In a preliminary study of waste-stabilization ponds recently commissioned by the Free State DWAF office, the current status of waste-stabilization ponds in the Free State was documented. Some of the key findings from the study were that the pond systems were generally well-designed and showed good operational performance, but scored very poorly in terms of maintenance, safety and supervision/management. A simple strategic decision-support tool was accordingly developed to guide future interventions. Considering that the above situation is not only limited to the Free State but is commonplace throughout the RSA, there is a need to document the occurrence of pond systems throughout the RSA, investigate their current operational status and practices followed, identify in what instances the technology is applicable or whether alternative technologies should be considered, identify how operation and maintenance (O&M) of these systems can be improved (through capacity building, technical guidelines, monitoring, etc.), and assess the potential for reusing treated effluent from pond systems. These aims are addressed in this project, using the Free State and the Eastern Cape as case-study areas. Guidelines will be prepared highlighting O&M procedures, common issues of concern, best practice techniques, criteria for selection of treated effluent for reuse purposes and criteria for selection of alternative technologies (if applicable). The existing MS Excel-based strategic support tool will be updated and further developed to a web-based format, allowing easy access to pond system information for all relevant stakeholders.

Estimated cost: R700 000  
Expected term: 2006-2008

*Evaluation of a South African clinoptilolite for  
ammonia-nitrogen removal from secondary  
sewage effluent for pollution control*  
Univ.Pretoria/ Dept. of Chemical Engineering  
No 1658

Ammonia discharged into the water environment accelerates eutrophication of dams and depletes dissolved oxygen in receiving waters, and, in its undissociated form, is also toxic to fish even at low concentrations (0.5 mg N/ℓ). The current discharge limit for am-

monia-nitrogen (NH<sub>3</sub>-N) in treated sewage effluent is 10 mg/ℓ (likely to be reduced to 6 mg/ℓ in the near future). At many wastewater works in the RSA, particularly in winter when biological activity slows down because of lower temperatures, it is difficult to produce treated effluent containing less than 10 mg/ℓ NH<sub>3</sub>-N by the usual biological nitrification process, with consequent negative environmental and ecological impacts. As an alternative or stand-by process, absorption of NH<sub>3</sub>-N by clinoptilolites (naturally occurring zeolites) has potential as an effective low-cost means for final polishing of treated sewage to reduce NH<sub>3</sub>-N to acceptable levels. Previous work in this regard has been carried out using imported clinoptilolites, with cost and forex implications, and knowledge is needed in the RSA on the performance of the locally-mined clinoptilolite for removing NH<sub>3</sub>-N from treated sewage. The aims of this project are to determine the performance of local clinoptilolite for removing NH<sub>3</sub>-N from treated sewage effluent on laboratory- and pilot-scale, to determine the efficiency of ammonia recovery from the spent regenerant, to develop appropriate process design criteria and costs, and to develop an operational and maintenance manual for the process.

Estimated cost: R317 000  
Expected term: 2006-2008

**Design Manual for Small Sewage Treatment Works**  
*Waterscience cc*  
**No 1660**

Many of the 1 500 (approximately) sewage treatment plants in the RSA are classified as 'small' works. The existing manual for the *Design of Small Sewage Treatment Works* was prepared by the Institute of Water Pollution Control (IWPC) some 20 years ago and is in need of updating as several new processes are available and the understanding of the activated sludge process, in particular, has advanced significantly since then. The manual also does not consider processes used in small plants of the package plant type as are commonly used in housing complexes. With technological advances and a number of changes in the procedures used in plant operation, a new manual covering these changes is required. The aims of this project are to evaluate current wastewater treatment

practices used in the RSA and internationally for small sewage treatment plants, produce a design manual for such plants, and conduct workshops to disseminate the information included in the manual as part of capacity building

Estimated cost: R250 000  
Expected term: 2006-2008

**Support to EU - EUROMBRA project Development of an anaerobic membrane bioreactor**  
*University of Natal/Pollution Research Group*  
**No 1661**

The highest development priority in the RSA 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 the RSA. This project supports an EU programme, and the potential for roll-out to a wider base, e.g. SADC/Africa/developing world, is thus strong.

Estimated cost: R 693 280  
Expected term: 2006-2008

**Programme 2: Sludge characterisation, treatment, utilisation and disposal**  
*Adopting internationally acceptable methods and building capacity to measure helminth ova in wastewater and sludge samples*  
*Zitholele Consulting (Pty) Ltd*  
**No 1662**

The WRC has funded the development of the *South African Wastewater Sludge Guidelines Volume 1 (Selection of Management Options)*. 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.

Estimated cost: R273 000  
Expected term: 2006-2007

**Programme 7: Sewerage reticulation**  
*A first-order national audit of sewerage reticulation issues*  
*Industrial and Urban Infrastructure (Pty) Ltd*  
**No 1671**

According to research needs analyses a range of issues relating to stormwater control and management require to be researched. The issues concerned range from strategic aspects such as norms and standards for stormwater management for informal and/or temporary settlements to more specific technical issues such as the need or otherwise for stormwater treatment before discharge, associated health concerns, the potential for stormwater reuse, e.g. for selected industrial uses, flood peak-to-average ratios, etc. This solicited project will aim at identifying, char-

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## Water Use and Waste Management

acterizing and prioritizing stormwater management issues requiring attention in human settlements, and developing strategic guidelines for dealing with these.

Estimated cost: R 400 000  
Expected term: 2006-2007

### **Programme 8:** **Development of guidelines for stormwater management strategies within integrated urban water management**

*Biotechnological co-treatment of industrial / mining effluents with sewage wastewaters*  
SRK Consulting  
No 1670

Sewerage reticulation systems represent a considerable capital investment in the overall provision of waterborne sanitation. Apart from recent research into developing technical alternatives to the conventional gravity sewer such as small bore ('solids-free') sewers, shallow sewers and vacuum systems, the sewerage systems responsible for receiving and reticulating sewage flows have received less attention than other sanitation issues. In this context the sanitation system employed is of obvious relevance, e.g. whether conventional waterborne, low-flush waterborne, or urine-diversion types, etc. From interactions over a period of time with a number of key stakeholders, it appears that the state of current, up-to-date knowledge is inadequate around a range of issues regarding sewerage reticulation in the RSA. This solicited project is being commissioned by WRC to provide a first-order assessment of the sewerage situation in the RSA, with the aims of identifying, characterizing and prioritizing the sewerage reticulation issues requiring attention, and developing strategic guidelines for dealing with these. The findings of this project will form the framework for and lead to a future roll-out of focused research projects dealing with specific topics.

Estimated cost: R 400 000  
Expected term: 2006-2007

### **Thrust 4:** **Industrial and mine-water management**

#### **Programme 3:** **Minimising Impact of Waste on the Water Environment**

*Arsenate resistance in microbial communities developing in maturing FA-AMD solids*  
University of the Western Cape/ Department of Microbiology  
No 1655

The WRC and the mining industry are investigating the use of fly ash to neutralize AMD and produce useful by-products, such as zeolites. The use of fly ash- AMD substrate as backfill in underground mines is under consideration. However, the potential mobilisation of undesirable metals and other contaminants by microbial activity, give rise to concern. A recently completed project (No. 1549) found that while microbial populations are slow to develop in the substrates, they are readily sustained once they are introduced. This project will continue with the current research and study specifically arsenate reactions, as proxy for other contaminants that are subject to redox reactions.

Estimated cost: R 220 000  
Expected term: 2006-2008

*Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments*  
Pulles, Howard and 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: R 501 300  
Expected term: 2006-2008

**Programme 4:**  
**Minimising waste production**  
*An investigation of innovative approaches to brine handling*  
Proxa  
No 1669

The problems associated with the management of inorganic waste products, (sludges and brines) that are being produced as a result of water treatment and recycling, present a major stumbling block to improved wastewater management. Available technologies are either prohibitively expensive or unsatisfactory because of the long-term liabilities and associated risks to water resources. This project will develop management solutions appropriate for the South African situation by assessing the current situation, establishing the present state of the art, developing a fundamental understanding of brine chemistry and the identification and proof of concept testing of promising innovative solutions. Promising solutions, which pass the proof of concept test, will be further evaluated in follow-on projects

Estimated cost: R 1 290 000  
Expected term: 2006-2008

*A pilot study into upstream cleaner production technologies for the petroleum refining industry to meet the requirements of the waste discharge charge system (WDACS)*  
Process Optimization and Resource Management  
No 1673

The main objectives of the Waste Discharge Charge System (WDACS), imminently due for implementation by DWAF, are to reduce water pollution by encouraging efficient resource utilization (incentive objective), recovering the costs of activities aimed at pollution abatement and damage caused by pollution (financial objective), discouraging excessive pollution (deterrent objective) and promoting sustainable water use (social objective). This project aims to develop an understanding of the treatment processes, applicable to various industries, which could be used to meet the requirements of the WDACS. The project will use a petroleum

refinery as a case study to investigate the financial impact of the WDCS on industry and to investigate source-reduction cleaner-production (upstream) options as opposed to an end-of-pipe treatment approach, exploiting a current real-life opportunity where these approaches to pollution prevention can be quantitatively compared. The specific aims of the project are to develop a prioritized list of upstream treatment technologies for the petroleum refining industry, and to quantify the financial implications to the petroleum refining industry of meeting the WDCS requirements.

Estimated cost: R229 200  
Expected term: 2006-2008

**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: R 337 600  
Expected term: 2006-2008

**Thrust 5:**  
**Sanitation and Hygiene Education**

**Programme 1:**  
**Rural sanitation 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 compound 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: R 800 360  
Expected term: 2006-2008

*A guideline document for the implementation of sanitation, health and hygiene education (HHE) programmes in informal settlements*  
*Nemai Consulting*  
**No 1656**

The provision of a guideline/tool for promotion of HHE in informal areas is a gap identified by current research. The attention and priority given to 'informal settlements' is generally lacking with the notion that people do not belong there. Also, current planning approaches neglect the situation and challenges in these settlements resulting in a burden of poverty and diseases. This has a negative impact on the wider society and approaches need to be introduced to ensure that informal settlement are afforded the knowledge of basic health issues which affect their environment.

Currently the services of environmental health workers are usually not directed at sanitation related health & hygiene promotion. Very few WSAs have a sanitation department/unit that deals with low-cost sanitation. Even fewer WSAs have sanitation managers. Where such sanitation departments/units exist, and there are sanitation managers, there are limited numbers of sanitation services managers who understand the specific requirements (and institutional demands) posed by alternative sanitation delivery. Ultimately, where there are such units, and they are managed, they do not have the human resources to address the technical, DRA and H&H requirements related to the provision of non-waterborne sanitation.

This study is a small step in assisting water services to engage with informal areas in the promotion of HHE and sanitation. The tool to be developed is aimed at empowering them on how to address the situation and provide a sustainable service. The current typhoid outbreak is a good example of the lack of education in informal areas, alleviated by poor management of water and sanitation services.

Estimated cost: R 570 000  
Expected term: 2006-2008

*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 already available posters, pamphlets and reports available at the WRC, DoH, DWAF and

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other such documents developed by water suppliers, NGO, DoE (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: R 400 000  
Expected term: 2006-2008

### **Programme 2:**

#### **Peri-urban sanitation research**

*Effective demand for alternative sanitation options in peri-urban settlements*

*Sigodi Marah Martin (Pty) Ltd*

**No 1664**

This project offers an innovative approach of using tried and tested approaches of contingent evaluation approaches that aim to improve the science and understanding of sanitation demand by exploring and applying existing and tried and tested approaches to sanitation. Through this process, it aims to provide knowledge and information as to what people in low-income areas are willing to pay for sanitation. This kind of knowledge and information is lacking. The lack of this information results in unpopular decisions and programmes being made on behalf of recipients. Further, this information could be relevant to informing policy at a national level and local level towards better programmes that are sustainable.

Estimated cost: R710 000  
Expected term: 2006-2008

### **Programme 4:**

#### **Institutional and management aspects of sanitation service delivery**

*Sustainable options for community level management of grey-water in settlements without on-site waterborne sanitation*

*University of Cape Town/Department of*

*Civil Engineering*

**No 1654**

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects, which

influences the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be possible for extension to the rest of South Africa. This will be supported by preparation of education material for community level training concerning grey-water management options and techniques.

Estimated cost: R 750 000  
Expected term: 2006-2009

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# 4 KSA 4 Water Utilisation in Agriculture



**Dr Gerhard Backeberg: Director**

## Scope

The strategic focus in this KSA, as described in previous years, is on increasing the efficient use of water for production of food, fibre, fuel-wood and timber; ensuring sustainable water resource use; reducing poverty and increasing the wealth of people dependent on water-based agriculture. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers is addressed through creation and application of water-efficient production technologies, models and information systems within the following inter-related sub-sectors of agriculture, namely:

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

The challenge for applied research and knowledge dissemination is to provide solutions to practical problems which are experienced in the process of utilisation, development and protection of water resources, thereby contributing to productivity growth in agriculture.

## Objectives

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

Portfolios of current projects have been grouped into strategic thrusts and programmes which directly address the above-mentioned objectives and are summarised as follows:

## Thrusts and programmes

### Thrust 1: Water Utilisation for Food and Fibre Production

**Scope:** The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.

Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in 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 fuelwood 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.

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

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.

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 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.

### 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 2006/07

In this KSA a holistic approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Key issues being addressed are the productivity of water use for crops and livestock, poverty eradication in rural areas and prevention of resource degradation. These efforts are aligned to the agricultural sector plan in South Africa and to the comprehensive Africa agricultural development programme of NEPAD. Work will continue to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following themes of the research portfolio:

- Irrigation and water use efficiency

- Fitness for use of 'grey-water' in peri-urban agriculture
- Water use efficiency in agro-forestry and woodlands
- Aquaculture in rural livelihoods
- Rainwater harvesting and conservation
- Adaptive research of technologies in rain-fed and irrigated agriculture
- Technology transfer of water management models
- Impact of land use management on point and diffuse pollution in agriculture.

During the past three to four years a strategic shift has been made to achieve a balance between research projects in irrigated and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further to practical application of results with technology transfer projects. In future research, emphasis will be placed on water use of drought-tolerant staple food crops and fruit tree crops; technically appropriate, socially acceptable and economically viable water harvesting and conservation practices; water treatment for food safety; guidelines and training material for on-farm and on-scheme water management; and optimisation of water use and value adding in the food supply chain.

## Budget for research portfolio in 2006/07

The approved funding of the research portfolio for 2006/07 leads to a committed funding budget of R17 791 532.

The focus of this portfolio will continue along the current trends.

## Core Strategy

### Strategic context

The water resource base is of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people.

Water utilisation can best be quantified as rainfall-dependent, surface water- and groundwater-dependent use. Approximately 12% and 62% of rainwater in South Africa is used annually for respectively dry-land cropping and by natural grasslands, woodlands and forests. Rainwater runoff and deep percolation become available as surface- and groundwater of which approximately 62% is used for irrigation. It is therefore clear that the biggest share of water is used for both extensive and intensive production in agriculture.

In South Africa, at least 35% of the economically active population are directly or indirectly dependent on agriculture. This consists primarily of small-, medium- and large-scale enterprises, which provide employment opportunities for formal and casual labour. Furthermore, 42.7% of the population are rural survivalists with traditional agrarian lifestyles. Recent estimates also show that 48.5% of the population are living below the poverty line.

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low at 4 to 5% of gross domestic product (GDP). The forward linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Agriculture is also a net exporter of food, contributing 10% of total exports of which 50% are processed products.

Critical issues in the forthcoming years and next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing income levels of consumers. Expansion of agricultural production on land suitable for cultivation will be constrained by the availability of water. At the same time there is a high ratio of people to cultivated land and a dependence on agriculture in rural areas, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences.

Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background the strategic focus of water research in this KSA will continue to be on:

- Increasing the efficiency of water use for food, fibre, wood and timber production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Ensuring sustainable water resource use in rain-fed and irrigated areas (i.e. improving the knowledge of natural processes and people-induced impacts of resource use)
- Increasing the household food security and profitability of farming and thereby the livelihoods of people dependent on agriculture (i.e. improving the knowledge of management processes by people who are using water).

In drawing up plans to implement these strategies, cognizance has to be taken of the following factors:

### Needs analysis

Previously identified needs, re-affirmed by recent reports, continue to give direction to applied research.

During 2000 the Presidential Imperative Programme on Integrated Sustainable Rural Development was announced. The goal of the programme is to promote development and improve the quality of life of

marginalised groups and communities. The objectives are to alleviate poverty through enhanced production, productivity, creation of employment opportunities and a more equitable distribution of resources. Outputs which are envisaged include agricultural production systems and sustainable utilisation and management of natural resources and the environment.

At the end of 2001 the Strategic Plan for South African Agriculture was released by the National Department of Agriculture, Agri SA and the National African Farmers Union (NAFU). The strategic goal is to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural sector, contributing to a better life for all. This strategic goal is expected to guide all relevant partners in their quest to deliver and implement a range of programmes in accordance with basic premises of amongst others:

- Fair reward for effort, risk and innovation
- Security of tenure for present and future participants
- The sustainable use of natural and biological resources
- Sound research, science, knowledge and technology systems
- Market forces which direct business activity and resource allocation.

The outcomes which are envisaged to flow from successful implementation of programmes include:

- Increased creation of wealth in agriculture and rural areas
- Increased sustainable employment
- Increased income and foreign-exchange earnings
- Reduced poverty and inequalities in land and enterprise ownership
- Improved farming efficiency
- Improved national and household food security
- Increased investment in agricultural activities and rural areas.

One of the three core strategies which are discussed in the strategic sector plan for agriculture is sustainable resource management which also impacts on water systems. Central

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

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 of the New Partnership for Africa's Development (NEPAD) (2003), places the focus on land and water management as one of three 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 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) finds that 'the poverty problem remains a predominantly rural phenomenon'.

Furthermore farming still provides 'a major source of income for many rural communities in South Africa' and therefore contributes to poverty alleviation. This role can be strengthened by investment in the drivers of agricultural development, namely human capital, biophysical capital, rural institutions and agricultural research. The conclusion is 'nonetheless, while agriculture plays a major role in poverty alleviation, promoting the growth of smallholder agriculture alone cannot solve the poverty problem in South Africa. More attention should also be given to the promotion of non-farm activities (e.g. agro-industries), particularly those that are linked to the smallholder agricultural sector. A strategy that strengthens farm/non-farm linkages is likely to yield better results with regard to employment and income generation'.

These needs as expressed by government and farmer representatives at a national and regional level are still relevant and as in previous years, highlight the key issues which must be addressed in the WRC research portfolio:

- Increased productivity of water for crop and livestock production
- Uplifting rural economies through commercial production
- Eradication of hunger and poverty
- Prevention of soil and water degradation
- Involvement of farmers in research.

### Technological trends

Efforts continue to stay at the forefront of technological developments and ensure application of existing technologies. This is achieved by purposefully leading the innovation cycle, which involves scientific research, practical application of inventions and exploitation of the commercial potential of the research output. A balance must therefore be found between research projects and technology transfer projects and also between research on appropriate technologies for irrigated and rain-fed agriculture.

With growing demand for water in the domestic and industrial water-use sectors, the competition for water currently used for agricultural production will increase in future. Technologies, models and methods are available to improve the efficiency of irrigation water use in different stages of, e.g. canal and on-farm water distribution, field application and irrigation scheduling. With the demand

for food also increasing in a globalised trade environment, agricultural production will have to be competitive in both local and overseas markets. While irrigated agriculture contributes 25 to 30% of gross production, technological and managerial innovations are required in all subsectors of agriculture to reduce costs and increase income.

In particular, attention will have to be given to rain-fed agriculture and the existing technologies which have been developed for water harvesting in Sub-Sahara Africa. The impending challenge for research is therefore to adapt or develop and apply technologies which will enable water conservation in rain-fed agricultural production on dry-lands, grasslands and woodlands. In the case of irrigation, locally available technologies must be integrated and the financial benefit of efficient water use must be demonstrated over all stages of water distribution and application. Emphasis must be placed on making all technologies and models user-friendly. This requires attention to the specific needs of traditional subsistence farmers and modern commercial farmers.

The twofold effort to develop technologies for increased water-use efficiency in both rain-fed and irrigated agriculture, is also in support of global trends: As part of the water focus of the World Summit on Sustainable Development (WSSD), the recommended target is to increase water productivity in rain-fed and irrigated agriculture to enable achievement of food security for all people without increasing water use above levels for 2000. Furthermore, one of the four programmes identified within the New Partnership for Africa's Development (NEPAD), is to expand the extent and operation of integrated land and water management, with the main emphasis on eradication of poverty in Africa. These trends have been re-enforced by the Comprehensive Africa Agriculture Development Programme of NEPAD, published in July 2003.

### Key stakeholders

Firstly, key stakeholders in this KSA remain as previously described. These are farmers who are represented by Agri SA and NAFU. Altogether these are an estimated 50 000 commercial farmers, 240 000 emergent farmers and 3 million subsistence farmers. Secondly, at local, provincial and national levels, key stakeholders are water user as-

sociations (WUAs), catchment management agencies (CMAs), Provincial Departments of Agriculture, the National Department of Agriculture and the Department of Water Affairs and Forestry. These individuals, groups and organisations remain the key stakeholders with which the WRC has to engage.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies must be designed 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 stayed the same as in previous years and are the Provincial Departments of Agriculture (PDAs), the National Department of Agriculture (DoA) through its Directorate: Water Use and Irrigation Development and the Department of Water Affairs and Forestry (DWAF) through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC is an initiative by DoA to give policy direction to development through integrated water management for agricultural use and DWAF has completed five pilot projects to implement the water conservation and demand management strategy in agriculture. An Interdepartmental Co-ordinating Committee on support for small-scale irrigation has also been formed, and as part of this action a task team is revising guidelines for project evaluation.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The NPA of Integrated Development 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, has a Sub-Regional Office for Southern Africa in Pretoria. Since the establishment of the IWMI Africa Office, which is now based in Ghana, the WRC is serving on the IWMI-South Africa Consultative Committee with the main function to determine priorities for IWMI's work in this sub-region. The mission of IWMI is to improve water and land resource management for food, livelihoods and nature. Research is done under four revised themes:

- Understanding basin-scale water productivity
- Increasing water productivity for sustainable livelihoods
- Low quality water, livelihoods, health and nutrition
- Water, sustainable agriculture and ecosystems.

The responsibilities of the South African Office include leadership and supervision of all work in Southern Africa; promoting strategic, applied research, capacity building and professional development; and collaboration with national, regional and international organisations.

#### *Providers of research*

The main suppliers of research projects are universities and technikons/colleges (currently Universities of Pretoria, KwaZulu-Natal, Free State, Stellenbosch, Rhodes, Fort Hare and Tshwane University of Technology); science councils (various Institutes of the Agricultural Research Council (ARC) and Environmentek of the CSIR); as well as established and emerging private consulting groups.

### *Strategic Initiatives Undertaken During 2006/07*

#### *National initiatives*

Following the re-election as Chairperson of the South African National Committee on Irrigation and Drainage (SANCID) for a 2<sup>nd</sup> term of 3 years, the annual general meeting

and two ordinary meetings were organised and chaired during April and September 2006 respectively. The most important event in this reporting period was the biennial SANCID 2006 Symposium which was held from 15-17 November 2006 at the Aventura Swadini Resort, Mpumalanga Province. The theme of the Symposium was 'The Changing Face of Irrigation in Southern Africa' and was attended by 106 delegates from different parts of the country. The opening address was delivered by the Chairman of SANCID and two sessions were chaired by WRC staff. It is noteworthy that one upgraded invited paper and 14 out of the 25 contributed papers which were presented are based on WRC research projects.

During the middle of the year the Network on Irrigation Research and Extension for Small-scale Agriculture (NIRESA) held its annual workshop at the Dzindi Irrigation Scheme in Limpopo Province from 19 to 20 July 2006. The workshop was organised and chaired by the WRC and involved 15 participants from the national and provincial departments of agriculture, science councils, universities and private companies. The themes for the workshop were 'Land tenure on smallholder irrigation schemes; collective action in relation to markets; water allocation in canal schemes and the role of extension on canal schemes'.

In order to compile a database of water-related research projects on agriculture, a questionnaire had been sent to 46 representatives of research organisations but was returned by only 22 of them. This low response (48%) will require more effort to compile a comprehensive database of water-related research projects on agriculture in South Africa.

During July 2006 the staff of KSA 4 made inputs and participated in the External Institutional Review. Based on the constructive comments made on the strategic direction and content of the business plan, it can be concluded that the review has led to positive outcomes.

#### *African leadership*

As part of the African leadership the WRC was represented in the 2<sup>nd</sup> Workshop on Agricultural Water Management for Eastern and Southern Africa from 18-22 September 2006 in Mozambique, which

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

was initiated by the International Fund for Agricultural Development (IFAD) together with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and ICRISAT (an institute of CGIAR) under a programme known as 'Improved Management of Agricultural Water in Eastern and Southern Africa' (IMAWESA). The purpose of the workshop was to facilitate the sharing of knowledge and experiences between those who conduct research, implement, manage and plan programmes in Agricultural Water Management (AWM) for smallholders, and the policy and investment decision-makers at national, regional and global levels. A key African initiative of KSA 4 has been its involvement in the Southern African Regional Association (SARIA), which the WRC is chairing. Attending the workshop provided the opportunity to discuss follow-up arrangements with members of the Southern African Regional Irrigation Association (SARIA) and further negotiate cooperative projects between Kenya, Tanzania and South Africa.

In the capacity as Chair of SANCID, the WRC submitted a proposal to host the 2<sup>nd</sup> African Regional Conference in South Africa during November 2007, which was accepted by members of the International Executive Council (IEC) of the International Commission on Irrigation and Drainage (ICID) on 16 September 2006 in Kuala Lumpur, Malaysia. A local Organising Committee consisting of staff members of the WRC, DoA and ARC has been constituted and the Programme Sub-Committee which is representative of the Southern, Western, Eastern and Northern regions of Africa as well as Finance Sub-Committee will be convened by the WRC.

During the ICID meetings in Malaysia further discussions took place to initiate a workshop to which members of SARIA were invited. These members are representatives of SADC countries who are presently or potentially members of ICID. The WRC in partnership with the DoA presented the workshop on 'Training to Promote Experiential Learning and Participatory Water Management by Farmers on Smallholder Irrigation Schemes' on 6-7 February 2007. The training was based on two WRC projects, namely **Building capacity in irrigation manage-**

**ment with wetting front detectors**, (WRC Report No TT230/04) and **Revitalisation of smallholder rainfed and irrigated agriculture – Guide for farmer trainers and facilitators**, (WRC Report No TT254/1-3/05). Over the two days the focus was on respectively experiential learning by means of the Wetting Front Detector (WFD) and participatory irrigation management through the **Guide for Farmer Trainers** (GFT). The programme manager of the International Programme for Technology and Research in Irrigation and Drainage (IPTRID) of the Food and Agriculture Association (FAO) was invited to participate in the workshop. The purpose of the workshop was to start a process to cooperate with IPTRID in providing continued training of farmers to implement the WFD and to present courses based on the GFT in sub-Saharan Africa.

### International initiatives

The triennial conference of the International Association of Agricultural Economists (IAAE) was attended from 12 to 18 August 2006 on the Gold Coast, Queensland, Australia. A contributed paper was presented by Grové B, Oosthuizen LK and Backeberg GR with the title: 'A dynamic risk optimisation model for evaluating profitable and feasible water management plans', which is based on the recently published WRC Report No 1266/1/06 by the University of the Free State. This paper was one of eight contributed papers presented by South African delegates during the conference. In addition the WRC participated in the Council Meetings of IAAE as Country Representative for South Africa.

The 57<sup>th</sup> International Executive Council (IEC) meeting of the International Commission on Irrigation and Drainage (ICID), the 3<sup>rd</sup> Asian Regional Conference and 7<sup>th</sup> International Micro-Irrigation Congress was attended from 10-16 September 2006 in Kuala Lumpur, Malaysia. Two WRC staff members made inputs during ICID Working Group meetings on respectively 'Irrigated agriculture under drought and water scarcity' and 'Management of poor water quality for irrigation'. Four out of six contributed papers presented by South Africans during the Asian Regional Conference are based on WRC research projects.

During the IEC meeting South Africa was awarded the **ICID WatSave Innovative Water Management Award** for the Water Administration System (WAS) which was developed with support and funding by the WRC over the past 20 years. The WAS is currently implemented for management of water requests, releases and accounts on all major irrigation schemes in South Africa, and has led to achievement of significant water savings on these schemes.

## Growing the Knowledge Base

### Capacity-building initiatives

Capacity building and competence development occur at the individual, organisational and community level:

### Individual capacity development

Currently 108 students are receiving training as part of KSA 4 projects, of which 83 (77%) are from previously disadvantaged (PD) backgrounds. The total number of students as well as students from previously disadvantaged background has therefore practically remained constant compared to 2005/06. Twenty eight female students (19 Black and 9 White) or 26% of the total number are receiving project-related training.

The table below highlights the institutions which are actively involved in capacity-building projects for 2006/07:

Organisation	Students from PD background	Total number of students
ARC	3	5
CSIR	7	9
University of Fort Hare	13	13
University of the Free State	9	14
University of KwaZulu-Natal	1	5
Sigma Beta	1	4
PICWAT	2	2
Pretoria University	11	12
Rhodes University	1	1
Rural Integrated Eng	7	8
SASRI	3	3
University of Stellenbosch	2	6
Tshwane Univ of Technology	20	21
Umhlaba Consulting	1	3
Zakhe Training College	2	2
<b>Total</b>	<b>83</b>	<b>108</b>

### Organisational capacity development

Nine current projects are being undertaken by private consultants. Three of these are emerging consultancy groups which have received research funding for the first time.

### Community capacity development

Ongoing efforts are being made to undertake participatory action research projects where farmers benefit directly while the research is being done. At least 50% of the current and new projects involve some form of on-farm research in previously disadvantaged communities which enables project-related education and training of farmers. More concerted focus on this type of research is envisaged for new projects in 2007/08 and thereafter. A draft agreement has been drawn up to license software developed as part of WRC-funded research projects. This has been sent to all project leaders who are currently using programs such as SAPWAT, BEWAB, SWAMP, Irricost, RiskMan and WAS and agreements still have to be finalised.

Leadership in water-centred knowledge comprised chairing national meetings of SANCID, NIRESA and SARIA; participating in international conferences and ICID workshops. An article was published in the international journal *Irrigation and Drainage* (Vol 55, June 2006) with the title 'The research and development strategy for water utilisation in agriculture - responding to diverse needs of farmers in South Africa' by Gerhard R Backeberg and Andrew J Sanewe. This article is based on the paper presented at the Special Session on 'Driving research for change in irrigation and drainage practices', 19<sup>th</sup> Congress of the International Commission on Irrigation and Drainage (ICID), Beijing, China, 12 September 2005.

Effective knowledge-sharing was achieved by organising seven workshops during April and May 2006 to develop the terms of reference (ToRs) for KSA research initiatives. A wide range of stakeholders from universities, science councils, government departments and private consulting groups were invited. During the workshops the strategic research implementation plan and the approach of solicited research proposals was explained. Draft ToRs were drawn up, which were thereafter refined and the final version published on the WRC website for the following solicited research projects:

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

Water use of fruit/tree orchards
Water use of drought-tolerant food crops
Quantitative investigation into the link between irrigation water quality and food safety
Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)
Rainwater harvesting and conservation (RWH&C) for range land and crop land productivity in communal areas in selected provinces in the semi-arid area of South Africa
Assessment of the economically beneficial contribution of water use to value chains in agriculture
Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement

On 6 and 7 June 2006 two information days were held in the Northern Cape Province in cooperation with the provincial Department of Agriculture and Land Reform. The purpose was knowledge dissemination of the findings of the WRC project on **Situation analysis of problems for water quality management in the lower Orange River region with special reference to the contribution of the foothills to salinisation** (WRC *Report No 1358/1/05*). Preparations were made by project staff from the ARC and the University of Stellenbosch and demonstrations took place in the field. Each day was attended by at least 30 farmers and agricultural advisors from local cooperatives. It was agreed that follow-up actions will be discussed with the provincial and national DoA as well as DWAF, to ensure systematic implementation of the recommended guidelines for water quality management and prevention or reclamation of salinity levels in soils.

A workshop on 'Decision Support Models for Irrigation Water Management' was held as part of a WRC project from 6-7 November 2006 to which representatives of 7 water user associations (WUAs) who participate in the project, were invited. During this project a geographic information system (GIS) is being developed in cooperation with the WUAs, and data are collected for implementation of the following models in response to end-user needs:

- SAPWAT for estimation of crop water requirements

- SWB for real-time irrigation scheduling
- RiskMan for simulation of cumulative probability functions associated with irrigation farming
- WAS for irrigation canal management
- ACRU for simulation of hydrology in sub-catchments.

Based on feedback received during the workshop it is clear that the biggest requirement for WUAs is to manage the irrigation scheme, with a related demand for effective implementation of the WAS. The SAPWAT, SWB, RiskMan and ACRU models are more likely to be implemented by advisors or consultants on irrigation schemes. The possibility was discussed to establish helpdesks by WUAs to facilitate an effective support service in order to promote implementation of the models for efficient water use from field to farm to scheme to catchment level.

KSA 4 participated in one WRC Open Day by showcasing relevant projects.

Continued efforts were made to improve the public understanding of water-related issues by means of popular articles in *The Water Wheel*, and providing brief summaries of recently published WRC reports in the magazine *Agri*, which is distributed nationally to farmers and agricultural interest groups. Finally, publication of 10 research reports is planned for 2006/07, while the publication of 1 report has to be postponed to 2007/08 due to extension of the project periods.

## Implementation Plan

### Research portfolio for 2006/07

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.

### Expected outcomes

In KSA 4 a holistic approach is followed to enable people to utilise water in a sustainable way for food production. This contributes towards improved living conditions, maintenance of the productive capacity of water resources and availability of food and fibre products from rain-fed and irrigated cultivation. The participation of end-users in research projects and the application of knowledge generated through research are considered to be key success factors. This approach has been accepted by stakeholders but more time is required to demonstrate impact and therefore no change is considered at this stage.

A description of the research thrusts and programmes is given in Table 1.

**TABLE 1****Overview and description of thrusts and programmes for 2006/07 for KSA 4**

<b>Thrust 1: Water Utilisation for Food and Fibre Production</b>	
<b>Scope:</b> <i>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.</i>	
<b>Programme 1:</b> <i>Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture</i>	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.
<b>Programme 2:</b> <i>Fitness-for-use of water for crop production, livestock watering and aquaculture</i>	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.

<b>Thrust 2: Water Utilisation for Fuel-wood and Timber Production</b>	
<b>Scope:</b> <i>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.</i>	
<b>Programme 1:</b> <i>Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations</i>	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.

<b>Thrust 3: Water Utilisation for Poverty Reduction and Wealth Creation In Agriculture</b>	
<b>Scope:</b> <i>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.</i>	
<b>Programme 1:</b> <i>Sustainable water-based agricultural activities in rural communities</i>	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.
<b>Programme 2:</b> <i>Integrated water management for profitable farming systems</i>	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.

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

### Thrust 4: Water Resource Protection and Reclamation in Agriculture

**Scope:** The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use

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

With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.

**Programme 2:**  
*Impact assessment and environmental management of agricultural production*

Agricultural decisions to use land and to conserve rainfall or to withdraw water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface 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 2006/07

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives of new projects which commenced between 01 April 2006 and 31 March 2007.

### Completed

#### Thrust 1: Water Utilisation for Food and Fibre Production

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

*The effect of deteriorating irrigation water quality on the growth and water use of selected crops*

*Department Soil Science, University of the Free State*

**No 1359**

It is estimated that 20% of the 1.3 million ha of irrigated land in South Africa is salt affected. This leads to reduced crop growth and in severe cases, even crop failure. This project was undertaken to investigate a number of issues regarding the effect of saline irrigation water for crop production on soils with shallow saline water tables. Experiments were conducted with wheat, beans, peas

and maize under controlled conditions in the laboratory, glasshouse and field with irrigation water that ranged from a low salinity of 15 mS/m to a high salinity of 600 mS/m.

In laboratory experiments the germination of only pea seed was reduced by increasing water salinity, viz. to 92% at 300 mS/m. However, water salinity above 150 mS/m started to inhibit the seedling growth of all four crops as indicated by coleoptile/hipocotile and root length. In glasshouse experiments parameters such as relative leaf area, above-ground biomass, root mass and seed yield declined with increasing irrigation water salinity. Peas proved to be the most sensitive crop followed by beans, maize and wheat, in line with literature. The field experiments were conducted in large drainage lysimeters filled with either a yellow sandy Clovelly soil or a red sandy loam Bainsvlei soil in the presence of a water table at 1.2 m. Except for wheat that produced better yields in the more clayey soil, the other three crops produced similar yields on both soils for similar irrigation water salinities. The growth of wheat, maize, peas and beans started to decline when irrigated with water of 600, 450, 300 and 150 mS/m, respectively.

In the field experiments, the evapotranspiration of all four crops declined with increasing irrigation water salinity. This decline is attributed to a decrease of osmotic potential associated with an increase in water salinity. A decrease in the osmotic potential of soil water to -300 kPa (equivalent to an electrical conductivity of 750 mS/m reduced evapo-

transpiration of wheat, maize, beans and peas, respectively by 7, 30, 38 and 53% (i.e. the same order as their tolerance to salinity). However, the water use efficiency of the crops, expressed in production of above-ground biomass per unit water used, started to decline only when the above mentioned irrigation water thresholds were exceeded. Likewise, the crop water uptake from the shallow water tables, decreased with an increase in irrigation water salinity in the same order as their tolerance to salinity.

At the end of a crop growing season the salts were found to have accumulated at or just below the capillary fringe of both soils, with maximum accumulation at 700 mm from the soil surface, where most of the water is taken up by crop roots. A single drainage cycle was able to remove between 2.0 and 35.0 ton salt/ha at a rate of 0.054 kg/ha-mm from the more sandy soil and between 0.8 and 13.5 ton salt/ha at a rate of 0.041 kg/ha-mm from the more clayey soil, depending on the initial salinity. Efficiency of salt leaching from both soils decreased rapidly when the depletion level rose above 80% of the total actual salts removed. Equations were derived to calculate the salt accumulation in soils with restricted drainage during a crop growing season and the amount of drainage water required for salt removal from the two soils.

The findings of this project led to the development of a stepwise procedure that can be followed to formulate the best management practices for controlling root zone salinity under different conditions. This procedure still

needs to be tested, verified and even modified at field scale before it can be extended to optimal practice and the establishment of guidelines for managing the salt load associated with irrigation at farm and scheme level.

Cost: R980 000  
Term: 2003 - 2006

## Thrust 2: Water Utilisation for Fuel-wood and Timber Production

### Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water-use efficiency of multi-crop agroforestry systems, with particular reference to small-scale farmers in semi-arid areas

Department Soil Science and Plant Production, University of Pretoria  
No 1047

The project was conducted in several phases, namely: (a) 'On-station' on the Hatfield Experimental Farm of the University of Pretoria in which pure stands of sorghum, cowpeas, sweet potatoes and *Leucaena leucocephala* were compared with intercropping of *Leucaena* hedgerows with the same crops in the alleys for three seasons; (b) 'On-station' at the University of Pretoria, in which pure stands of sorghum, maize and *Leucaena* were compared with intercropping of *Leucaena* hedgerows with the same crops in the alleys for the two seasons; (c) 'On-farm' sylvopastoral system in Venda to produce forage and fodder for a small-scale communal dairy project; (d) 'On-farm' alley cropping systems (with maize and *Leucaena*), at Sekakane and Chuene Maja, compared with mono-culture maize and (e) Community development in the Sekakane and Chuene Maja areas.

Monitoring of competition for light and water in this project indicated that:

- Row orientation of trees in alley cropping (this changes constantly in insulating conditions where most plantings are on the contour), at the latitudes in the study areas, does not have a major effect on light interception during the summer months, but it could have negative impacts on the southern side of rows in the winter months,

depending on the pruning/hedge row policy for the trees. The effect will also vary tremendously depending on the intercrop. Temperate species generally have lower threshold values at which they can still photosynthesize effectively compared to tropical species, but even within each of these groups there is considerable variation in shade tolerance. Complementary work, conducted at Hatfield, has demonstrated that while virtually all the intercrop annual row crops did extremely poorly in the rows adjacent to the trees, *Panicum maximum* (a tropical C4 perennial grass species) was at its best virtually under the canopy of *Leucaena coppice*. This observation might, however, be confounded by the high fertility under the canopy of the leguminous tree crop.

- While the favourable soil conditions and better rainfall conditions at Hatfield would hypothetically reduce negative competition for water because of the deeper rooting habit of the trees, in practice competition for water in the upper soil layers was very strong in the rows closest to the trees (probably because under the experimental conditions there was little or no recharge of subsoil moisture and trees competed in the shallower horizons for moisture). On the 'on-farm' site at Sekakane which was the only co-operative site to yield satisfactory production data, it appeared that in the poorest season maize survival and productivity was severely impacted up to 5m from the trees, while in the best season ( $\pm 360$ mm of rain which was by no means a good season) maize rows 3m from the trees (border rows of intercrop had the best yielding plants) were affected.

These results should be interpreted in the context of two factors:

- Additional studies conducted on *Leucaena* by the University of Pretoria found that the lateral spread of tree roots was much greater where unfavourable sub-soil conditions impeded root penetration
- Simulations of the water balance (using the SWB model) in a range of soils under a range of rainfall conditions indicate that under unfavourable rainfall conditions there is no water recharge of the deeper soil layers in 6 of the 9 scenarios examined. As a result there would be

strong competition for water between different plant species in the upper soil layers as opposed to complementarity under better growing conditions.

Under marginal climatic and soil conditions (and the latter may be affected by financial ability of small-scale farmers to ameliorate (rip, deep plough, drain, lime, fertilize the soil)), the results from the project support the avoidance of competition between different crops in alley systems and the optimization of mono-culture agronomic practices. Under good climatic and soil conditions (prime land capability with minimal erosion hazard) the choice of land-use system would be governed by economic considerations, although certain land users will persist with less profitable enterprises because of personal preferences. In South Africa, characterized by high climatic variability (even in high potential areas), diversification, mixed farming or spreading the risk is recommended. Where this is practiced annual crops, perennial crops and fodder trees could be combined in a range of alternative land use scenarios, which apart from mono-cultures, crop rotations and intercropping, might include different forms of agroforestry systems.

Considerable inputs into the functionality of different agroforestry models and their uses, has demonstrated that some of these could find application in developing systems or 'what if-scenarios' incorporating trees, which could improve crop productivity and sustainability. At the same time, however, it must be emphasized that extensive research must still be conducted to provide a sound basis for predicting crop and tree productivity. Furthermore, it must be recognized that while the technology of implementing alley cropping systems in harsh environments is still in its infancy it will remain a challenge to gain acceptance by land-users who also have to operate under difficult socio-economic pressures. Agro-forestry/alley cropping should clearly be an integral part of extension programmes designed to provide alternative ways for land users to improve the productivity of their land. It should not be seen as an objective in itself but rather as one of numerous strategies to realize community development goals.

Cost: R1 151 000  
Term: 1999 - 2006

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

### **Thrust 3:** *Water Utilisation for Poverty Reduction and Wealth Creation In Agriculture*

**Programme 1:**  
*Sustainable water-based agricultural activities in rural communities*  
*Principles, approaches and guidelines for participatory revitalisation of smallholder irrigation schemes*  
ARCUSS GIBB  
No 1463

In 2003 the WRC funded a three-year project to develop guidelines for the revitalisation of smallholder irrigation schemes in South Africa. A national database of 317 schemes covering approximately 50 000 ha was compiled. These are located mainly in the former homelands. While most of these schemes have collapsed or are under-utilised they continue to draw substantial funding from the Government for social and economic upliftment, often with limited success. 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.

*'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.

The guidelines present alternative pathways to constructive change on schemes, with full appreciation of the complexity and diversity on and between the schemes. They are based on meaningful involvement and

information exchange between farmers, plot-holders and technical experts and thus ensure co-constructed plans for land-tenure, agricultural, technical, institutional, marketing and financial aspects. Best practice shows that major investment in human capital development is critical and that land-market stimulation can, in many cases, unlock potential. Interventions need to address all aspects of irrigation scheme operation and farm system planning, and avoid single-sector interventions such as infrastructure upgrading, mechanisation or institutional development alone. The *Guidelines* present ways forward to achieve greater success.

Cost: R 1 195 000  
Term: 2003 - 2006

### **Thrust 4:** *Water Resource Protection and Reclamation In Agriculture*

**Programme 1:**  
*Sustainable water resource use on irrigation schemes and within river catchments*  
*Multidimensional models for the sustainable management of water quantity and quality in the Orange-Vaal-Riet convergence system*  
Department of Agricultural Economics,  
University of the Free State  
No 1352

Salinisation of various irrigation schemes has become a problem in South Africa. One such area that experiences salinisation problems is the Lower Vaal and Lower Riet irrigation areas, upstream from where these rivers converge and flow into the Orange River. From a total irrigation area of 12 556 ha in the Orange-Vaal Water Users Association, 23 % is either slightly or severely affected by salinity problems.

The overall aim of this study was to develop and integrate multi-dimensional models for sustainable management of water quantity and quality in the Orange-Vaal-Riet (OVR) convergence system.

A multidisciplinary and integrated research method was identified to be necessary at two levels, namely the micro and macro/regional level. At micro level, biophysical (agronomy, hydrology and salinisation: crop yield functions) are linked to a farm eco-

nomical model which extrapolates to irrigation block level, providing the data required for the regional economic model.

The main results from the research are the following: Salinisation is an important problem in the study area that needs special management attention. The relative importance of the problem differs between WUAs and irrigation blocks. The hydrology results show that the Lower Riet Irrigation Block has the highest soil salt concentration in the upper zone followed by the Orange-Vaal Irrigation Block and the Scholtzburg Irrigation Block, with the lowest soil salt concentrations occurring in the Orange-Riet Scheme Irrigation Block. Economic results show that the greatest loss due to salinity is experienced in the Lower Riet Irrigation Block, to the value of R6 962 per hectare per year, followed by Scholtzburg with R2 596 and the Orange-Vaal Irrigation Block with R2 218.

From various management options, 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. At regional level the direct and indirect benefits of modelled improved drainage (and subsequent investment in higher value crops) proved far greater than the costs of drainage, and produced the highest index for socio-economic welfare (ISEW), and an addition of jobs to the irrigation and linked industries over the long term. The total real cumulative cost (2005 basis) of salinisation over a period of 15 years for the whole study area was calculated at R955 million, a good benchmark to use to leverage funds for remediation action.

This above-mentioned finding presents an overwhelming case for the full sustainability ('green box') grant assistance of additional irrigation drainage in the interest of increased sustainable regional socio-economic welfare.

The main recommendations of this research project is that drainage installation for facilitation of leaching, needs to be promoted in the Orange-Vaal WUA and especially in the Lower Riet Irrigation Blocks in the study area. Factoring in the costs of drainage into irrigators' water use charges, is less than the additional financial benefits derived from the drainage, and should therefore be acceptable to farmers. This should, however,

be re-evaluated with a detailed survey and feasibility study.

Cost: R1 397 950

Term: 2002 - 2006

#### **Programme 2:**

##### ***Impact assessment and environmental management of agricultural production***

*Predicting the environmental impact and sustainability of irrigation with gypsiferous mine-water*

*Coaltech 2020*

*No 1149*

Over the last decade, several initiatives were undertaken to assess the feasibility of irrigation with mine wastewaters. The use of gypsiferous mine wastewater presents an opportunity to stabilize dry-land crop production and enables dry season production, whilst at the same time providing a cost-effective method of minimizing excess mine drainage. The expected mine decant has potential to support in excess of 6 000 ha of irrigation in the Olifants River Catchment. Previous research provided proof about the shorter term feasibility and sustainability, from an irrigation perspective, of using gypsiferous waters for irrigation of a range of crops at two sites (at Kleinkopje Colliery). The objectives of this project were to expand the evaluation to a range of mine-water quality / soil combinations, to further develop the ability of the SWB model to predict gypsum precipitation reactions, crop response, soil water and salt balance, and leachate water quality and to predict the likely long-term impact of irrigation with gypsiferous water on the groundwater system. The study was carried out at three mines: Kleinkopje Colliery near Witbank, New Vaal Colliery near Vereeniging, and Syferfontein near Secunda. All sites were centre-pivot irrigated. The Institute for Groundwater Studies undertook the groundwater monitoring to ascertain the effect of mine-water irrigation on groundwater levels and quality.

The major problem experienced at all three sites was water-logging due to poor site selection. Water logging and associated reduced yields were most obvious during summer months, when control over the soil-water regime is difficult due to rainfall. The problem is not related to the chemistry of the water used for irrigation, as it was observed that crop performance was good in

well-drained areas of fields. Crop production under irrigation with mine-water rich in Ca and SO<sub>4</sub> was thus found to be feasible and sustainable if properly managed. No symptoms of foliar injury due to centre pivot sprinkler irrigation with gypsiferous mine-water were observed on any of the crops. Crops like sugar beans, wheat, maize, potatoes and pastures were successfully produced. Land preparation and fertilization management are critical for successful crop production, especially on rehabilitated soil. Pasture production with sodium sulphate-rich mine effluent was also feasible at least in the short term (three years) but would need a well-drained profile and a large leaching fraction to prevent unsustainable salt build-up. Unfortunately, these waters do not present much of an opportunity for gypsum precipitation, which is able to reduce the salt load of the receiving waters in the case of calcium and sulphate-rich mine-waters.

The SWB model was refined and successfully validated by comparing simulations to measurements of crop growth, soil water balance and salt redistribution obtained in the field trials. The simulation of crop growth (canopy cover) can be considered to be sufficiently accurate to give reasonable estimates of the soil water balance. The model also predicted soil solution concentrations reasonably well, and this gives some confidence in the predictive capacity of the model for long-term impact assessments of irrigation with saline mine-waters.

The overall water quality trend in the deeper aquifer indicates that the water quality has not shown significant deterioration over the 8-year monitoring period. The likely long-term impact of irrigation with gypsiferous water on the groundwater system was also assessed by running long-term simulations with SWB and a groundwater model. Irrigating large areas with gypsum rich mine wastewater could be feasible and sustainable if careful attention is paid to the specificity of each situation. If large-scale irrigation is permitted, threshold groundwater values should be established to determine if irrigation should be allowed to proceed, or whether mitigation measures are required.

This project thus confirmed the technical feasibility of using gypsiferous mine-water for the irrigation of a wide variety of crops on a range of soils, if appropriately managed and suitable soils were selected. Although only minimal impact on groundwater was found after eight years and favourable longer

term predictions were made, the long term impact on water resources requires further investigation.

Cost: R1 530 000

Term: 2000 - 2005

#### **Current**

##### **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***

*Quantification of the water use of four tree*

*crops in the Lowveld of Mpumalanga*

*ARC*

*No 1046*

Fruit tree species (high-value crops) have different water needs. These needs also change with growth stages - and are subject to climatic and edaphic factors. Where water becomes limiting, a decision tool becomes paramount so that farmers can decide beforehand which crops to produce. Such a tool also enables authorities to plan future expansions better, based on sound water budgeting. The aim of this research is to provide information on plant water use at various stages of growth. Water use by mango, avocado, litchi and macadamia nuts is measured. Trees between one and twenty years old are used. This information will be used to develop guidelines for water budgeting within the fruit industry.

Estimated cost: R776 000

Expected term: 1999 - 2006

##### ***Standards and guidelines for improved efficiency of irrigation water use from dam-wall release to root zone application***

*ARC/IAE*

*No 1482*

Irrigated agriculture is the single largest user of water in South Africa. With expansion of domestic and industrial water use, competition for the existing lawful use in irrigation will increase. The levels of efficiency of water use which are currently attained will be

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

scrutinised and particular attention will have to be given to the management of water use. Broadly defined, management of water use starts at dam wall releases, through river or canal conveyance, on-farm storage and distribution, in-field application up to root zone storage. However, the problem is that at present there is no standardised terminology, comparable benchmarks or generally acceptable guidelines to improve water use and irrigation efficiency. These issues must be urgently addressed in order to provide consistent management advice and comply with the requirements of the National Water Act of 1998 regarding compulsory licensing and periodic review of licences. For the purpose of planning, design and operation of water supply systems, definitions of various efficiency terms need to be clearly stated, understood and accepted by all stakeholders. The site-specific criteria and tools which will be used to measure efficiency and practically achievable benchmarks need to be established. In order to achieve this, the proposed research project must be undertaken on a representative number of irrigation schemes which should include but are not limited to the following: Loskop; Tabina; Middle Letaba; Crocodile/Komati; Pongola; Makhatini; Gamtoos; Sundays; Orange-Riet; Vaalharts; Breede; Hex; Hartbeespoort.

Estimated cost: R4 500 000

Expected term: 2004 - 2009

***Adapting the Wetting Front Detector to the needs of small-scale furrow irrigators and providing a basis for the interpretation of salt and nutrient measurements from the water sample***  
*University Pretoria/Plant Production and Soil Science*  
**No 1574**

The Wetting Front Detector was developed by Australian scientist Richard Stirzaker following a number of years work at the Tompi Seleka College of Agriculture in the Limpopo Province. The WRC funded a project (WRC Report No. TT 230/04 entitled *Building Capacity in Irrigation Management with Wetting Front Detectors*) between June 2000 and December 2003 to continue the development of the Detector and introduce the technology to irrigation farmers in South

Africa. Early results from field trials and feedback from farmers were sufficient to convince an irrigation agronomist from a South African Irrigation Manufacturer, Agriplas Pty Ltd, to consider developing the detector into a commercial product. The project was nominated by SANCID as contender for the WATSAVE award and won the international prize for 'Outstanding Contribution to Water Saving and Water Conservation in Agriculture' presented by the International Commission of Irrigation and Drainage in France in 2003. However, the Detector, which strives to make more efficient irrigation accessible to the majority of farmers, is in its infancy. In particular, there is a lack of understanding of how to deploy the device for furrow irrigation and how to interpret the salt and nutrient concentrations measured from solution captured by the detector. Most of the current requests for information and support arise from these applications; furrow irrigation and solution sampling. Ninety five percent of the research work on the Detector has been carried out on drip, micro-jet, and sprinkler systems. Most of the small-scale farmers, a key target audience, use furrow irrigation. The WRC Report No TT 230/04 provides conflicting evidence on the usefulness of detectors for furrow irrigation. Pilot studies carried out in Australia have demonstrated that monitoring of salt and nitrate can provide very useful information to farmers. In South Africa, 54 people using Detectors were asked in a survey why they were interested in the technology and 20% replied that their interest lay in monitoring electrical conductivity and nutrients in the soil water sample collected by the Detector. Numerous enquiries about which solutes to monitor, what techniques to use and how to interpret the result as soon as the Detector becomes widely available are anticipated. Therefore, there is an urgent need to do the underpinning science in order to provide reliable information.

Estimated cost: R1 202 000

Expected term: 2005 - 2008

***Real-time irrigation advice for small-scale sugar-cane production using a crop model, weather data and cellular communication***  
*SASRI*  
**No 1576**

Water use efficiency in irrigated sugar-cane agriculture is notoriously low and could be increased dramatically if farmers applied established scheduling methods. A recent survey showed that 70% of sugar-cane farmers use dragline irrigation and that 50% of these use fixed irrigation schedules. This leads to severe over-irrigation in times of low water demand and impacts negatively on the profitability of irrigated sugar-cane production and on the environment. Pressure is also building for water users to demonstrate efficient use of the scarce and sought-after resource. The main reasons for non-adoption of scheduling technology as determined from a survey that was conducted were:

- The complexity of technology in relation to practical constraints on the farm
- An under-estimation of the benefits of accurate scheduling. This applies especially to small-scale growers who do not have access to computers, the Internet or expensive equipment.

The challenge therefore is to provide simple, practical and useful advice to farmers using state of the art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. The Agronomy Department at SASRI has developed a prototype of a system (called *My Canesim*) consisting of the following: Weather data recorded by automatic weather stations and remotely downloaded daily through the cellular network; A web-based simulation model that suggests irrigation actions; An Internet-based user interface for advisors and extension staff to enter field, crop and irrigation system data and to view simulation results; The automatic distribution of irrigation on/off advice in isiZulu through SMS technology to farmers' cellular phones. In a pilot case study, the system was implemented in 2004 on a limited scale in Pongola. Irrigation advice is provided to six small-scale growers and its impact monitored. Initial results are very promising and indications are that water savings of 30% and cost reduction of R 1 400/ha could be achieved for small-scale growers. There is enough evidence to push for wider implementation of this service. These direct benefits are possible on 8 000 ha to more than 1 500 small-scale farmers in Pongola, the Makatini flats, and the Komati area. The technology could also be used by commercial

growers on 56 000 ha. Indirect environmental benefits are reduced water extraction from river systems, and reduced runoff, deep drainage and water pollution.

Estimated cost: R350 000  
Expected term: 2005 – 2008

***Increasing water use efficiency of irrigated sugar-cane production by means of good agronomic practices***  
**SASRI**  
**No 1577**

Low irrigation water use efficiency (IWUE) has been identified as a major problem in irrigated areas and this is even more important when the source of water is limited. Results reported by Olivier and Singels (2003) indicate that IWUEs of between 12 to 18t cane/100mm irrigation are possible as compared to 6t cane/100 mm averaged in the Onderberg at present. Agronomic practices such as the use of a trash (plant residues) blanket, growing suitable varieties, reduced row spacing and appropriate irrigation scheduling could increase the IWUE by saving water and/or increasing yield. Thorburn et al. (1999) have indicated that a trash blanket can reduce soil evaporation by an amount equal to 16% of annual rainfall. However, a trash blanket could also have a negative effect on the crop by slowing down initial growth, tillering and radiation interception and creating problems with trash worm and *Eldana*. Recent plant crop results by Olivier and Singels (2003) have shown that yields of a drip-irrigated plant crop can be increased by 10% and IWUE by 6 % when changing row spacing from the standard single row spaced at 1.5 m to dual rows spaced at 1.8 m. The response to trash blanketing and high density planting depends on variety. According to Singels and Smit (2003) the very large yield responses to row spacing (53% per 1m reduction) reported in Australia are the result of certain varieties having a low tiller production potential in the plant crop and therefore performing poorly in wide rows. It is believed that IWUE could be increased considerably by providing farmers with custom-made irrigation scheduling strategies for specific trash blanket, variety and row spacing combinations. Simple and easy-to-use irrigation calendars (with appropriate cycle and stand times) will be gener-

ated for areas with overhead irrigation by applying an accurate crop model to historic climate data. The outcomes of this research will include recommendations on best management practices (BMP, combinations of trash blanket, variety, row spacing, and irrigation scheduling strategy) for efficient and profitable use of irrigation water. Information will be available for the development of a trash blanket algorithm for the *Canesim* simulation model.

Estimated cost: R234 500  
Expected term: 2005 to 2008

***Integrating and upgrading of SAPWAT and PLANWAT to create a powerful and user-friendly irrigation planning tool***  
**PICWAT**  
**No 1578**

SAPWAT is an easy to understand, user-friendly program that is currently used by more than 200 users as an aid to the planning of irrigation requirements of crops and for training of farmers and students in both the commercial and the beginner-farmer category. Although it is a good educational aid for the understanding of crop irrigation requirements, it has some shortcomings, two of these being the inability to store the results of calculations and the inability to import weather station data for the expansion and updating of its existing weather station data. PLANWAT, the development of which was paid for by the International Water Management Institute, was initiated, amongst others, to overcome one of the above problems, namely the inability to store calculated data. SAPWAT is run out of PLANWAT and the resultant crop irrigation requirements are stored in a data file to enable the user to build an expected water requirement picture for backyard and community gardens, fields, farms, water users associations and for drainage regions. PLANWAT has a water harvest module where the output of SAPWAT is used to calculate required water harvest areas and required storage capacities for run-on situations of water harvesting, mainly for Third World situations. Its one drawback is that it does not provide for in-field water harvesting situations. In addition, as a planning tool the present combination of the two programs does not provide for interactively determining the best potential

scenarios of irrigation water use coupled to gross crop margin to enable farmers to select the best option for their circumstances. A need has been expressed that the capabilities of SAPWAT be expanded to also provide for automated or semi-automated calculations of irrigation water requirements for cases where mass calculations have to be done for river systems. The project will aim to integrate these programs into a sensible unit and upgrade them to fulfil a more complete role as a planning aid for irrigation requirements of crops and the related economic scenarios.

Estimated cost: R537 500  
Expected term: 2005 - 2007

***Programme 2:***  
***Fitness-for-use of water for crop production, livestock watering and aquaculture***  
***Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams***  
***Division of Aquaculture, University of Stellenbosch***  
**No 1461**

Most irrigation areas make use of on-farm storage dams to store water until it is required for the irrigation of crops. The existence of these dams presents an opportunity to utilise them also for fish production. Benefits associated with this dual use of farm dams include the additional income associated with such an enterprise, the supply of fresh fish as protein source for local communities, the creation of additional employment opportunities and a potential reduction in fertiliser requirements for crop production, as a result of the enrichment of the irrigation water by fish food and excrement. Potential disadvantages of such an integrated water use system, are the operational restrictions the one use will place on the other (e.g. the dam cannot be completely emptied), concerns about the fitness of irrigation water for fish production and the fitness of aquaculture water for crop production and some irrigation systems. Although dual use is practiced in many countries, it is not common in South Africa. In the light of the potential benefits associated with the integration of aquacultural production with irrigation practice, it is proposed that the interaction

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## Water Utilisation in Agriculture

between these two practices, the benefits and disadvantages associated with such integration and ways to maximise the benefits, be investigated for two case studies. Specific attention should be given to water quality effects and the precautionary measures that are required in order to maintain fitness-for-use need to be identified.

Estimated cost R 1 000 000

Estimated term: 2003 – 2007

### *Guidelines for sustainable use of grey-water in small-scale agriculture and gardens in South Africa*

*University of KwaZulu-Natal/School of Biological and Conservation Sciences  
No 1639*

The *White Paper on Agriculture* emphasises food security. Since household and urban food gardens form part of the spectrum of production systems and processes that can contribute to food security, they are supported by government. However, a shortage of water to supplement rainfall often limits the application potential of these systems. The use of grey-water may overcome this limitation by providing a dependable water source that is under the control of the household gardener. Grey-water is the untreated household effluent that is produced from baths, showers, kitchen and hand-wash basins as well as washing machines. More than half of the indoor household water use is normally used for these purposes and can thus potentially be intercepted by the household for additional uses. Initial indications from a scoping study to evaluate the fitness-for-use of grey-water in urban and peri-urban agriculture are that there is considerable potential to use this largely untapped source to augment household food security. However, there are also risks involved with the practice that need to be better assessed and quantified under controlled conditions. These risks are largely associated with factors that affect the sustained productivity of the irrigated soil and health considerations. A workshop is planned to prioritise these risks and finalise the appropriate experimental approach to address them before finalising the terms of reference and soliciting project proposals

Expected cost: R1 670 000

Estimated term: 2005-2008

### *Thrust 2: Water Utilisation for Fuelwood and Timber Production*

#### *Programme 1: Water-efficient production methods and systems in agroforestry, woodlands and forestry plantations*

*Water use in relation to biomass of  
indigenous tree species in woodland, forest  
and/or plantation conditions  
CSIR  
No 1462*

Information on the water use of trees is essential in order to manage different land-use activities. Currently no information is available on the water use of indigenous trees in relation to biomass production. The central question that must therefore be answered is the following: What is the net benefit of water used by indigenous woodlands compared to commercial forest plantations? For this project it will be important to consider a limited number of species for stands of indigenous trees. Since the emphasis is on water-use efficiency, the water use for the harvestable above-ground biomass production for different end uses should be quantified. The focus should be on slow-growing and initially fast-growing indigenous trees in defined catchments or bio-climatic zones. The following climatic conditions and regions should be considered: Cold-tolerant (Highveld, Piet Retief); subtropical (coastal and Mpumalanga Lowveld); and temperate (KwaZulu-Natal midlands, Mpumalanga escarpment and Transkei in the Eastern Cape). The water use/biomass relationship of indigenous trees and comparison with existing information for trees in commercial forests must enable future comparisons of the productivity and value of water used under different tree production systems.

Estimated cost: R 2 249 616

Estimated term: 2003 – 2008

#### *Agro-forestry systems for improved food production through the efficient use of water*

*Environmentek, CSIR  
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.

Small-holder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a 'shift' from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands.

In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor.

This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally.

Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa.

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment.

Estimated cost: R3 250 000  
Expected term: 2004 - 2009

### **Thrust 3:** **Water Utilisation for Poverty Reduction and Wealth Creation In Agriculture**

**Programme 1:**  
**Sustainable water-based agricultural activities in rural communities**  
*Integrating flood-plain agriculture into a diverse rural economy by enhancing co-operative management: A case study of the Pongola*  
*Institute for Natural Resources*  
**No 1299**

The effective management of the Pongola River flood plain has been unsatisfactory ever since the completion of the Pongolapoort Dam. This study aims at promoting effective co-operative management of the river system on a sustainable and democratic basis. Lessons learned here will contribute to formulation of policies and institutions to achieve sustainable use of river systems in rural South Africa. This project is strongly based on the principles of a participative action plan.

The aims of the project are to:

- Learn about promoting effective co-operative management around sustainable use of river systems in rural areas
- Redirect the pattern of resource use on the Pongola River flood plain towards a shared vision reflecting a diverse and sustainable economy
- Establish a confident and capable team of researchers drawn from previously marginalised sectors.

Estimated cost: R880 000  
Expected term: 2002 - 2006

### **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 agroforestry systems**

*Environmentek, CSIR*  
**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 agroforestry systems on increasing fodder production in rural farming systems
- To determine the effect of agroforestry 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: R1 500 000  
Expected term: 2002 - 2006

### **On-farm application of in-field water harvesting conservation techniques of small plots in the central region of SA** *ISCW, ARC* **No 1355**

Technology exchange and adoption are the best possible ways of evaluating the success of any research project. Water harvesting using in-field basins, has improved yield for a number of crops. The technique, however, needs to be communicated widely – and tested *in situ*. This project aims at engaging smallholder farmers, who often do not have irrigation facilities, and those who operate in dry areas, to use the technique under some guidance.

This project will disseminate knowledge and technologies that will improve productivity of rain-fed agriculture. Extension services, which have been identified as the weak link in rural agricultural development, will also be targeted by this project.

Estimated cost: R800 000  
Expected term: 2002 - 2006

### **Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research, Limpopo Province** *Tshwane University of Technology* **No 1464**

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research was completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion

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## Water Utilisation in Agriculture

of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. The research project on 'best management practices for small-scale subsistence farming' requires commitment and co-operation amongst researchers, farmers and the community. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. However, the intention is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. This should be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R 1 200 000  
Estimated term: 2003 - 2007

### *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 sys-

tem. 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: R 3 000 000  
Expected term: 2003 - 2008

### *Best management practices for smallholder farming on two irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research* *University of Fort Hare* *No 1477*

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsis-

tence farming. The research project on 'best management practices for small-scale subsistence farming' therefore requires commitment and co-operation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000  
Expected term: 2004 - 2009

### *Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province* *University of Fort Hare* *No 1478*

Approximately 74% of South Africa's 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 exert even more pressure on the rainwater resource base, particularly among the poor.

The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area.

Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system.

The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop

cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 000 000  
Expected term: 2004 - 2009

***Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods***

***Rural Integrated Engineering (Pty) Ltd  
No 1575***

The rural landscape of South Africa is characterized by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the Government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate

need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Expected cost: R2 750 000  
Estimated term: 2005-2009

***Nutritional value and water use of indigenous crops for improved rural livelihoods***

***University of Pretoria/Centre for Nutrition  
No 1579***

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (WRC Report No 944/1/04). It is also important to determine the nutritional value and water requirements of these crops. The best combination between indigenous crops and a range of home-grown vegetables, and other foodstuffs to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (WRC Report No 1267/1/04). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosa, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households. Further consultation with stakeholders has to take place to develop the specific objectives and deliverables of this project.

Expected cost: R2 250 000  
Estimated term: 2005 - 2009

***Programme 2:  
Integrated water management for profitable farming systems***

***Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape***

***Department of Agricultural Economics,  
University of the Free State  
No 1250***

An important aim of the Water Conservation and Demand Management Strategy for the agricultural sector is to provide a regulatory support and incentive framework to improve irrigation efficiency. This can be achieved by firstly ensuring that volumetric water tariffs reflect the financial cost of supply and, secondly, by promoting voluntary reallocation of water resources from lower-valued to higher-valued uses on farms and between farms within agriculture. For irrigation farming this means that farming operations must be restructured. However, production of, e.g. high-value perennial crops also involves higher financial and business risks. This is caused by the high capital outlay and the time lag before full production is reached as well as variable export prices and changing consumer preferences over time. Although risk management through, e.g. crop diversification or market forecasts and price hedging can be implemented, the question is how far the shift to higher valued crops can be taken. Presently it is not known what the financial boundaries are within which water reallocations can be managed sustainably on a farm level and what the potential impact is on a regional economic level. Knowledge of these issues is of particular importance for irrigation areas in provinces such as the Northern Cape where agriculture is the dominant economic sector. Instability influences not only employment and income on farms, but also processing and input supplying industries through forward and backward linkages. This is emphasised by the recent turmoil in the global deciduous fruit market, which has also affected table-grape production in the lower Orange River. The proposed project will analyse the related production and marketing risks and develop models which link economic activities on a farming level to the regional level. The model will be tested in the particular study area but will be applicable in any area. The main aim of this project is to quantify the impact of market risk on the effi-

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## Water Utilisation in Agriculture

cient use of irrigation water and to determine the multiplier effects of irrigation farming accompanied by a shift in production patterns.

Estimated cost: R1 333 729  
Expected term: 2001 - 2006

### *Water resource management for profitable small-scale farming along the banks of the Orange River*

*Department Agricultural Economics,  
University of the Free State  
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 - 2006

### *Technology transfer and integrated implementation of water management models in commercial farming*

*CPH Water  
No 1481*

Large investments have been made by the WRC in developing models for water management from field to catchment scale. These models are the following:

**SWB:** Generic, mechanistic model for real-time irrigation scheduling at field scale

**SAPWAT:** Planning tool for determining crop water requirements at field, farm or irrigation scheme level

**RiskMan:** Simulation model of net cash-flow for water use and crop combination at specified risk levels at farming scale

**WAS:** Integrated water requests, water distribution and accounts system at irrigation scheme scale

**ACRU:** Hydrological modelling at catchment scale

All of these models are already being implemented or are undergoing technology transfer. A stage has now been reached where the integrated implementation of the models can be demonstrated. At the same time there are many changes in the environment in which farm management takes place, which emphasise the need for decision-support. The target groups who can potentially benefit through decision support include staff of regional offices of DWAF or CMAs, staff of WUAs, agricultural advisors or extension officers and leading farmers on irrigation schemes.

A major hurdle which has been experienced in practice is setting up the models for implementation. This hurdle can be overcome by actually installing a GIS, collecting data and demonstrating the use of the models. The pre-requisite is to engage with end-users in order to determine and respond to real needs. In order to achieve this, a framework must be presented which illustrates flexibility of choice in the linking of different models, the opportunity for common databases generation and exchange of data

This project is based on consultation between the WRC and DWAF, and technology transfer of the specified water management models will be undertaken on selected irrigation schemes in the following river catchments: Crocodile (east); Olifants (east); Pongola or Mhlatuze; Sundays or Gamtoos; Breede; Orange-Riet; Orange-Vaal; Crocodile (west); Great Letaba in order to promote integrated implementation.

Estimated cost: R2 250 000  
Expected term: 2004 - 2007

### *Revitalisation of provincial fish hatcheries and training facilities to promote profitable aquaculture*

*Rhodes University/ Dept 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 TT235/04). This study showed that the present factors constraining aquaculture in rural areas were mainly a consequence of a lack of policy and institutional capacity and that the development of rural aquaculture will depend principally on a public sector led intervention, inclusive of technical support and fingerling supply. The study revealed that there are many state-owned hatcheries and training facilities falling under various Government Departments that are unproductive, privatised, or defunct. Though not assessed these assets are worth millions of Rand. Based on the survey results it was further agreed that the involvement of the private sector in rural aquaculture would be essential for sustainable growth. As policy issues were being addressed by the National Department of Agriculture, it was suggested that the WRC should support the undertaking of workshops in preparation for participatory action research (PAR) with the various public and private sector stakeholders to appraise the potential role of these hatcheries in the light of emerging policy, and where applicable to develop a framework for a community private public partnership (CPPP) to revitalise government hatcheries that are currently under-utilised. The workshops have been completed and the PAR can now proceed. The PAR is a process which includes research and implementing goals and objectives. Stakeholders in the Limpopo, Mpumalanga and Eastern Cape Provinces

will be engaged and an end-point will be identified (for example, through CPPP revitalising a specific government hatchery). Once the end-point has been identified, the role of the PAR implementers would be to actively facilitate and record the process, so that it is successful and repeatable elsewhere.

Expected cost: R2 250 000  
Estimated term: 2005 - 2008

#### **Thrust 4:** **Water Resource Protection and Reclamation in Agriculture**

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

*Can effective management of riparian zone vegetation significantly reduce the cost of catchment management and enable greater productivity of land resources?*

Environmentek, CSIR

No 1284

Riparian zone management has become an important issue in water conservation in South Africa and water resource managers are under increasing pressure to assess the impacts of different land uses and management practices on catchment water yield. This has been exacerbated by the introduction of the new Water Act, which has prompted the Department of Water Affairs and Forestry to develop a framework for managing the use of water by streamflow reduction activities (SFRAs). This calls for the ability to predict and monitor the impacts of SFRAs on water and on the protection of water resources within each water management area.

Since riparian soils are mostly the wettest and most fertile within a catchment, and are therefore the most productive, there is great interest in moving away from the use of a standard width throughout the catchment, and rather to identify the required limits to the riparian zones on the basis of more objective criteria. What is unclear is the size and significance of this moderating influence. This project will therefore investigate how effective management of riparian zone vegetation can reduce the cost of catchment management and enable greater productivity of land resources.

The aim of this research project will be to investigate the links among vegetation, saturated zone dynamics, and runoff generation for the different classes of riparian zone, and to test the hypothesis that riparian zone vegetation has a significantly variable effect on catchment water yields.

Estimated cost: R727 500  
Expected term: 2001 - 2006

##### **Programme 2:** **Impact assessment and environmental management of agricultural production** *Modelling non-point source (NPS) pollution in agriculture from field to catchment scale* Sigma Beta Consulting No 1516

It is increasingly recognised that non-point source (NPS), or diffuse pollution, plays a major role in the degradation of water quality; specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, pesticides and some heavy metals. It is furthermore increasingly accepted that it is unfeasible to properly manage water quality without addressing the contribution from non-point-sources. Consequently, attention is increasingly devoted to the quantification of NPS pollution and to identify means to control it cost-effectively at source. Since most of the land area is utilised for agricultural activities, agriculture has both locally and internationally been implicated as a major source of NPS pollution. It is therefore necessary to assess the contribution that the different agricultural activities make to the different manifestations of NPS pollution, to devise the means through which these can be controlled and to determine and predict the effect that control measures will have to reduce NPS pollution. Understanding the production, delivery, transport and use components of agriculture-derived NPS loadings of water resources and having a predictive ability about the fate of agriculture-related NPS constituents are discrete research themes that will enhance the usefulness of the existing guidelines in the agricultural domain. The contribution of irrigation activities towards the salinisation of water resources has been studied for quite some time and is currently still receiving attention. Other water quality issues of concern that are potentially aggravated by agricultural activities are eutrophication (through fertiliser leaching and wash-off from human settlements),

sediments (as a result of erosion), pathogens (from intensive animal production units), pesticides (through the application of insecticides, fungicides and herbicides) and some heavy metals. Although agricultural activities that give rise to the latter water quality issues have been the subject of previous studies, the present level of knowledge concerning them is not as advanced as for irrigation-induced salinisation of water resources. The project will address those issues that require priority attention, with regard to NPS pollution.

Estimated cost: R5 000 000  
Expected term: 2004 - 2009

Herewith the list of the new projects which commenced between 1 April 2006 and 31 March 2007.

#### **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** *Guidelines for irrigation management in pasture production* CSIR, Environmentek 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

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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 second 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 150 000  
Expected term: 2006-2011

### **Thrust 3:** *Water Utilisation for Poverty Reduction and Wealth Creation in Agriculture*

**Programme 1:**  
*Sustainable water-based agricultural activities in rural communities*  
*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, 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 bio-physical aspects of in particular infield RWH&C has been done (see *WRC Report No 1176/1/03*). A start has also been made to evaluate the social acceptability and economic viability of this technique (see *WRC Report No 1267/1/04*). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R 2 800 000  
Expected term: 2006-2011

**Programme 2:**  
*Integrated water management for profitable farming systems*  
*Development of training material for extension in irrigation water management*  
*University of Pretoria, 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 bio-physical 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: R1 870 000  
Expected term: 2006-2011

#### **Thrust 4:** **Water Resource Protection and Reclamation in Agriculture**

##### **Programme 1:** **Sustainable water resource use in 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) have 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 utilized 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: R 2 400 000  
Expected term: 2006-1010

##### **Programme 2:** **Impact assessment and environmental management of agricultural production Applications of rainfall forecasts for agricultural related decision making in selected catchments** *University of KwaZulu-Natal, School of BEEH* **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 five 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 agrohydrology and applications in agricultural decision-making. The project aims to develop techniques and models for translating forecasts of up to one year in advance into applications for decision support.

The WRC has funded several projects over almost two decades on research on climate variability with a focus on forecasting, modelling and database development. These include *inter alia*:

- Development of a raster database of annual, monthly and daily rainfall for Southern Africa (WRC **Report No. 1156/1/04**)
- A flood nowcasting system for the eThekweni Metro: **Volume 1** and **2** (WRC **Report No. 1217/1/04** and **1217/2/04**)

# 4 KSA 4 (continued)

## Water Utilisation in Agriculture

- 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 utilized.

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 two or three critical catchments, the findings of this study will be extrapolated to other catchments.

Estimated cost: R2 850 000  
Expected term: 2006-2011

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# KSA 5 Water-Centred Knowledge



**Dr Kevin Pietersen:**  
(Director until 30 April 2007)

## Scope

Over the past few years, this KSA has focused on the development and protection of knowledge resources. The building of knowledge management capabilities, in terms of technology and fundamental business processes has indeed improved our effectiveness as an organisation. The embodiment of the culture of knowledge management forms the basis of the WRC mission and is the focus of the WRC vision, that of becoming a true knowledge hub. Again over the past three years, there was a determined effort to focus on the basic building blocks necessary to support the knowledge management objective of the WRC.

Driven by external needs, the WRC continues to strive to improve its position as the dynamic hub for water-centred knowledge, innovation, and intellectual capital in South Africa and even further a field in Africa and the developing world. There has been recent interest in the WRC strengthening their position in Africa and abroad as a result of the success experienced within the past three years. The knowledge to be managed is both explicit, documented knowledge and tacit (subjective) knowledge. Management of knowledge in the WRC will therefore entail all the processes associated with the identification, sharing and creation of knowledge. This will require systems for the creation and maintenance of knowledge repositories, and for the support of the cultivation and facilitation of the sharing of knowledge and organisational learning. Internally, for the WRC to

succeed in knowledge management, it has to view knowledge as an asset and to develop organisational norms and values, which support the creation, and sharing of knowledge, both internally as well as externally.

Therefore, in general, the KSA will focus on deriving value from its intangible assets; full utilisation of information systems to manage data, information and knowledge; full utilisation of a system that tracks who is using our knowledge products (Technical reports); Increasing the circulation of our journals; Improving document and information management internally; and the management and/or administration of research projects.

## Objectives

Knowledge management in a knowledge-intensive organisation like the WRC has a strategic support function as well as being an enabler. In addition, the KSA has broadened its scope to actively support the water sector in its strategic knowledge initiatives. The objectives of the KSA have been reviewed based on the previous year's experience and what needs to be achieved within the next financial year and can be grouped as follows:

### Internally focused objectives

- To enhance the core processes of research support and management by improving access to relevant knowledge
- To support the emergence of the culture of knowledge management
- To develop and maintain consistent data architecture to enable the flow of content through a fund management system to support the core business of the organisation
- To support innovation and commercialisation through proper management and protection of the WRC's patent portfolio.

### Externally focused objectives

- To participate and lead knowledge-dissemination initiatives including sharing and networking supported by functional, user-friendly research and water information systems (e.g. Water Information Network (WIN))
- To build and strengthen knowledge links with Africa and globally

- To continuously improve knowledge transfer and dissemination through feedback from users, dissemination of reports, guides, scientific and non-scientific journals, and by providing support to other technology transfer initiatives
- To develop a state of the art communications systems, to enable quick, meaningful contact between the WRC and the water sector / stakeholders.
- To continuously develop better and more efficient knowledge dissemination tools and channels.

## Thrusts

The achievement of the above objectives will be supported by a structure or a framework of a number of thrusts (which form a number of management areas/functional groups). A creative approach to knowledge management will be achieved within these management areas.

### Thrust 1: Knowledge Management and the Water Information Network (KM) [Focus: 70% external; 30% internal]

The focus of this thrust is knowledge-sharing and knowledge dissemination to meet the objectives of the WRC (of being a knowledge hub) in its knowledge creation and learning activities and the core process of knowledge generation. It will develop a culture based on the understanding that 'knowledge resides in the user and not in the collection of information'... it is the reaction of the user to a collection of information that matters'. Thus there needs to be a clear link between this KSA and the other water KSAs, who will be at the core of the knowledge management activities. Further, this thrust will oversee that the WRC maintains access to the necessary information to make appropriate decisions internally as well as externally. This management area will also act as a resource centre to meet information requirements of the WRC and the water sector in general and will lead and participate in other knowledge sharing and knowledge dissemination activities. It will also strengthen the WRC's ability to exchange information and data on develop-

# 5 KSA 5 (continued)

## Water-Centred Knowledge

ments around water management issues, while continuing to disseminate technical reports and technology transfer documents. There will be an added effort to improve the quality of the reports and other knowledge dissemination media. This will entail a focus on e-publishing and e-business.

The KSA also acknowledges that the knowledge base must remain dynamic, and globally competitive. In pursuing this goal, there will be increased focus to collaborate with other countries and/or researchers in the international arena. Such initiatives will pursue while leveraging WRC's funding for these initiatives.

The KSA, in line with the WRC mission has led the establishment of the Water Information Network (WIN-SA) initiative. WIN-SA is a knowledge management initiative to serve the water sector, and it aims to ensure that the body of knowledge in the sector is well managed, readily accessible and applied, leading to improved decision-making and performance, especially of local government. The WRC is the custodian of WIN, and has successfully implemented WIN and introduced the benefits of this initiative to the water sector.

### **Thrust 2:** *Publications and Public Understanding of Science (PPUS)* *[focus: 80% external; 20% internal]*

Key focus for the next financial year will be on driving the handling and digital storage of documents, archiving, and maintaining library and information services. More emphasis will be placed on improved dissemination of knowledge sourced locally and globally (originating from the national and international arena) through the publication of an internationally rated journal and further simplifying the knowledge for the consumption of the general public.

### **Thrust 3:** *Knowledge Transfer and Commercialisation (KTC)* *[focus: 80% external and 20% internal]*

This thrust will focus on the effective management of all the WRC's patent portfolios, all issues relating to intellectual property rights and their protection. It will also support innovation and commercialisation of research

and research products, while also supporting the WRC in the management of its contracts with researchers and suppliers.

### **Thrust 4:** *Information and Communication Technology (ICT)* *[focus: 50% external; 50% internal]*

This area aims to meet the information and communication needs of the WRC's stakeholders and also the internal needs of the WRC regarding information management. This is essential as ICT has become the popular service delivery tool to the WRC stakeholders. Further development and application of enabling and support systems and tools, will be the focus of this coming financial year. Key focus will be on designing tools for driving water-centred knowledge dissemination, through portals and the Internet. Another key focus is improving the organisation's information processing abilities, especially with respect to research project management (or project fund management) and its competencies concerning information security and risk management and compliance with best practice.

### **Budget for 2006/07**

The approved funding of fixed costs, running costs, printing and publishing costs and human resource costs leads to committed funding of R 9 413 628 for the year 2006/07.

### **Core Strategy**

#### **Strategic context**

Having carried out a knowledge dissemination survey, the results of such have guided us into identifying the key issues to be addressed this coming financial year. In the past we have tested out various approaches for knowledge dissemination. The changes envisaged in the context as described previously will be more in line with producing tools that will capture the human attention to utilise more effectively the knowledge generated and also to contribute more meaningfully to the overall knowledge cycle. Through these we shall continue to demonstrate, both internally and externally the benefits of sound knowledge management.

As in the past, there has been no shift in the view that information generated by various sources is not a very rich carrier of human interpretation for potential action. Knowledge resides in the user's subjective context of action based on that information. It is therefore logical to account for human attention, innovation and creativity needed for renewal of archived knowledge, creation of new knowledge and innovative applications of knowledge in new products and services that may be transferred or commercialised.

Following progress already achieved during the past financial year, this KSA continues to dynamically redefine itself while addressing the critical issues of organisational adaptation, relevance, and competence in response to dynamic positioning of the WRC. Essentially, this KSA will continue to aim to embody organisational processes that seek synergistic combination of data and information processing, capacity of information technologies and the creative and innovative capacity of human beings. Through dramatic improvements in the utilisation of technologies and new methodologies to enhance knowledge sharing, networking, etc., this KSA will redefine knowledge management and the way we access the pool of external knowledge to leverage our own knowledge resources, adding value to it and channelling it to where it will be beneficially used.

The business objectives of the WRC are externally focused and are based on investing in water research and development and developing competence and skills while making optimal use of the latest global information/knowledge and other available technologies. While the four water-centred KSAs are focused on investment in the creation of new knowledge and capacity-building, using the latest communication technologies and tools, the products thereof are linked and enhanced through other externally available information to prepare it for dissemination, transfer or sharing knowledge. Through this, and continually supporting the core processes of the WRC, the WRC business objectives will be achieved.

Having implemented the above, this KSA will continue to assist in positioning the WRC as a knowledge hub characterised by efficient systems for knowledge sharing and dissemination, with special emphasis on communication technologies, and improving access to information for ALL to make beneficial decisions.

### Needs analysis

Proper understanding of users and their needs is the main determinant of how knowledge should be packaged – it is the collection of information that matters. The users are both internal and external customers. Both internal and external customers as identified previously are the same as described before. The way we approach this has not changed.

From the knowledge dissemination survey, it is clear that there is a need to improve knowledge dissemination via the electronic media. The ability to download information from the WRC webpage, and easy access to information has been identified as the greatest need.

### Internal customers

#### Research managers and staff of the WRC

Appropriate information is required for planning activities and decision-making especially with respect to research project management. Staff members need to be able to access the information base of the organisation and be empowered to take decisive action.

The KSA shall continue in the belief that the overarching need is to develop one seamless system for employees to navigate, even though the information may ultimately be pulled from several different systems 'behind the scenes'. From the user's point of view it is a system that is always ready to supply the content that is needed, may it be performance data, budget, policies, professional contacts, experts and specialists, current research data, etc. This is the basic framework for the new fund management system under development.

### External customers

The level of knowledge of water-centred knowledge management in the communities in general is limited and that position has not changed much. The establishment of the Water Information Network (WIN) is seen as a strategic way of serving our external customers. The following issues are still considered high priority, even for 2006/07:

- Improvement of public understanding of water issues
- Effective dissemination of information (right place, right time) through WIN
- Being the real hub for water information
- Improving the efficiency of downloading information from the WRC's webpage.

#### Government departments, local government and municipal officers, private service providers, decision-makers and policy-makers

At every stage of knowledge accumulation, the above-mentioned category of users is almost always the main target group. It is important that the "knowledge workers" in this sector make their decisions by increasing the amount of relevant information they have access to, introducing the elements of expertise and experience through collaboration capabilities and shortening the time it takes to make better decisions. Hence, the special initiative, WIN, has been positioned to address this pool of customers.

#### Stakeholders and user communities

These will continue to include water boards, municipalities, community associations, development groups, consultants, etc. Encouraging free flow of information fosters innovation, and in today's information-driven economy, organisations may uncover the most opportunities, and ultimately derive most value from intellectual assets. Knowledge sharing must serve as the foundation for collaboration.

#### Researchers and service providers

The ongoing reassessment of key assumptions, renewal of existing knowledge, creation of new knowledge and its application, requires that the knowledge available at a certain point in time and context be accessible.

#### Communities and general public

South Africa cannot change to sustainable water management without community co-operation and the latter cannot co-operate if they do not understand. The basis for understanding is knowledge. The **water sector** in general also faces the challenge of being able to link up and work globally and regionally.

#### Technological trends

The recent development in communications technology including the voice over IP issues has opened a range of opportunities to improve the real-time sharing of information, and enabling decisions on the go. The KSA will drive the exploitation of such technologies, not only creating a water information hub, but a water information hub of the digital era.

Document management systems linked to workflow continue to be high priority for this KSA for the near future. Recent developments have rendered these systems highly reliable. Whilst this was identified much earlier as a priority development, it has to wait for the completion of the Fund Management System which will be implemented during 2006/07.

### Key stakeholders

Creation, transfer and dissemination of knowledge require an appropriate knowledge base, that is water-related experts, practitioners, academics, science councils, the government (at all levels) and other research organisations. The WRC has to be able to effectively translate needs into research ideas and further transfer research results and new technologies to end-users or end-user representatives and communities.

Other key stakeholders include the water sector, service providers, user communities and the general public.

### Other players

A number of national and international organisations work in collaboration with the WRC and in some cases formal agreements exist. These include the following as examples:

- American Water Works Association Research Foundation (AWWRF)
- International Water Association (IWA)
- Water Research Foundation (WRF)
- International Water Management Institute (IWMI)
- Water and Sanitation Collaborative Council (WSSCC), etc.
- France (IRD, CIRAD and CNRS)
- DST bilateral co-operation programmes.

## Strategic Initiatives Undertaken During 2006/07

### National initiatives

- The WRC was one of the sponsors at the Biennial Stander Evening which was held at the CSIR Conference Centre. The recipients of the Stander Evening Awards were largely supported through WRC research projects.
- The KSA participated in the *National Water Week* through a river monitoring day event held with school learners. The event

# 5 KSA 5 (continued)

## Water-Centred Knowledge

was held simultaneously in Pretoria and Pietermaritzburg. The KSA was also one of the judges at the SA Youth Water Prize. The KSA also held *Short Story Competition* for school learners and published a special publication.

- A special *Women in Water, Sanitation and Forestry* publication was written and edited for DWAF. It was also disseminated to schools to promote an increase in the number of girls in the water sector.
- The KSA was involved in briefings to the Science and Technology (S&T) and the Water Affairs and Forestry Parliamentary Portfolio (WA&F) Committees. At the S&T Portfolio Committee, the WRC outlined the role of the WRC as well as the WRC projects that reflected water-related technology. The Portfolio Committee on WA&F held public hearings on water quality during June 2006. The WRC delivered a presentation to this forum. The Chairperson of the Committee, Ms Connie September, mentioned the WRC presentation in a television broadcast. Her comments related to the informative nature of the WRC presentation. The WRC also presented at the WA&F Portfolio Committee public hearings on 'Socio-economic growth and service delivery towards rural development'. The briefing was well-received and resulted in building relationships with the different members of Parliament, especially the Chairperson of the Portfolio Committee.
- The WRC was requested by the Chairperson of the Portfolio Committee on Water Affairs and Forestry, Ms Connie September, to brief the Portfolio Committee on various aspects of water resource issues. This was coordinated by the KSA and was held on 23-24 January 2007 in Langebaan/Saldanha. This was followed by the Portfolio Committee strategic planning session for the 2007 Parliamentary Session. The course addressed the following issues:
  - Water Policy, Law and Governance
  - Institutions for Water Resource Management
  - Water Resource Planning and Development
  - Water Quality Management.

The training course was well received and resulted in a public acknowledgement by Ms Connie September at the strategic forum of DWAF held with water-related public entities.

- The WRC initiated an Institutional Review to provide the WRC with an external, independent assessment of its current operations. The KSA was tasked with coordinating the logistical arrangements of this Review. Favourable comments were received from the Review Panel Members about the arrangements. The outcomes of the review were intended to be used as an input to its next five-year plan. Panel members comprised six members: three from South Africa and three international panel members.
- The KSA arranged and participated in a number of DWAF/WRC workshops in order to create synergy between the two organisations. The KSA Director participated at a number of forums to seek further alignment between the two organisations such as the DWAF Strategic Planning Forum with various water-related public entities. The intention is to strengthen and improve the WRC relationship with its shareholder, DWAF, in order to promote effective use of water-centred knowledge in policy formulation and decision-making within DWAF and also to support the DWAF leadership role in the water sector, thereby working towards meeting national priorities.
- A unique and beneficial partnership in an urban water management project between the University of KwaZulu-Natal and the eThekweni Municipality was formalised. The partnership was a result of WRC research capacity investment enabling scientific solutions to many of the water service challenges of this municipality.
- The effluent treatment plant at Gelvenor Textiles was officially commissioned on 19 June 2006. This is a role model for cooperation between Government and the textile industry. The process has been made possible with assistance in best practice by various organisations, including the WRC.
- The KSA was part of a site visit at Langebaan on 'Biogeochemical Controls on the Plant Biodiversity within a Saltmarsh Ecosystem'
- The School of Agriculture, Rural Development and Forestry of the University of Venda had an Open Day at which the WRC participated
- The KSA formed part of a site visit at the Kruger National Park to view the model of a fish-way that has been specifically

designed for fish species that are indigenous to South Africa

- The KSA supported a workshop presented by KSA 1 on remote sensing techniques to determine soil moisture which is crucial for flood forecasting
- The WRC was part of a site visit to a project that is investigating the impact of tree water use on hydrological processes. The project involved the use of a new evaporation monitoring technique.
- The KSA will promote desalination guidelines, which is the outcome of research funded by the WRC and DWAF.
- The KSA has contributed towards knowledge sharing and leadership by the WRC, expressed in terms of the number of national activities:
  - The following Open Days were held:
- University of the Western Cape (this was followed by a technical tour to the Berg River Dam)
- Press Club Function
- WRC Knowledge Forum: Current realities and challenges in sanitation improvement – Future perspectives and needs.
- The following exhibitions were held:
  - WISA Biennial Conference
  - SABC Career and Training Faire
  - SANCID Biennial Symposium
  - Johannesburg Water Festival
  - National Water Summit

### African initiatives

- The WRC is the water focal point for NEPAD – Office of Science Technology Development. This resulted in an agreement with NEPAD – OST (with French Government support) to:
  - Convene the NEPAD Task Team on Water Science and Technology Development in Cairo, Egypt on 19 November 2006
  - Convene an inter-ministerial dialogue between the bureaux of African Ministers Council on Water (AMCOW) and the African Ministers Council on Science and Technology (AMCOST)
  - Develop a comprehensive profile of African institutes that would be considered for designation as members of the proposed Network of Centres of Excellence in Water Sciences
  - Develop and implement a business plan for the Network of Centres of Excellence in Water Sciences and Technology Development.

- The KSA Director is the coordinator for a UNEP-funded study that focuses on assessing the vulnerability of Africa's water resources to environmental change
- The KSA Director is on the Board of the Water Research Fund of Southern Africa (WARFSA) and also part of a consortium termed African Water that is linking African researchers to the European Union (EU) framework research programmes. The KSA also participated in the Inter-Academy Panel Workshop on Water Resource Management. This involved members throughout Africa.

### International initiatives

The KSA participated in a number of global initiatives:

- The KSA Director was invited to a number of workshops in Japan on groundwater management. He gave a number of keynote lectures to various forums
- The KSA Director was invited to discussions with the British Geological Survey on collaborative groundwater research projects
- The KSA Director is a contributing lead author to the water chapter as part of the *Global Environment Outlook*.
- The KSA Director participated in the Global Forum on 'Building Science, Technology and Innovation Capacity for Sustainable Growth and Poverty Reduction', held in Washington DC, USA.
- The SAFe Water project was launched on 9 May 2006. The SAFe Water initiative is a French/South African partnership to cooperate in water science and technology development. Funding is being provided by both countries and the intention is to promote the constitution of bilateral networks, involving each team from each country.

### Stakeholder Relations

#### Effective interaction with media

The following instances of media coverage about WRC activities were:

- Fishways (*SABC Radio Afr/Eng; 50/50*)
- Bottled water (*Independent Newspapers, Business Day, SABC Radio, East Coast Radio, Radio 702*)
- Pesticides
- Water Administration System (WAS) Award (*SA Irrigation*)

- Biosure (*J. Water, Sewage and Effluent Treatment*)
- Drinking water (*SABC Radio, SABC 3*)
- Ecotourism
- World Meteorological Organisation (*Water and Sanitation; SABC Radio, SABC Africa*)
- Knowledge Forum: *Sanitation* (SABC 3)
- SAFe Water Workshop
- SARIA Training Workshop (*SABC Radio Okhombo Project (50/50)*)

### Public appreciation

#### Citations

The following citations were noted with respect to KSA activities and participation in various initiatives:

- Workshop on Participating in FP7. Article <http://www.emwis.net/thematicdirs/events/sev923531>
- Supporting African Involvement in the EU Research Framework Programme. Article <http://vague.eurecom.fr/initiatives/fol060732/proj091846/org650263>
- *AMCOST Bulletin - Vol. 3* No. 1 22 November 2006 – 'Inter-Ministerial dialogue on building an African network of centers of excellence in water sciences and technology'
- *The Japan Economic Review - Vol. 38* No. 9. Friday, 15 September 2006 – 'Need to place groundwater usage under state control and protect water quality'
- *Geobulletin* - September 2006 – 'Various Presidents' Columns'
- *Business Day*-Thursday, 15 June 2006-'Safe water for all'
- *Cape Times*, 21 June 2006 - 'It's about to hit the fan, warns survey: SA's sewage works are ticking time bombs'
- *Cape Times*, 14 June 2006 - 'MPs told to lay off bottled in favour of tap water'
- *Cape Times* 14 June 2006 - 'Seawater desalination found too expensive'
- *African Water Newsletters* – Various contributions to the newsletter
- *Research Africa* 19 September 2006- 'Not a drop to drink: Kevin Pieterse explains what policymakers need to know to boost water sciences in Africa'
- *World Water Forum Bulletin* 21 March 2006 'Capacity development strategies and social learning'
- *Global Envision* - 31 March 2006 - 'Poverty in Africa linked to water management'
- *Friends of Ethiopia* - 10 April 2006 - 'Poverty in Africa linked to water management'

- *Reuters News Service, Kenya* - 10 March 2006 -, 'Poverty in Africa linked to water management'

#### The following profiles of researchers have been published in Amanzi:

- Nozibeli Mjoli – Generosity personified
- Christine Colvin – Knowing the drill
- Hannes Rautenbach – Above the weather
- Maggy Momba – Water – Qualitatively Speaking! (including a profile of her students)
- Wim van Averbek – My African Dream
- Mompoti Nyebe Baiphethi (M.Sc. Agric. student)

### Scope for 2006/07

Even though some of the key areas and the issues within the key areas have been prioritised during 2005/06, still a lot of work had to be done during the 2006/07 financial year to continuously improve the benefits of knowledge management. Practically, it will only be in 2007/08 that we are better positioned to fully execute the identified priority activities. While the scope may appear to have changed conservatively, the level at which these are going to be carried out is different. At the same time, we need to acknowledge that most of these are about the way we do business and hence can be defined under continuous improvement.

### Intellectual property

In order to encourage successful invention and subsequent solid patents, the WRC will continue to address the creative needs of the researchers and foster an inventive environment within the research area and engage with the researchers at all levels. By supporting the creation and protecting technological developments the WRC strives to further improve knowledge transfer (utilisation and commercialisation) of its research results (in collaboration with its research providers and the water sector at large) where and when applicable.

### Publications and public understanding of science

There will be some special publications and initiatives design to capture public interest in Water and Water-related issues. The continuous improvement of *The Water Wheel* as a public understanding of science tool will continue to capture the younger members of our society.

# 5 KSA 5 (continued)

## Water-Centred Knowledge

### Information and communication technology

There will be more emphasis on the deployment of the newly developed Fund Management System (FMS). Information safety will be improved with the implementation of rigorous risk assessment and mitigation measures. Compliance with audit and regulatory requirements will be a key focus area and will include conclusive resolution of all outstanding audit issues.

In keeping with government's drive towards increased use of Open Source technology solutions, the WRC's intranet will be redeveloped using an Open Source Content Management framework. Ongoing initiatives in the adoption and use of relevant communication technology will see full implementation during this financial year. These will include the cell phone-based communication systems and 3G internet access for senior management staff.

### Knowledge Management and Water Information Network (WIN)

There is a need to view any organisation as a human community capable of providing diverse meanings to information output generated by such activities as research and development. The challenge is to make the organisational information base accessible to external organisations and individuals. This is important, given the increasingly fast-paced and dynamic business environment that creates disconnections between the process of decision-making at the top and implementation of such decisions at the grassroots. This is even truer in the water sector.

The preferred approach to information processing should be tested in the near future. Two approaches (water metaphors) are utilised, through WIN as follows:

- It is important to find useful knowledge, bottle it, and pass it around

There is a great big river of data out there. Rather than building dams to try and bottle it all up into discrete little entities, we just give people canoes and compasses.

### Highlights for the 2006/07 Financial Year in Terms of Thrusts

#### Thrust 1: Knowledge Management and the Water Information Network

##### Water Information Network (WIN-SA)

The year 2006/07 has been the second year of the envisaged WIN-SA growth phase. This period has seen a growth in the product offerings of WIN-SA, with a significant improvement in network synergy and co-ordination. Of particular significance were the new product offerings in the capacity building core thrust. WIN facilitated two training programmes. The first one was on brokering sector collaboration, which is a much-needed skill in any environment that requires intergovernmental coordination and collaboration. This was done in collaboration with DWAF, and Building Partnerships for Development in Water and Sanitation. Twenty-six change agents from across the country were trained in how to manage collaboration in their various roles in the water sector.

WIN-SA started the process of developing the *WIN-SA Learning Journey Manual* together with SIPU International. This has seen the training of 10 learning journey facilitators from different organisations across the water sector. Huge strides have also been made in terms of coordinating the WIN Network, and bringing the activities of WIN partners to the attention of the broader water sector, mainly through the WIN Partners Forum which is an annual learning and sharing event that brings together a wide variety of stakeholders.

On knowledge documentation, WIN-SA started a collaborative project on the documentation of Free Basic Services lessons. This has fostered stronger relations with DPLG and has gone a long way towards helping local government to share experiences on the provision of free basic services.

Governance and institutional arrangements had been the biggest hurdle that WIN has had to jump. It was highly essential to strengthen the governance structure and

to ensure that a level of sector comfort is reached when it comes to the leadership of WIN. The first sitting of the WIN-SAC (Strategic Advisory Committee) took place in October 2006. This Committee is chaired by the WRC, and has WSSLG representation. Five lessons were completed as part of the DPLG lessons series. These are the topics covered: Illegal Connections in Middleburg; Policy Compliance and Proper Financial Management in Zululand; Upgrade and Metering in Madibeng; Greater Giyani Turnaround Strategy; and Breede River/Winelands WS on farms. The lessons-learning programme is going to adopt a more regional focus in 2007/08, which means WIN will engage more with municipalities in one province and facilitate inter-municipal dialogue through existing provincial structures. A scoping study has already been conducted in the Free State Province and the programme will be implemented in the coming year.

#### Thrust 2: Publications and Public Understanding of Science

At the conclusion of a project and also while research is still under way, results are evaluated in respect of possible use and application and depending on the nature of the results a decision is taken on publication, dissemination and application thereof.

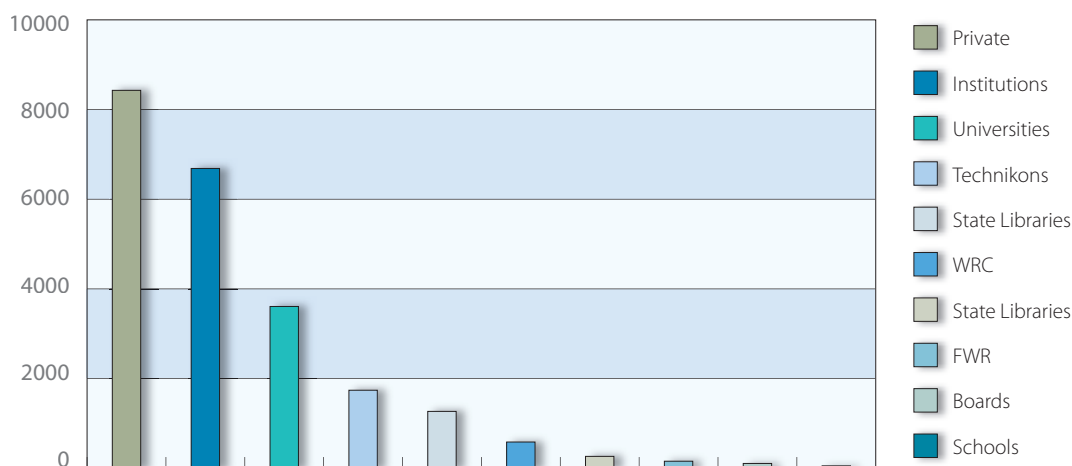
##### List of WRC publications

A continuously updated list of WRC publications is posted on our Website ([www.wrc.org.za](http://www.wrc.org.za)) for perusal by users and orders for reports may be placed either electronically, telephonically or by fax.

An effective marketing strategy for the knowledge assets was developed. A report catalogue of selected TT reports has been compiled and is being widely distributed. During the year under review 99 new reports were published and approximately 20 281 reports were dispatched upon request from stakeholders; some of these were sold and the income generated in this way came to R81 577.

The following graph shows the distribution of reports to stakeholders during 2006/07:

### Totals of reports distributed to stakeholders during 2006



An efficient printing strategy based on print-on-demand was implemented and has considerably reduced the overall costs for knowledge dissemination, e.g. storage and postage.

The following table shows the most popular reports requested and distributed during the year under review:

Total	Most Popular Reports Distributed During 2006/07	KSA
950	TT 265/06: Handbook for Waterworks Operation	3
775	TT 247/05: An Illustrated Guide to Basic Water Purification Operations	3
721	TT 262/06: The Development of a Framework for Understanding Human-Rights Based Approaches and Integrating them into Water Resources Management in South Africa	3
522	TT 261/06: Guidelines for the Utilisation and Disposal of Wastewater Sludge: Volume 1 of 5: Selection of Management Options	3
255	1430/1/05: Climate Change and Water Resources in Southern Africa	3
234	TT 276/06: Cross-Sector Policy Objectives for Conserving South Africa's Inland Water Biodiversity	2
198	TT 248/05: Guidelines for Irrigation Water Measurement in Practice	4
182	TT101/98: Quality of Domestic Water Supplies. Vol 1: Assessment Guide	3
173	TT 270/06: Guide for Local Government Cooperation with Catchment Management Agencies.	1
161	TT 271/06: Guide for Catchment Management Agency Cooperation with Local Government.	1
154	1414/1/05: Environmental Water Requirements in Non-Perennial Systems	2
151	TT 117/00: Quality of Domestic Water Supplies, Volume 2: Sampling Guide	3
150	1163/1/06: Development of a Water Quality Index for Estuarine Water Quality Management in South Africa	2
146	1310/1/05: Development of Criteria for the Design of Fishways for SA Rivers and Estuaries	2
143	1214/1/06: An Assessment of Sources, Pathways, Mechanisms and Risks of Current and Potential Future Pollution of Water and Sediments In Gold-Mining Areas of the Wonderfonteinspruit Catchment	2
141	KV 174/06: National Wetland Inventory: Development of a Wetland Classification System for South Africa	2

# KSA 5 (continued)

## Water-Centred Knowledge

134	TT 250/05: Water Poverty Mapping: Development and Introduction Using a Case Study at the Local Municipal Scale for the Eastern Cape	3
133	TT 246/05: Ecological Sanitation - Literature Review (ecosan)	3
123	TT 266/06: A Desalination Guide for South African Municipal Engineers (We distributed more than 400 copies of this report since the beginning of 2007)	3
119	TT 217/04: Environmental Water Quality in Water Resources Management	2
117	1380/1/06: A Methodical Approach to Health and Sanitation Integration	3
114	1398/1/05: Origin, Fate and Clinical Relevance of Water-Borne Pathogens Present in Surface Waters	1
114	1479/1/06: A Scoping Study to Evaluate the Fitness-For-Use of Greywater in Urban and Peri-Urban Agriculture - Scoping Study	4
114	TT 279/06: A Study of Roman Water Law, with Specific Reference to Water Allocations and Prior Appropriation	1
110	1344/1/06: The Assessment and Classification Of Inorganic Manganese Containing Wastes	3
109	1248/1/06: The Evaluation of the Anaerobic Baffled Reactor for Sanitation in Dense Peri-Urban Settlements	3
104	TT 243/04: Managing Estuaries in South Africa: A Step By Step Guide	2
103	1358/1/05: Situation Analysis of Problems for Water Quality Management in the Lower Orange River Region with Special Reference to the Contribution of the Foothills to Salinisation	4
102	1439/3/06: Use of Human Excreta from Urine-Diversion Toilets in Food Gardens: Agronomic and Health Aspects: Vol 3	3

### Water SA

In 1975 it was decided to establish a peer-reviewed scientific water journal which would appear quarterly. **Water SA** is the WRC's accredited scientific journal which contains original research articles and review articles on all aspects of water science, technology and engineering. Its appearance created a forum for South African scientists and engineers to present their research results both nationally and internationally.

**Water SA** continues to serve the South African research community in this way, but in recent years it has also had increasing support from overseas authors as far afield as China, Ukraine, Spain, Argentina, Finland, Korea, Turkey, Australia, Belgium, Canada, Thailand, Denmark, Croatia and the USA.

It has a strict refereeing system whereby all articles submitted for publication are first referred to referees. Thereafter, a decision is taken on whether or not the article should be published. In 2006/07 **Water SA** published 71 articles written by 223 authors and reviewed by about 150 international and Southern African reviewers. **Water SA** has an extensive local as well as overseas readership. Since

the beginning of 1997 the full text version of the journal has been available free of charge on the Internet via the WRC website (<http://www.wrc.org.za>) and from April 2005 onwards it has been published free of charge as an open source e-journal with print copies available on request at a nominal fee.

**Water SA** also enjoys world-wide coverage by all the major international abstracting services that publish and distribute summaries of articles which appear in **Water SA**. In addition it is abstracted on **African Journals Online (AJOL)** <http://www.inasp.info/ajol> and on SABINET (the main SA company facilitating electronic access to information) under e-publications.

Over a span of almost 30 years the journal has moved from the paper era to the electronic era, employing the most advanced publication technologies currently available.

### The Water Wheel

The WRC continuously strives to improve public understanding of water research and development issues. One way of disseminating information is through its magazine, **The Water Wheel**. Published six times a year, the magazine continues to grow in popularity, serving a diverse audience ranging from

water sector professionals and government officials to farmers, non-governmental organisations and school learners. At present, more than 8 300 copies are distributed throughout South Africa and into African countries.

**The Water Wheel** informs the public about the application of science and scientific processes, methods and research in the water field. The publication covers a variety of topics, ranging from climate change and freshwater conservation to the reuse of treated wastewater and groundwater issues. Feature articles do not only report on WRC projects, but also on the positive contribution of water research to society and the improvement of life of South Africans in general.

While the publication is still available free of charge, advertising space is sold in **The Water Wheel** in an attempt to defray the continuously escalating production costs and postage. Advertising rates are available from **The Water Wheel** editor at the WRC. During the year under review, the magazine was not only distributed to subscribers, but was also made available at significant water events, such as the WISA Conference, which took place in Durban.

### **Amanzi**

**Amanzi**, the WRC bi-monthly external newsletter, is now fully electronic. It has a wide readership that is growing daily. The newsletter features profiles of prominent researchers as well as students who are involved in WRC-funded research. **Amanzi** also publishes news and events relating to the water sector as well as synopses of the latest WRC reports.

### **Thrust 3: Knowledge Transfer and Commercialisation**

The WRC has a widely accepted Intellectual Property (IP) Policy and a Benefit-Sharing Policy. These policies clarify its contractual requirements for future research projects and improve the level of understanding/knowledge regarding the protection of IP within the water research community. The WRC continues to play an active part in the activities of the South African Research and Innovation Association (SARIMA), and engages with other institutions, such as the Innovation Fund and the Department of Science and Technology on the developments in the IP rights arena.

The WRC continues in its effort to license and earn income from its licensed IP. A new IP manager has commenced duty during July.

During 2006 the WRC has seen growth in its IP portfolio. In this connection, the WRC has filed six provisional patent applications, a clear indication of the commitment on the WRC to continue to provide South Africa and the world at large with applied knowledge and water-related innovation. The six provisional patents filed include the following patents:

- Biosensor
- Method of detecting the presence of micro-organisms in a solution
- Olive wastewater treatment
- Passive sampler
- Application for ash and its derivatives and
- Synthesis of zeolites

We have already filed complete patent applications for all the patents that were due for completion in May and June 2007. Only one provisional patent application entitled 'Method and Apparatus for Treatment of Industrial and Domestic Wastewaters Using

Dual-Stage Membrane Bioreactor Process' was filed in 2007.

With creative licensing strategies, the WRC can assist in fostering sustainable development, which, in the WRC's view, will allow transfer of technology with the aim of promoting a better quality life for all. In this connection, a high percentage of the patent portfolio is licensed out. Currently, we have licence agreements with reputable South African and international companies. These include:

- The BioSURE™, a cluster of 36 patents which is licensed to ERWAT. Products arising from this cluster have gone through the development and piloting phases and a meeting with ERWAT is scheduled to discuss a strategy on how to protect improvements discovered during the said phase.
- The Petro™ process, a cluster of 8 patents, was licensed to Presario. The licence has since lapsed and we are currently in the process of assigning our rights to Mr P Meiring, the co-owner of the patent, since co-ownership is no longer in line with our IP policies.
- Filtration Membrane Technology (CUF), a cluster of 5 patents of which licensing negotiations with two commercial partners have reached the final stage and a non-exclusive licence agreement is expected to be signed before the end of the year
- The acid mine drainage process is currently licensed to environmental technology agencies and royalties have not yet been received as the product is still under development
- Detection of fouling membrane patent is currently licensed to a German company and the product is still under development.

We are now in the process of formalising our relationship with an American company dealing with marketing and licensing of technology.

The WRC also aims to build awareness and improve IP management internally and at academic institutions. The WRC is currently developing guidelines to deal with the procedure for disclosure and commercialisation of its IP portfolio. We are currently developing a new website for the new technology transfer office.

### **Thrust 4: Information and Communication Technology**

A key highlight has been the successful use of the Fund Management System (FMS). The first annual proposal cycle has progressed from web-based submission stage, through initial screening and review, to final evaluation and ultimately to contract stage. All these processes have been achieved within the FMS. The system has proven to be robust and user-friendly and has received many favourable comments.

Another important achievement has been the positive IT audit report that reflects notable improvements in IT practices and compliance. Great strides have also been made in the development of the Content Management Intranet using the Joomla! Open Source software application. The new-look intranet will be launched during the 2007/08 financial year.

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# Impact Areas

*The core strategy of the WRC requires a number of key impact area issues of national importance to be addressed. Each of the KSAs, through its own portfolio of thrusts and programmes, makes an important contribution to addressing these issues. However, to ensure that the WRC research portfolio as a whole achieves the desired impact with regard to each of these key strategic issues, they are dealt with specifically in four impact areas established purposely to provide for necessary integration and leadership roles and functions. Apart from being of national importance, the issues addressed by the impact areas enjoy regional and international priority, as the agendas of major events and movements such as the WSSD, successive meetings of the World Water Forum as well as NEPAD have clearly shown.*

The integrating function of the impact areas entails drawing together programmes and projects which address the relevant impact area issues and which are under way within the portfolios of each of the KSAs. Leadership and support is also provided for new KSA initiatives which can further knowledge with regard to impact area-related strategic thrusts. The impact areas may also drive specific programmes/ projects that are overarching and relate to all KSAs in a general manner.

The impact areas address the following key issues:

- Water and Society
- Water and the Economy
- Water and the Environment
- Water and Health

## ***Integrating Logframe for the WRC Impact Areas***

Besides providing new social, economic, environmental and health-related perspectives on the creation, dissemination and transfer of water-centred knowledge by the WRC, the impact areas provide links to the higher-level objective of improving quality of life for all South Africans by addressing the strategic issues of society, economy, environment and health.

The logframe described in the previous year's plan was reviewed and it was concluded that the overarching view, goals and outcomes described therein have not changed and are appropriate and applicable to the current macro and micro-environment of the WRC. The logframe continues to provide an overarching framework, illustrating the link between the higher-level, quality-of-life objective of the WRC and the consolidated goals, intermediate goals, purpose, and outputs of the all the impact areas. This overarching view relates closely to individual logframes for each of the impact areas, and, therefore, also illustrates the link between the portfolio of strategic issues in each impact area and the WRC's mission.

## Water and Society



**Dr Andrew Sanewe: Head**

### Scope

The scope of this impact area continues to address water as a social good and the vital role water plays in social development. It provides an integrating framework for, and further facilitates expansion of, that research and development within the different KSAs which contributes to a sound balance between the manner in which water resources are used and cared for by society, and the benefits which society as a whole derives from the use of water. The impact area endeavours to find ways to assist society in developing a sound understanding and appreciation of the various issues around water as a scarce resource, as these relate to the need for equitable (including transboundary) sharing of the resource, avoidance of conflict, promotion of co-operative water resource management and productive and sustainable resource use. Finding improved, sustainable and socially acceptable ways of meeting society's needs for water services is another important focus area because of the continuing service backlog. Furthermore, inter-linkages between poverty issues, gender issues and access to water and water services need to be established, and the knowledge gained applied in promoting poverty alleviation and better quality of life for society as a whole.

### Objectives

As described in the previous year's business plan, the aims of this impact area are to facilitate and integrate WRC research and development initiatives which promote:

- Healthy perceptions and balanced awareness of key issues relating to water as a scarce and shared resource
- Water services which are socially acceptable, affordable and available to all
- Empowered communities able to participate effectively in water institutions
- Ready access to water for the poor, women, the youth and the disabled.

### Thrusts

#### **Thrust 1:** *Water as a Shared Resource*

This thrust will continue to focus on investigating hydro-political issues within South Africa and the SADC region. Issues include the inter-sectoral and transboundary sharing of water, water scarcity in relation to demand, water quality, and the roles of water in various economic and societal sectors. Appropriate research initiatives will aim at alleviating impacts of scarcity and degraded water quality on society and the water environment, thereby reducing potential for conflict, and promoting healthy co-operation with regard to integrated, sustainable management. Research in this thrust will support policy and decision-making regarding the allocation of water (over and above the Reserve) to various development sectors, namely domestic, industrial and agricultural.

#### **Thrust 2:** *Social Needs for Water Services*

The focus of this thrust remains on analysing and understanding society's needs for water services. This will lead to guidelines aimed at enhancing utilisation of limited water resources and finance in sustainable service provision. Such understanding will ensure that the real needs of society are known and addressed in a flexible and socially acceptable manner. Issues around payment for water, ownership of potable water schemes, hygiene and sanitation will be investigated.

#### **Thrust 3:** *Gender and Other Limitations Regarding Access to Water*

Research within this thrust will continue to focus on investigating the extent to which gender, age and physical disability influence access to water resources. Knowledge will assist in the development of policy guidelines for improving equity in water access among users.

#### **Thrust 4:** *Poverty Alleviation*

The focus of research within this thrust remains the linkages between water and poverty. This will lead to effective strategies for using water resources to break the poverty cycle and promote food security.

### Research portfolio

The funding for research projects supported by the various KSAs and focusing on this impact area, is estimated at about R10.3 million for 2006/07 (R900 000 less than 2005/06).

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2006 and 31 March 2007.

### Completed Projects

#### **Thrust 1:** *Water as a Shared Resource*

*Promoting democracy through the IWRM process: Developing a model for sustainable relationships for the management of a scarce natural resource*

CSIR  
No 1294

This research was aimed at developing an understanding of how to govern shared, scarce natural resources. Worldwide there is increasing pressure on society to achieve eq-

# Impact Areas (continued)

uitable, efficient and sustainable use of ecosystem goods and services. The challenge that governments face is to reconcile the distribution of costs and benefits for society as a whole. The process that should underpin this reconciliation must be founded on trade-offs that have continually to be achieved through democratic processes. Only if these trade-offs are made democratically is it possible to expect the popular support that leads to compliance. In this way, attainment of equitable, efficient and sustainable use of ecosystem goods and services will reflect the extent to which democracy is institutionalised in society and the agencies that act on its behalf.

The research was conducted in the Sabie-Sand catchment in Mpumalanga Province, South Africa. The project was divided into three phases. The objective of Phase I was to develop familiarity with relevant underlying theories and to describe the social-ecological system in the Sabie-Sand catchment with respect to decision-making structures, processes and behaviours. From this, issues were selected to focus the action research phase of the project (Phase II). The objective of Phase III was to draw lessons from the research experience and to highlight the implications for the development of appropriate relationships and cultures for sharing a common property resource.

Phase I identified three models, or frameworks, that would be particularly useful in guiding the research. These were Senge's process for profound change, a form of action research known as appreciative enquiry, and Cook's model for understanding empowerment.

Phase I also identified a number of issues around river resource governance in the Sabie-Sand catchment. These were:

- Large discrepancies between organizations and individuals
- Very little co-ordinated decision-making between organisations, which tend to engage government to resolve resource issues, rather than each other
- A lack of formal representation of the interests of many resource users
- A predominance of decision-making structures that were not necessarily geared to address their constituency's resource-related issues.

A number of opportunities were also identified:

- The Sabie River Irrigation Board had a vision to expand its scope to include a number of downstream users. In this way, the board would enhance its representation and empower others. This offered a significant opportunity to the research project
- The private forestry sector (global forest products) and the Kruger National Park stood out as organisations that are outward-looking, well-resourced and able to seek, engage and drive co-operative processes. They are at opposite ends of the catchment, again providing an opportunity for focus and for integrating upstream/downstream concerns.

At the end of project Phase I, differentials in levels and types of empowerment emerged as a major obstacle to stakeholders' collective capability to develop shared understanding and make wise trade-offs. Learning about what constitutes empowerment and co-operative empowerment therefore became a focus area for Phase II of the project. The Cook model of empowerment was used to guide the research team and resource stakeholders.

Phase II focused on action research. It applied strategic adaptive management (SAM) concepts in its approach. SAM is based on the acceptance of the uncertainty and variability inherent in social-ecological systems and the need to proceed with incomplete information. Thus, management should be experimental, adaptive and learning-oriented, so that learning from each round of implementation informs the next. This approach moves away from the balance of nature theory to a concept of nature as a system of hierarchical patches that are changing and diverse over space and time.

Phase II of the research project proceeded, in the first place, as a series of individual consultations with the 'well resourced' stakeholders. Once their agreement was obtained to participate further in the process, a joint workshop between the stakeholders, the research team, and DWAF was held.

There were a number of outcomes arising from the above process. Well-resourced stakeholders were willing to engage and invest in local-level informal processes, but

they felt that they would benefit greatly from explicit acknowledgment and endorsement of their endeavours by DWAF. Related to this, there is a question about where the responsibility of an informal process ends, and where that of more statutory processes begins. There was also a perceived need for adequate and appropriate representation when people strive to make decisions together. There is a tension between being representative (i.e. having all groups present, but perhaps not participating equally) and building relationships, perhaps more slowly but more thoroughly and meaningfully, to achieve full representation.

The research conducted during this project has allowed the team to identify a number of important lessons regarding co-operative resource governance. These include the following:

- Relationship-building cannot be rushed (as predicted by Senge's model)
- Repeated reinforcement is important for sustaining relationships
- Stakeholders can learn to value relationships as much as the decisions they support
- Informal resource governance processes require support from formal processes, and there is a risk of failure if they are not supported
- There is a need to balance the requirements for empowerment (which takes time) representation (which can be achieved relatively rapidly, but does not necessarily lead to voluntary compliance and truly empowered resource sharing)
- Individual champions, or catalysts, play a critical role in sustaining and fostering relationships in informal resource sharing processes.

Cost: R1 416 700 (KSA1)

Term: 2002 - 2005

*Towards integrated catchment management in the Mlazi River: A model for participation in the South African context*  
Farmer Support Group, University of KwaZulu-Natal  
No 1157

In 1994, various residents, resource managers and researchers with an interest in the area around the Ntshongweni Dam were approached by Raymond Auerbach concerning

social and environmental problems in the area. Although then Research Coordinator for Farmer Support Group, he was at the same time also a local farmer in a small subcatchment of the Sterkspruit, a tributary of the Mlazi River. With the help of seed funding from Umgeni Water, and the positive engagement of many people, information was gathered, a proposal was submitted to the WRC and an initial catchment management workshop was held in November 1994. At this point, the focus was on the Sterkspruit (or *Mncadodo* Stream), the Ntshongweni area and Dam, and the Mlazi River between Mpumalanga Township and the Dam. The programme was called the Ntshongweni Catchment Management Programme (NCMP).

When WRC approved the pilot proposal for 1995 and 1996, three more staff members were appointed in addition to the coordinator (ecologist; catchment development facilitator; and agriculture facilitator). Activities gathered momentum, with a remarkably positive response to the pamphlet (published in 1996). At the end of 1996, WRC agreed to double the level of support, to enable the appointment of a publicity and information officer, a craftwork facilitator, an environmental educator, an office manager, a conservancies consultant and later an upper catchment agricultural facilitator (with help from Mondli), and a conservation Officer (employed by the Umlaas Irrigation Board Catchment Project). These 11 people have undertaken a remarkable range of activities over the past 6 years. Together with 6 Dutch students and several more South African students, they have built up a body of experience in integrated catchment management (ICM). The programme has grown from a small core of activities in one subcatchment, to a more comprehensive attempt to bring people together throughout the Mlazi River catchment, and also influences Metropolitan Durban through staff involvement in developing an Environmental Management System based on an understanding of the importance of ICM. The name of the programme has now been changed to the Mlazi River Catchment Programme (MRCP) to reflect this more comprehensive scope. However, as a lower level of support was given to the third phase of the programme, activities could not be extended into the lower catchment, and the staff complement was reduced from 10 staff members to 5 members.

The main activities of the programme can be described under the headings water demand management research, environmental education, rural development and community capacity building, local government development and environmental monitoring. In each of these fields, a considerable number of activities were undertaken, representing technical, social and ethical aspects of catchment management.

Cost: R1 000 000 (KSA 1)  
Term: 2000-2001

*Stakeholder participation in the establishment and governance of catchment management agencies (CMAs): Best practice guidelines*  
*Department of Geography, Rhodes University*  
*No 1434*

The NWA puts emphasis on the decentralisation 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 marginalised groups are also taken into consideration in the governance of CMAs?
- How can civil society be best organised to play a meaningful role in the management of water resources at a catchment and subcatchment level?

Cost: R1 000 000 (KSA 1)  
Term: 2003-2005

*Integrated development planning for estuaries*  
*Institute of Natural Resources, Rhodes University*  
*No 1485*

The Eastern Cape Estuaries research and management programme which was initiated in the late 1990s to empower the communities living beside these estuaries to manage

the resource sustainably. The integration of knowledge generated into the Integrated Development Planning (IDP) process is a necessary step towards sustainable management of estuaries and building the capacity in this will entrench this for the future. This sustainable management is also required in terms of existing legislation.

Like other ecosystems, estuaries offer a range of services and attributes that generate value and contribute to human welfare. A suit of methods have been developed to establish economic value and the application of these indicate that estuaries confer significant benefits to society. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas. The course contains modules on economic value, estuary functioning, impacts on estuaries, estuary management and enterprise opportunities that can be derived from estuaries.

Cost: R1 220 000 (KSA 2)  
Term: 2004 - 2007

*Strategic review of current and emerging governance systems related to water in the environment in South Africa*  
*Pegasys Strategic Management*  
*No 1514*

A particular governance system should be matched to and aligned with the biophysical and ecological processes occurring within the ecological system that supports a society or community.

**Interpreting Water Governance:** The complete system of governance for water may be represented as a three-dimensional system of:

- Elements, including principles & mandate, policies & legislation, regulatory framework, institutional arrangements and practice
- Levels, from international, national, regional, local to neighbourhood levels
- Responsibilities of government, non-government organisations and civil society.

**International Context:** Defining what constitutes international water law is simply due to the preponderance of customary international law at this level. For governance of water in the hydrological cycle, the most

# Impact Areas (continued)

relevant initiatives are those related to climate change, management of transboundary water resources and environmental management. These initiatives and law are taken as context for the national governance evaluation.

**National Policy and Legislation:** Conclusions about the broad legislative environment are relevant for water governance in South Africa such as:

- The Constitution sets the parameters for good water governance
- The legislated governance system for water has several elements, with the National Water Act and Water Services Act administered by DWAF at its core.

**Evaluation of the Governance Systems:** While the policy and legal environment has been generally well developed in South Africa in accordance with government policy since 1994, the implementation of this policy and legislation has been generally uneven, inconsistent and often inadequate to meet the challenges facing the country. Therefore the key focus of the evaluation is on the regulatory environment and practice. It does this specifically from the perspective of the water governance, and prioritisation is primarily based on the associated impact on the water environment. For practical reasons, the synthesis takes a physical media approach, focusing on governance of air, land and water.

**Air Governance:** Specific issues that may benefit from further investigation include:

- Opportunities and institutional arrangements for joint planning, management and regulation of air and water quality (linked to land quality) at a catchment basin scale, through the catchment management strategy process
- The technical, procedural and institutional considerations for addressing water resource impacts as part of the air emissions licensing process.

**Land Governance:** From the wide-ranging review and evaluation of land governance from a water-hydrological perspective, the following are examples of the priority issues identified:

- The opportunities for effective coordination of land-use governance through catchment management

processes, and appropriate mechanisms to institutionalise the required cooperative governance

- The institutional capacity of local government to effectively perform its functions related to management of the hydrological cycle, particularly around integrated development planning, municipal service delivery, waste management and land use authorisation.

**Water Governance:** In addition to the water-related issues associated with land governance, specific governance issues related to the water environment include as examples:

- Governance of catchment management agencies at all levels, within a paradigm of cooperative, integrated, developmental and participatory management
- Governance considerations and mechanisms for the development of catchment management strategies through a consultative process and their alignment with local development planning (IDP, WSDP) and provincial planning processes (PDGS).

**Challenges to Good Water Governance:** There are a number of fundamental challenges to improving water governance in South Africa such as:

- Change and maturity in the governance systems
- Institutional change and decentralisation.

Given the magnitude of these strategic challenges, it is remarkable that there is a relatively effective governance system in the water and related sectors. From this synthesis and evaluation, it is apparent that an institutional champion is required for promoting coherent and harmonised implementation of water governance related to the entire hydrological cycle. While DWAF must continue to play this role at a national policy level, it is proposed that catchment management agencies provide a focus point for improving governance of water in the hydrological cycle at a catchment level.

Cost: R 500 000 (KSA1)

Term: 2004-2005

## **Thrust 2:** *Social Needs for Water Services*

**An identification and review of the factors in rural water services that facilitate and impact on local economic development in the Eastern Cape Rural Support Services No 1437**

There has been ongoing debate in the water and sanitation sector regarding the importance of viewing water services projects as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. One of the main issues related to this is the importance of, and ongoing need for local economic development in rural areas. This is an aspect which should be addressed in both the planning and implementation stages of any project with the full participation of community members. However, the current framework for delivery does not allow for the facilitation and promotion of economic development. This is particularly problematic given the current context of unemployment and poverty in rural areas. This study endeavoured to identify the factors that both facilitate and impact on local economic development (LED) both during and after the implementation of water services projects, in an attempt to address poverty and underdevelopment in rural areas.

The term 'local economic development' generally refers to a process of creating wealth through the mobilisation of human, financial, social, physical and natural resources or capitals. The core issue in LED is about the creation of wealth and jobs. The aim of local economic development ultimately is to produce higher standards of living, improve the quality of life, alleviate poverty, create more and better jobs, advance skills and build capacity for sustained development in the future.

An analysis of both the desk research and the field research has revealed a number of factors that both facilitate and impact on LED in water services. The facilitating factors identified relate primarily to an understanding of the concept of LED, supportive and accountable local government and access

to sufficient water, land and credit. The main factors that impact on LED are the lack of understanding of the concept of LED, and the fact that there are no linkages between water related institutions and LED institutions both within and outside the community. Clearly, the lack of access to land, water and credit are also factors that impact on LED in water services.

The findings from this research project reinforce a number of the key issues raised in the literature and provide further information in support of the positive impacts that can be expected if water services projects were viewed as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. Improved water supplies can lead to both direct and indirect opportunities for improved productivity. More water, of better quality and provided more reliably, can provide the water needed for productive activities such as irrigation of a backyard or community vegetable garden or for micro-enterprises such as hair salons or brick manufacture. Indirect gains may sometimes be even more important than direct benefits in that they can apply to both water-based and non-water-based activities where saved time and money can be invested in activities that bring positive returns to capital or labour. It is clear that without specific training being provided to rural communities on LED there is unlikely to be a significant shift in the understanding of LED and the improvement of rural economies. It is recommended that community members are exposed to awareness raising and training on the importance and meaning of LED. In addition, community members should be capacitated to understand the IDP process and their roles and responsibilities in relation to the development of the IDP.

Cost: R 300 000 (KSA 3)  
Term: 2003 – 2005

*Sustainable development indicators for urban water systems: Case study evaluation of the Thohoyandou and Makhado (Louis Trichardt) municipalities (NS)*  
*University of Venda*  
**No 1517**

This study aimed at applying the concepts and sustainable development indicators developed by the UN and check their relevance in a developing country context. Twenty SDIs were proposed for urban water systems and categorized in terms of four environmental and technical systems: freshwater, drinking water, wastewater and sewage sludge. Twenty SDIs were tested for urban water systems in the Makhado and Thohoyandou municipalities and 16 were found to be useful for the current situation in the study area and were recommended for future studies. Some SDIs like raw water withdrawal, drinking water quality, drinking water consumption, drinking water quality, waste production loads to receiving waters, access to drinking water, sanitation and development indicators were easy to apply in the study areas as data were easily available. Some of the SDIs like access to water and sanitation, water quality and affordability of services (economic indicator) were similar to the key performance indicators of the South African Department of Water Affairs & Forestry. The current situation for many of the indicators studied for the water and wastewater systems is not moving towards sustainability and some improvements are necessary in the operation of the systems to make them sustainable.

Cost: R150 000 (KSA3)  
Term: 2004 - 2006

*Case study of a district municipality water services authority experience of implementing local government and water services related policy initiatives. An action-oriented research support (NS)*  
*Palmer Development Group*  
**No 1518**

As a motivation to the establishment of the Forum, it was noted that South African municipalities have been through a major transition over the last few years with the revised demarcation of municipal boundaries and the related creation of two tier local government. Further there had been rapid change in the policy environment with new legislation introduced governing municipal affairs (Municipal Structures Act, Municipal Systems Act, Municipal Finance Management Act), new funding policy (equitable share, mu-

nicipal infrastructure grant) and new water sector policy (The Strategic Framework for Water Services, free basic water, free basic sanitation). All this had presented considerable challenges to municipalities.

While there is considerable research in these various fields, much of it was not packaged in a way which was useful to district municipalities and those who work with them. Further there was no established way of sharing what learning was taking place. Therefore it was proposed that the WRC could have a major impact by supporting an action oriented research project aimed at gaining an understanding of what was needed by districts and then providing the necessary research support to them and ensuring that this information is shared.

Using funding from the WRC, the District Water Services Managers' Forum was established. The idea was for a relatively small group of high-level water services managers from district municipalities, who operate under the difficult circumstances outlined above, to get together with some fairly limited research support to have quick access to information which they could use to improve their planning and service delivery arrangements. It was believed that such an initiative would save the water services sector significant resources by improving efficiency in decision making and service delivery through minimising duplication in terms of funding similar investigations, bad decisions, and committing similar mistakes by different WSAs because of lack of information sharing.

The District Water Services Managers' Forum (the Forum) was formally established on 9<sup>th</sup> of June 2004. During this period, the Forum has proved to be a good platform for information sharing, learning and action research for managers.

The Forum provided an important platform for the managers to:

- Learn from each other through sharing of experiences when implementing policy and legislation;
- Identify research support needs that are of priority to them as they respond to the challenges facing them;
- Minimise duplication of effort and the likelihood of committing the same

# Impact Areas (continued)

- mistakes thereby improving overall efficiency in the use of public resources
- Consult and formulate shared perspectives on policy proposals and developments especially in as far as they affect service delivery in their environments

The Forum is proving to be an effective mechanism of knowledge sharing and lessons learning for DM WSAs. It has also grown in stature within the sector over the past year and it provides a platform for water services managers/ practitioners to input in key national sector initiatives.

Cost: R400 000 (KSA3)

Term: 2004 - 2006

## *Involving traditional healers and myths and stories in hand-washing/hygiene education / sanitation promotion initiatives*

*Sigodi Marah Martin*

**No 1521**

In South Africa nearly 80% of the population rely on the services of Traditional Health Practitioners (THPs) in matters of health and well-being, often prior to engaging the formal health service sector, making them potentially a key partner and stakeholder in community health education. Despite this being the case there seemed little evidence of the potential role that THPs could play in sanitation, health and hygiene being explored or promoted.

### **The specific objectives of this project were:**

- To investigate if there are myths or traditional practices that can assist with encouraging positive hand-washing behaviour and how can these be practically incorporated into hand-washing promotion, hygiene and sanitation education and sanitation promotion initiatives
- What is the potential for engaging traditional healers in South Africa to assist with carrying messages related to this?
- Could a similar model be used as was utilised for involving them in initiatives to combat HIV/AIDS?

The results showed that there is definitely potential for THPs to be involved in HH&S promotion due to their definitive influence on

the daily life of communities in South Africa. In order to maximise this potential role there are a number of challenges that need to be addressed. These include, but are not limited to, the paradigmatic differences between the biomedical and traditional health disciplines as well as the historical relationship of THPs to the legislative context and formal health care infrastructure.

In terms of specific recommendations the research findings point out that there should be active encouragement of the participation of THPs in any HH&S initiative. A participatory approach will be most effective when engaging THPs and the development of specific materials about engaging THPs in HH&S issues should build on those utilised in this research project and others in the water services sector. Deliberate strategies are also required to create processes that allow for new paradigmatic health services to emerge which will integrate the strengths of the disciplines of biomedical and traditional health. From the literature review, it also became clear that taking into account traditional values and integrating them in efforts geared towards HH&S promotion initiatives is imperative in a cultural context. It is therefore important to explore how this integration of traditional and cultural ways of thinking and living can happen at a level which practically impacts the way that communities live.

Cost: R326 000 (KSA3)

Term: 2004 - 2006

## *Benchmarking of domestic water consumption in selected South African cities*

*Rand Water*

**No 1536**

The study aimed to determine water consumption per erf and to relate this to erf size, number of consumers, etc. Included is calculation of return flows. Forty eight municipal treasury databases were collected and extracted for archiving in this study. This includes four metropolitan municipalities (Johannesburg, Tshwane, Ekurhuleni and Cape Town) and 151 cities or towns. The total number of stands in the databases exceeds 2.5 million, of which 1.5 million are non-vacant stands. The number of records (i.e. water meter records) in the databases exceeds 2.7 million. In most cases, the data record includes actual water meter readings, reading

dates and estimated monthly consumption figures for more than two years. Data for all types of users with metered consumption are included in the database, including domestic, commercial, industrial and educational users. To ensure the integrity of the data, two data cleaning phases were implemented. The main findings on domestic water demand were that:

- Inland stands use significantly more water than coastal stands
- Water demand is positively correlated with both stand value or income and stand size
- The current design guidelines underestimate the demand for small stands, and overestimate the demand for large stands
- Higher income users have both higher demand and larger variation between summer and winter demand. This is mainly due to garden irrigation.
- Townships and informal settlements have very little variation in their demands
- The average water consumption per suburb was calculated and compared to the current South African design guideline as. It was found that 39 % of the 1 188 suburbs fell below the lower and 8 % above the upper envelope curve of the guideline
- The return flow in the sewer system is only linked to indoor demand and thus does not have much seasonal variation
- The result is that the sewer return flow as a percentage of the water demand shows the reverse behaviour of the water demand pattern. The return percentage is highest for the lowest income groupings and lowest for the highest income groupings. The highest income grouping has the greatest variation in return flow percentage, and this percentage is highest during the winter months and lowest during the summer months. Garden irrigation is the main reason for this behaviour.
- 47 % of the average suburb demands fell inside the design envelope proposed by the South African design guidelines
- Inland water demand is significantly higher than coastal demand
- There is strong evidence that domestic water demand increases with both increasing stand area and stand value (or income).

Cost: R250 000 (KSA3)

Term: 2004 - 2005

**Development of a national water consumption archive**  
*Rand Afrikaans University*  
**No 1605**

Domestic water consumption is a function of various factors, including stand size, income, household size, climate, pressure and water price. However, the overriding problem with studying water consumption is that quality data are difficult to get hold of. In recent years, a unique software product called SWIFT (Sewer and Water Interface from Treasury) was developed, allowing access to municipal treasury databases to obtain demographic and water consumption information of large numbers of users. This is a very valuable source of information on the topic of water consumption both now and in the future. This project aimed to ensure that this valuable source of information is not lost. A procedure was developed to collect existing and future water demand data from the different municipalities in South Africa and installing the data in an archive that is accessible to researchers and other interested parties in South Africa. Forty eight municipal treasury databases were archived in this study. This includes four metros (Johannesburg, Tshwane, Ekurhuleni and Cape Town) and 151 cities or towns. The total number of stands in the databases exceeds 2.5 million, of which 1.5 million are non-vacant stands. The number of records (water meter records) in the databases exceeds 2.7 million. In most cases, the data for each non-vacant record include actual water meter readings, reading dates and estimated monthly consumption figures for more than two years. Data for all types of users with metered consumption are included in the database, including domestic, commercial, industrial and educational users. A method was developed and documented for the sustained archiving of future Swift databases. Methods for making the data accessible to researchers and other interested parties in South Africa were investigated. Because of the very detailed and sensitive nature of the data in the archive, legal opinion has expressed that used in the wrong way, the developers of the archives can be held responsible. It is therefore recommended that the archive be held by the University of Johannesburg and sent to applicants only on request and after signing an indemnity form. Information on the archive and this report are available from the website [www.uj.ac.za/wrg/](http://www.uj.ac.za/wrg/).

Cost: R150 000 (KSA3)  
Term: 2005 – 2006

**Thrust 4:**  
**Poverty Alleviation**

**Water-use efficiency of multi-crop agroforestry systems, with particular reference to small-scale farmers in semi-arid areas**

*Department Soil Science and Plant Production, University of Pretoria*  
**No 1047**

The project was conducted in several phases, namely: (a) 'On-station' on the Hatfield Experimental Farm of the University of Pretoria in which pure stands of sorghum, cowpeas, sweet potatoes and *Leucaena leucocephala* were compared with intercropping of *Leucaena* hedgerows with the same crops in the alleys for three seasons; (b) 'On-station' at the University of Pretoria, in which pure stands of sorghum, maize and *Leucaena* were compared with intercropping of *Leucaena* hedgerows with the same crops in the alleys for the two seasons; (c) 'On-farm' sylvopastoral system in Venda to produce forage and fodder for a small-scale communal dairy project; (d) 'On-farm' alley cropping systems (with maize and *Leucaena*), at Sekakane and Chuene Maja, compared with mono-culture maize and (e) Community development in the Sekakane and Chuene Maja areas.

Monitoring of competition for light and water in this project indicated that:

- Row orientation of trees in alley cropping (this changes constantly in insulating conditions where most plantings are on the contour), at the latitudes in the study areas, does not have a major effect on light interception during the summer months, but it could have negative impacts on the southern side of rows in the winter months, depending on the pruning/hedge row policy for the trees. The effect will also vary tremendously depending on the intercrop. Temperate species generally have lower threshold values at which they can still photosynthesize effectively compared to tropical species, but even within each of these groups there is considerable variation in shade tolerance.

Complementary work, conducted at Hatfield, has demonstrated that while virtually all the intercrop annual row crops did extremely poorly in the rows adjacent to the trees, *Panicum maximum* (a tropical C4 perennial grass species) was at its best virtually under the canopy of *Leucaena* coppice. This observation might, however, be confounded by the high fertility under the canopy of the leguminous tree crop.

- While the favourable soil conditions and better rainfall conditions at Hatfield would hypothetically reduce negative competition for water because of the deeper rooting habit of the trees, in practice competition for water in the upper soil layers was very strong in the rows closest to the trees (probably because under the experimental conditions there was little or no recharge of subsoil moisture and trees competed in the shallower horizons for moisture). On the 'on-farm' site at Sekakane which was the only co-operative site to yield satisfactory production data, it appeared that in the poorest season maize survival and productivity was severely impacted up to 5m from the trees, while in the best season ( $\pm 360$ mm of rain which was by no means a good season) maize rows 3m from the trees (border rows of intercrop had the best yielding plants) were affected.

These results should be interpreted in the context of two factors:

- Additional studies conducted on *Leucaena* by the University of Pretoria found that the lateral spread of tree roots was much greater where unfavourable sub-soil conditions impeded root penetration
- Simulations of the water balance (using the SWB model) in a range of soils under a range of rainfall conditions indicate that under unfavourable rainfall conditions there is no water recharge of the deeper soil layers in 6 of the 9 scenarios examined. As a result there would be strong competition for water between different plant species in the upper soil layers as opposed to complementarity under better growing conditions.

Under marginal climatic and soil conditions (and the latter may be affected by financial ability of small small-scale farmers to ameliorate (rip, deep plough, drain, lime, fertilize the

# Impact Areas (continued)

soil)), the results from the project support the avoidance of competition between different crops in alley systems and the optimization of mono-culture agronomic practices. Under good climatic and soil conditions (prime land capability with minimal erosion hazard) the choice of land land-use system would be governed by economic considerations, although certain land users will persist with less profitable enterprises because of personal preferences. In South Africa, characterized by high climatic variability (even in high potential areas), diversification, mixed farming or spreading the risk is recommended. Where this is practiced annual crops, perennial crops and fodder trees could be combined in a range of alternative land use scenarios, which apart from mono-cultures, crop rotations and intercropping, might include different forms of agroforestry systems.

Considerable inputs into the functionality of different agroforestry models and their uses, has demonstrated that some of these could find application in developing systems or 'what if-scenarios' incorporating trees, which could improve crop productivity and sustainability. At the same time, however, it must be emphasized that extensive research must still be conducted to provide a sound basis for predicting crop and tree productivity. Furthermore, it must be recognized that while the technology of implementing alley cropping systems in harsh environments is still in its infancy it will remain a challenge to gain acceptance by land-users who also have to operate under difficult socio-economic pressures. Agro-forestry/alley cropping should clearly be an integral part of extension programmes designed to provide alternative ways for land users to improve the productivity of their land. It should not be seen as an objective in itself but rather as one of numerous strategies to realize community development goals.

Cost: R1 151 000 (KSA 4)  
Term: 1999 – 2006

***Principles, approaches and guidelines for participatory revitalisation of smallholder irrigation schemes***  
*ARCUS GIBB*  
**No 1463**

In 2003 the WRC funded a three-year project to develop guidelines for the revitalisation of smallholder irrigation schemes in South

Africa. A national database of 317 schemes covering approximately 50 000 ha was compiled. These are located mainly in the former homelands. While most of these schemes have collapsed or are under-utilised they continue to draw substantial funding from the Government for social and economic upliftment, often with limited success. 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.

'**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.

The guidelines present alternative pathways to constructive change on schemes, with full appreciation of the complexity and diversity on and between the schemes. They are based on meaningful involvement and information exchange between farmers, plot-holders and technical experts and thus ensure co-constructed plans for land-tenure, agricultural, technical, institutional, marketing and financial aspects. Best practice shows that major investment in human capital development is critical and that land-market stimulation can, in many cases, unlock potential. Interventions need to address all aspects of irrigation scheme operation and farm system planning, and avoid single-sector interventions such as infrastructure upgrading, mechanisation or institutional development alone. The **Guidelines** present ways forward to achieve greater success.

Cost: R 1 195 000 (KSA 4)  
Term: 2003 - 2006

## Current

### **Thrust 1:** ***Water as a Shared Resource***

***Integrating flood-plain agriculture into a diverse rural economy by enhancing co-operative management: A case study of the Pongola***  
*Institute for Natural Resources*  
**No 1299**

The effective management of the Pongola River flood plain has been unsatisfactory ever since the completion of the Pongolapoort Dam. This study aims at promoting effective co-operative management of the river system on a sustainable and democratic basis. Lessons learned here will contribute to formulation of policies and institutions to achieve sustainable use of river systems in rural South Africa. This project is strongly based on the principles of a participative action plan.

#### **The aims of the project are to:**

- Learn about promoting effective co-operative management around sustainable use of river systems in rural areas
- Redirect the pattern of resource use on the Pongola River flood plain towards a shared vision reflecting a diverse and sustainable economy
- Establish a confident and capable team of researchers drawn from previously marginalised sectors.

Estimated cost: R 880 000 (KSA 4)  
Expected term: 2002 - 2005

***Community-based research on the influence of rehabilitation techniques on the hydrology of degraded catchments***  
*CSIR/ Environmentek*  
**No 1316**

Two neighbouring communities of Mnweni and Okhombi in the Amazizi and Amangwane Tribal Wards have both embarked upon intensive job creation programmes which have focused on the rehabilitation of degraded areas. Both areas are situated in the foothills of the Drakensberg which forms the main catchment area for KwaZulu-Natal. Loss of grass cover on these steep mountain slopes has resulted in poor

water infiltration, increased runoff and severe soil erosion. Soil erosion is seen as a major threat to water resources and land productivity. The communities have been assisted in their erosion control efforts by various institutions including the University of KwaZulu-Natal, Farmer Support Group, CSIR, Dept. of Agriculture and KwaZulu-Natal Nature Conservation services.

One of the objectives of this project is to implement participatory monitoring whereby the rural participants record and analyse differences and change. This will provide an opportunity for learning where the people contribute to the monitoring process and are empowered to take subsequent decisions. In this way local capacity is enhanced and the communities become involved in technologies that fit local and environmental conditions.

**The research aims to:**

- Determine the effect of different rehabilitation techniques on runoff and soil loss
- Identify and prioritise rehabilitation interventions for establishing baseline conditions in the study areas
- Establish land users' perceptions on soil erosion and rehabilitation in conserving water
- Determine soil conservation measures that will be socially acceptable and physically effective in communal areas.

Estimated cost: R984 000 (KSA1)  
 Expected term: 2002 -2007

***A catchment management strategy for the Kat River***  
*Rhodes University*  
**No 1496**

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

**The objectives are to:**

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

Estimated costs: R2 100 000 (KSA 1)  
 Expected term: 2004 - 2007

***Approval and licensing of groundwater development and use***  
*Parsons & Associates*  
**No 1510**

Currently, granting approval for groundwater development and use falls within the responsibility of DWAF, DEAT and their delegated regional and local authorities. Authorisation is legislated under the National Water Act (Act 36 of 1998), the Environment Conservation Act (Act 73 of 1989, and amendments) and the National Environmental Management Act (Act 107 of 1998). Unfortunately, current procedures for granting approval for groundwater use are unnecessarily restricting groundwater development. This is because the two departments follow different procedures with respect to assessing groundwater use applications. Neither department has clear procedures, guidelines and /or definitions, thus preventing their officials functioning in a standardised manner. In many instances, the officials who make decisions

regarding procedures to follow or information required have no basic understanding of geohydrology. Lack of clear guidance regarding procedures, information requirements and co-operative governance result in officials adopting conservative, uninformed attitudes regarding information they require before considering approval for groundwater development and use. It is thus proposed that a multi-disciplinary research project be undertaken so that a solution can be found and developed and efficient and effective cooperative governance promoted. Resulting documentation will be the industry standard for exploring, developing and usage of groundwater supplies in South Africa.

**The objectives are:**

- To identify legal requirements for authorising groundwater developments, and develop a decision-support system that will allow officials, applicants and the general public to ascertain information that the officials require to assess applications to develop and use groundwater
- Development of workable definition for the term "bulk water supply", an activity for which an environmental impact assessment is required
- Review the general authorisations, as applied by DWAF to groundwater
- Review of DWAF licence information requirements and licensing procedures
- Review the EIA regulations applicable to groundwater
- Develop a decision-support system that will allow users to ascertain information officials require to assess applications to develop and use groundwater
- Develop a standardised code of practice / standard operating procedure so that as little environmental damage as is practically possible results from exploration drilling and pumping tests
- Compile a set of required and best practice with respect to managing small or low volume groundwater abstraction schemes.

Estimated costs: R390 000 (KSA 1)  
 Expected term: 2004 – 2006 (Extended)

***Industry-government partnerships for the development of sector-based standards for the water environment***  
*Karin Bowler Enterprises*  
**No 1511**

# Impact Areas (continued)

The aim of this project is to develop a partnership approach between industry and government for setting of agreed environmental standards, based on the Dutch 'covenant' model and utilising the provisions of the NWA for setting minimum standards for water uses which impact on the water environment, and implementing these through the use of provisions for environmental co-operation agreements which are contained in the National Environmental Management Act. The approach is to work at pilot scale for one industrial sector and one aspect of the water environment, in order to develop a generically applicable model.

Estimated cost: R400 000  
Expected term: 2004-2006

## *Implications of South Africa's trade policies for water policy and water resource management*

*University of Pretoria*  
**No 1564**

This project is to develop a strategic understanding of the linkages between trade policies and water policy in South Africa, and the implications of trade policies for water resources and water management, as well as to identify points or issues for future related research to support policy development, analysis and implementation in the water sector and linked economic sectors.

Estimated cost: R 530 000  
Expected term: 2005 -2007

## **Thrust 2:** *Social Needs for Water Services*

### *Protocols for 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 resources 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: Developing a protocol for defining spring-flow sustainability index; assessing the value of isotopes in characterising the sustainability of springs with the isotopic signature; and developing a weighting system to assess the sustainability of spring flow.

Estimated cost: R734 100 (KSA 1)  
Expected term: 2004 - 2008

### *Human rights and equitable access to water* **AWARD** **No 1512**

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). This concept is an expression in real terms of the constitutional intention to provide water to meet basic human needs (currently taken to be 25 l /person-day) before water can be allocated for use by the various sectors. 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.

#### **The objectives are:**

- An exploration of the concept of 'water as a human right' within the context of the South African legal framework
- Enhanced understanding, capacity and competence within Local Government to implement the National Water Act and allocate water resources with consideration for the concept of 'The Reserve'

- To produce and test learning support materials regarding the concept of the Reserve
- To research, understand and document the way that access to water resources as a human right can be implemented in South Africa

To share findings generated by a research orientation with other catchments and local governments in South Africa.

Estimated cost: R173 100 (KSA 1)  
Expected term: 2004 - 2005

### *Education awareness and behavioural change requirements to improve safe water practices*

*Environmentek, CSIR*  
**No 1522**

The main aim of this study is to determine or identify the water handling practices and behaviours which have a negative impact on users. Then use this as the basis to develop a framework for action and guidelines on improving hygiene behaviour. The study could break new ground and lead to new approaches which will lead to benefits in better health and hygiene promotion.

Estimated cost: R650 000 (KSA 3)  
Expected term: 2004 - 2006

### *Water services franchising: An innovative approach to water services delivery in rural and peri-urban areas*

*Umgeni Water*  
**No 1610**

The project aims to assess water franchising for delivery of services in peri-urban and rural areas. The concept proposed is a very new and innovative subject area. The study builds on outputs from a completed scoping exercise, which recommended that the principles and concepts be further established and proven, which would then allow piloting and implementation much more attractive. The concepts will contribute to wider participation of small scale entrepreneurs in the management of water services

Estimated cost: R600 000 (KSA 3)  
Expected term: 2005 - 2007

### *The state of community consultation in the provision of water services*

*Sigodi Marah Martin*

**No 1616**

It is imperative that in a changing institutional environment the concepts of community involvement are not lost. As Water Services Authorities take the helm of service delivery, it needs to be ensured that the community aspects are not lost. This study will look at the level and status of community consultation on a range of water services issues. It will aim to identify typical problems areas and successes and come up with recommendation for improving community participation in the sector. This will be of importance to the sustainability of projects, and also to the regulation of water services. This study will undertake a qualitative and quantitative survey to determine the level or status of community consultation.

Estimated cost: R700 000 (KSA 3)

Expected term: 2005-2007

### *Knowledge/information management and advocacy*

*Hlathi Development cc.*

**No 1635**

The overall aim of this programme is to improve access to sanitation research information and to develop effective mechanisms for promoting implementation of best practice by the sector role-players. The study will investigate:

- Development of a sanitation knowledge/information dissemination strategy including appropriate distribution channels, for example, the concept of sanitation resource centres
- Preparation of sanitation best practice guidelines

Development of a strategy for promoting application of research, this research should address the entire process from research topic identification to dissemination, advocacy, and the integration of new knowledge into human resource development initiatives within the sanitation sector.

Estimated cost: R 300 000 (KSA3)

Expected term: 2005 –2006

### *Thrust 3: Gender and Other Limitations Regarding Access to Water*

#### *Best practice institutional and project guidelines based on national and international experience to manage the impact of gender in the South African rural water sector*

*Council for Geoscience*

**No 1612**

Over the past 10 years a lot of emphasis has been afforded to the aspect of gender in the provision of water and sanitation services both at a local level and international level. In fact, it has become a requirement in many initiatives and has become part of policy and legislation. Yet, with all these requirements is progress being made. This project aims to understand the impact of gender on the management of rural water supply and the effects of decentralization of services. Are these new arrangements supporting gender mainstreaming? This is what the study will be highlighting.

Estimated cost: R600 000 (KSA 3)

Expected term: 2005-2007

### *Thrust 4: Poverty Alleviation*

#### *Management for new establishment of profitable small-scale farming with reference to the Lower Orange River*

*Agricultural Economics, University of the Free State*

**No 1354**

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According

to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment.

The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa.

#### **Sub-aims are to:**

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme

Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000 (KSA 4)

Expected term: 2002 - 2006

#### *On-farm application of in-field water harvesting conservation techniques on small plots in the central region of SA*

*ARC/ISCW*

**No 1355**

Technology exchange and adoption are the best possible ways of evaluating the success of any research project. Water harvesting (under dry-land production) using in-field basins, has improved yield for a number of crops. The technique, however, needs to be communicated widely – and tested *in situ*. Smallholder farmers, who often do not have irrigation facilities, and those who operate in dry areas, will use the technique under some guidance. This project will disseminate knowledge and technologies that will improve productivity of rain-fed agriculture.

# Impact Areas (continued)

Extension services, which have been identified as the weak link in rural agricultural development, will be targeted by this project.

Estimated cost: R800 000 (KSA 4)  
Expected term: 2002 - 2006

***Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research, Limpopo Province***  
*Tshwane University of Technology*  
**No 1464**

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research was completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. The research project on "best management practices for small-scale subsistence farming" requires commitment and co-operation amongst researchers, farmers and the community. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. However, the intention is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. This should be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R 1 200 000 (KSA 4)  
Expected term: 2003 - 2007

***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: R 3 000 000 (KSA 4)  
Expected term: 2003 - 2008

***Best management practices for smallholder farming on two irrigation schemes and surrounding areas in the Eastern Cape and KwaZulu-Natal through participatory adaptive research***  
*University of Fort Hare*  
**No 1477**

Most agricultural research is often not packaged according to the requirements of subsistence farming. In some instances research results are not adapted and therefore not directly useful for small-scale farming operations. As a result, extension, technology transfer and adoption need to receive more attention. In the past, extension services normally did not participate in the research projects, resulting in limited or no support for the intervention after the research had been completed. The need for early involvement of both farmers and extension services in this research project cannot be overemphasised as this leads to better diffusion of knowledge, thus making the intervention more sustainable. The benefits of the research intervention should be apparent to the farmers as early as possible. Motivation and promotion of awareness among the end-users with regard to the objectives of the intervention and the ways to achieve them are essential. It is acknowledged that research results available for water management in commercial farming are applicable to subsistence farming, and need not be repeated. The aim of this project is to make existing knowledge, indigenous and new technologies, useful for the particular circumstances of subsistence farming. The research project on "best management practices for small-scale subsistence farming" therefore requires commitment and co-operation amongst researchers, farmers and the community. This will be done through participatory action research which combines research, education and action to the direct benefit of farmers and surrounding communities.

Estimated cost: R4 500 000 (KSA 4)  
Expected term: 2004 - 2009

***Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province***

*University of Fort Hare*

**No 1478**

Approximately 74% of South Africa's 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 exert even more pressure on the rainwater resource base, particularly among the poor.

The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area.

Water harvesting and conservation techniques have had limited impact elsewhere, and in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system.

The research project on "water harvesting and conservation" promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 000 000 (KSA 4)

Expected term: 2004 - 2009

***Agro-forestry systems for improved food production through the efficient use of water***

*CSIR/Environmentek*

**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.

Small-holder agriculture, particularly in Africa, has been faced with land degradation. This is due to a number of factors, including poor management and limited production factors. In order to improve the status of land resources and sustain their productivity, there is a need for a "shift" from the current production practices. Agro-forestry (AF) systems (whereby there is a deliberate planting of trees in combination with food/forage crops for the benefit of people and the environment) have been reported to be potentially productive in degraded and marginal soils. Agro-forestry is also perceived to have potential for the rehabilitation of such degraded and/or marginal lands.

In South Africa, however, AF systems are relatively unpopular, yet the majority of the subsistence farmers are dependent on degraded lands for their agricultural production. A major challenge is to enable such farmers and poor communities to produce optimally under such constraints, simultaneously rehabilitating and improving the land resource. This will ensure both sustainable production and food security, while improving the livelihoods of the poor.

This project aims to address a number of questions that need to be answered in order for agro-forestry to be adopted locally.

Questions exist as to which AF systems are suitable, given the bio-climatic zones/specific ecosystems within South Africa; what spatial and/or temporal agro-forestry systems will be appropriate for emerging/subsistence farmers within the current resource confines; what are tangible benefits of agro-forestry in relation to:

- End users
- Environment
- Soil health
- Agricultural potential
- Specifically, the impacts (positive/negative) of agro-forestry on natural water resources for specific bio-climates in South Africa.

The key to some terminology used is specified below:

- Soil health – all physical, chemical and biological components that are important to agriculture
- Efficient use of water – water consumed in relation to dry matter produced
- Water balance – water applied, infiltration, retention, runoff, percolation, etc.
- Production – quantity, quality, commercial value of food/fuel/forage products
- End users – farmers (local, small-scale), incorporating local knowledge through participative assessment.

Estimated cost: R3 250 000 (KSA 4)

Expected term: 2004 - 2009

***Participatory development of training material for agricultural water use in homestead farming systems for improved livelihoods***

*Rural Integrated Engineering (Pty) Ltd*

**No 1575**

The rural landscape of South Africa is characterized by high levels of poverty with approximately 70% of the country's poor residing in these areas. Most of the rural poor are vulnerable to malnutrition and the incidence of diseases such as HIV/AIDS. While research in smallholder farming has increased substantially in the last decade, much of the information generated has not been packaged for resource-poor farmers. Most of these farmers are illiterate but experienced in farming. Therefore, initiatives geared towards improving productivity of smallholder farmers need

# Impact Areas (continued)

to acknowledge indigenous knowledge to ensure that the intervention is sustainable. Several categories of smallholder farmers can be broadly identified according to the smallholder's progress on a path of development from food-insecure household, to subsistence and emerging farmer to profitable commercial small-scale farmer. These farmers can further be differentiated according to the type of production location ranging from homestead yards, dry-land fields to irrigated fields. One of the overarching principles of the Government's integrated food security strategy is that the food-insecure should be made agents of their own development. However, smallholder farmers currently have limited access to any training, and formal training is focused mostly on available courses of commercial production practices, which are especially inappropriate to food-insecure households. The project intends to develop training guidelines for food-insecure households. The fulfilling of this desperate need has to be done in collaboration with experienced development facilitators and agricultural colleges who are mandated specifically to train farmers in different regions of South Africa.

Estimated cost: R2 750 000 (KSA 4)  
Expected term: 2005-2009

## *Real-time irrigation advice for small-scale sugarcane production using a crop model, weather data and cellular communication*

SASRI  
No 1576

Water use efficiency in irrigated sugar-cane agriculture is notoriously low and could be increased dramatically if farmers applied established scheduling methods. A recent survey showed that 70% of sugar-cane farmers use dragline irrigation and that 50% of these use fixed irrigation schedules. This leads to severe over-irrigation in times of low water demand and impacts negatively on the profitability of irrigated sugar-cane production and on the environment. Pressure is also building for water users to demonstrate efficient use of the scarce and sought-after resource. The main reasons for non-adoption of scheduling technology as determined from a survey that was conducted were:

- The complexity of technology in relation to practical constraints on the farm

- An under-estimation of the benefits of accurate scheduling. This applies especially to small-scale growers who do not have access to computers, the Internet or expensive equipment.

The challenge therefore is to provide simple, practical and useful advice to farmers using state of the art technology such as crop models and weather stations, and to convince farmers of the benefits of irrigation scheduling through on-farm demonstration. The Agronomy Department at SASRI has developed a prototype of a system (called *My Canesim*) consisting of the following: Weather data recorded by automatic weather stations and remotely downloaded daily through the cellular network; A web-based simulation model that suggests irrigation actions; An Internet-based user interface for advisors and extension staff to enter field, crop and irrigation system data and to view simulation results; The automatic distribution of irrigation on/off advice in isiZulu through SMS technology to farmers' cellular phones. In a pilot case study, the system was implemented in 2004 on a limited scale in Pongola. Irrigation advice is provided to six small-scale growers and its impact monitored. Initial results are very promising and indications are that water savings of 30% and cost reduction of R 1 400/ha could be achieved for small-scale growers. There is enough evidence to push for wider implementation of this service. These direct benefits are possible on 8 000 ha to more than 1 500 small-scale farmers in Pongola, the Makatini flats, and the Komati area. The technology could also be used by commercial growers on 56 000 ha. Indirect environmental benefits are reduced water extraction from river systems, and reduced runoff, deep drainage and water pollution.

Estimated cost: R350 000 (KSA 4)  
Expected term: 2005-2008

## *Nutritional value and water use of indigenous crops for improved rural livelihoods*

University of Pretoria/Centre for Nutrition  
No 1579

Under-nourishment is a major problem in many rural and peri-urban communities, particularly amongst children. A variety of indigenous crops can meet the taste and

dietary requirements of household members. Completed research by the ARC has tested the drought tolerance of crops such as cowpea, bambara groundnut and marog (WRC Report No 944/1/04). It is also important to determine the nutritional value and water requirements of these crops. The best combination between indigenous crops and a range of home-grown vegetables, and other foodstuffs to achieve a balanced diet, has to be evaluated. In a study by the University of the Free State on the socio-economic acceptability of in-field rainwater harvesting and conservation for homestead food production, the minimum area necessary to meet the caloric requirements of a household was calculated (WRC Report No 1267/1/04). Given the seasonal variability of rainfall, appropriate technology similar to that tested by the Tshwane University of Technology (Khosha, 2003) has to be evaluated to supplement water supply and stabilise food production in homestead gardens. The purpose of this project is to investigate the linkages between dietary requirements, nutritional value, water requirements and technology for production of a combination of food crops. Laboratory, on-station and participative action research will be undertaken to develop best practices in order to improve food security and well-being of households. Further consultation with stakeholders has to take place to develop the specific objectives and deliverables of this project.

Estimated cost: R2 250 000 (KSA 4)  
Expected term: 2005-2008

Herewith a list of the new projects which commenced between 1 April 2005 and 31 March 2006.

## *New Projects*

### *Thrust 1: Water as a Shared Resource*

*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

that socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices, play 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, alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400 (KSA 1)  
Expected term: 2006-2008

## **Thrust 2:** **Social Needs for Water Services**

### **Sustainable options for community level management of greywater in settlements without on-site waterborne sanitation**

*University of Cape Town/Dept of Civil Engineering*  
**No 1654**

This study builds on a current WRC study aimed at quantifying the amount of grey-water generated in non-sewered areas. Identify the social challenges to effective grey-water management in areas without on-site waterborne sanitation. This study identifies the quantities and quality of grey-water generated, and also identifies some of the technical challenges. From this study it has been identified that there are strong social and behavioural aspects, which influences the way grey-water is managed and disposed. This study will investigate ways of overcoming social and related obstacles in order to create sustainable management options relevant to the local communities and identify ways of mitigating environmental impacts. It is anticipated that the output in the form of a sociological model will be possible for extension to the rest of South Africa. This will be supported by preparation of education material for community level training concerning grey-water management options and techniques.

Estimated cost: R750 000 (KSA 3)  
Expected term: 2006-2009

### **Effective demand for alternative sanitation options in peri-urban settlements**

*Sigodi Marah Martin (Pty) Ltd*  
**No 1664**

This project offers an innovative approach of using tried and tested approaches of contingent evaluation approaches that aim to improve the science and understanding of sanitation demand by exploring and applying existing and tried and tested approaches to sanitation. Through this process, it aims to provide knowledge and information as to what people in low-income areas are willing to pay for sanitation. This kind of knowledge and information is lacking. The lack of this information results in unpopular decisions and programmes being made on behalf of recipients. Further, this information could be relevant to informing policy at a national level and local level towards better programmes that are sustainable.

Estimated cost: R710 000 (KSA 3)  
Expected term: 2006-2008

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

*Rhodes University*  
**No 1688**

Institutional arrangements supporting the implementation of the National Water Act (No. 36 of 1998) and the Water Services Act (No. 108 of 1997) are devolved across all three tiers of government. At a regional level, water resource management [WRM] is currently being transferred from regional DWAF offices to catchment management agencies (CMAs), facilitated by water user associations [WUAs] with additional stakeholder input from catchment forums including local government. Water services authorities [WSAs] are to manage water service provision [WSP]; local authorities can act as WSAs. Challenges to local government are therefore considerable, particularly where capacity and financial resources are limited. Added challenges are posed by municipal and water management area boundaries that do not coincide; the inattention to the linkages required for sustainable WRM to

support WSP; and little guidance given to the links between WUAs, catchment forums and local government. This project emerges from the recent call for researchers' participation in the design of Integrated WRM (IWRM) institutional arrangements research programme. Local government needs to establish WSP within an IWRM, in an environmentally sustainable manner. In order for local governments to effectively contribute to catchment WRM, understanding point and non-point source management, with questions of water quality and quantity impacts on resource management, is essential.

Estimated cost: R537 000 (KSA 1)  
Expected term: 2006-2008

## **Thrust 4:** **Poverty Alleviation**

### **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, 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 bio-physical 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

# Impact Areas (continued)

International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social- economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R2 800 000 (KSA 4)  
Expected term: 2006-2011

## *Development of training material for extension in irrigation water management*

*University of Pretoria, AEERD  
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 ex-

ensionists 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 bio-physical 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: R1 870 000 (KSA 4)  
Expected term: 2006-2011

## *Productive use of domestic water for sustainable livelihoods*

*Nemai Consulting  
No 1666*

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional sources to improved water supplies and the

requirements in terms of quality and quantity are not well understood. Current approaches to providing piped water supplies to poor communities do not factor these additional requirements of water for poor communities to be able to sustain their livelihood. Further the general approach and thinking to productive uses is limited to small-scale agriculture; however, in many cases domestic water is used for many other productive uses. It is also not understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study aims to seek is whether current levels of basic water supply are adequate to cover the productive use of communities and establish the levels of supply that will be adequate. Secondly, it seeks to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems

Estimated cost: R700 000 (KSA 3)  
Expected term: 2006-2008

## *Contact person*

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## Water and the Economy



Mr Meiring du Plessis: Head

### Scope

The scope of research addressed by this impact area has remained unchanged from the previous year. In the SA context water is first and foremost treated as a common (social) good. Water is recognised as being essential for sustaining life and is a commodity to which people and the aquatic environment have a legally protected right. However, water is also recognised as an economic good, the use of which has a major impact on the creation of wealth and the well-being of people. Almost without exception, there is an increasing interest in assessing the economic value of water, using water as a catalyst for the generation of wealth and prosperity, and using economic instruments to increase efficiency and effect desired behavioural change among water users. The use of water tariffs to effect changes in water consumption and the use of waste discharge charges to internalise pollution costs and, in so doing, effect pollution reduction and desirable improvements in water quality, are currently being investigated with a view to implementation.

This impact area will continue to integrate the economic aspects of water-related investigations funded by the KSAs. It will also identify overarching issues that need to be addressed at a higher level of integration. Projects and activities under this impact area will determine the value of water, and assess its role in wealth creation and the use of economic instruments in changing the behaviour of society at the appropriate micro-, regional and national levels.

### Objectives

As in the previous year, this impact area aims to be instrumental in integrating the economic aspects of water-related investigations that are under way within the WRC's KSAs, and in identifying and initiating further important investigations which may be needed in this impact area, Water and the Economy. The primary aim of the research portfolio facilitated through this impact area is to demonstrate the applicability of economic principles in the water field and to provide convincing evidence as well as sound knowledge and support to water management institutions and implementing authorities. The legal framework is already reasonably accommodating and stakeholders are therefore expected to be receptive to the knowledge generated.

#### Secondary objectives are to:

- Assess the value of water for different sectors of the economy
- Investigate the economic advantages and disadvantages of water resource development
- Assess the use of economic instruments to effect behavioural change regarding water utilisation
- Evaluate the use of economic instruments to promote equitable and efficient water allocation and distribution.

### Thrusts

All thrusts in this impact area remain unchanged from the previous year.

#### Thrust 1: *The Value of Water to Different Sectors of the Economy*

The value of water, which continues to be addressed in this thrust, is different for the various sectors of the economy (e.g. to agriculture, cities, ecology, forestry and industry, health services) and for different parts of the country. It is important to know the absolute and relative price (or a surrogate thereof) that users are either willing or able to pay for water in order to assist decision-makers regarding the allocation and development of water resources. Earlier studies have determined the economic value of water in sev-

eral of the important catchment areas in the country and for a few of the important economic sectors. Innovative means will have to be employed to establish the value that must be attached to water-linked ecosystems. A start has been made with establishing an econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development.

#### Thrust 2: *The Economic Advantages and Disadvantages of Water Resource Development*

This thrust continues to focus on quantifying the economic benefits which might arise as a result of the chain effect that water resource development has on wealth creation, or the costs which might be incurred as a result of pollution of the water environment. Because of the economic benefits and associated multiplier effects, water resource development is often a powerful stimulus to wealth creation and secondary development. Conversely, water development can also have negative effects such as environmental pollution or a reduction in the availability of water for the environment. Most projects to date have dealt with the economic effects associated with irrigation development. A completed study has addressed the negative economic effects associated with salinity, while a study to model the cost associated with eutrophication was started. Further studies need to be undertaken to determine the economic costs associated with other forms of pollution (e.g. microbial pollution) and the economic value associated with improved health as a result of providing purified water, etc.

#### Thrust 3: *The Use of Economic Instruments to Effect Behavioural Change Regarding Water Utilisation*

This thrust is based on the rationale that where an economic value is attached to the use of water, it also presents the opportunity to effect behavioural change. Increasing the water tariff on a sliding scale as consumption increases, is an economic instrument to encourage water conservation. Similarly,

# Impact Areas (continued)

pollution can be reduced in an economically efficient way by levying a charge on waste discharges. A diverse range of projects aimed at changing behaviour with respect to water use and at assessing the susceptibility of users to economic stimuli have been conducted. The most prominent of these are projects in support of the development of the Waste Discharge Charge System currently being implemented by DWAF.

## **Thrust 4:** *The Use of Economic Instruments to Promote Equitable and Efficient Water Allocation and Distribution*

Economic instruments can be powerful instruments to achieve equitable and efficient water utilisation. Examples of issues included in this thrust are the use of cross-subsidisation to promote equitable distribution of water, privatisation of water services to promote efficient service delivery, and trading of water use licences to achieve optimal redistribution of water in the interest of greater economic efficiency and most efficient use of resources. Projects have been started to facilitate the establishment of water institutions and reduce the transaction costs, which are hindering the establishment of an efficient water market, and to investigate the sustainability of sanitation services.

## **Research portfolio**

The funding for research projects supported by the various KSAs and focusing on this impact area is estimated at about R6.5 million for 2006/07, which represents an increase of almost 50% from the previous year.

The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2006 and 31 March 2007.

## **Completed**

### **Thrust 2:** *The Economic Advantages and Disadvantages of Water Resource Development*

*An identification and review of the factors in rural water services that facilitate and impact on local economic development in the Eastern Cape Rural Support Services No 1437*

There has been ongoing debate in the water and sanitation sector regarding the importance of viewing water services projects as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. One of the main issues related to this is the importance of, and ongoing need for local economic development in rural areas. This is an aspect which should be addressed in both the planning and implementation stages of any project with the full participation of community members. However, the current framework for delivery does not allow for the facilitation and promotion of economic development. This is particularly problematic given the current context of unemployment and poverty in rural areas. This study endeavoured to identify the factors that both facilitate and impact on local economic development (LED) both during and after the implementation of water services projects, in an attempt to address poverty and underdevelopment in rural areas.

The term 'local economic development' generally refers to a process of creating wealth through the mobilisation of human, financial, social, physical and natural resources or capitals. The core issue in LED is about the creation of wealth and jobs. The aim of local economic development ultimately is to produce higher standards of living, improve the quality of life, alleviate poverty, create more and better jobs, advance skills and build capacity for sustained development in the future.

An analysis of both the desk research and the field research has revealed a number of factors that both facilitate and impact on LED in water services. The facilitating factors identified relate primarily to an understanding of the concept of LED, supportive and accountable local government and access to sufficient water, land and credit. The main factors that impact on LED are the lack of understanding of the concept of LED, and the fact that there are no linkages between water related institutions and LED institutions both within and outside the community. Clearly, the lack of access to land, water and credit are also factors that impact on LED in water services.

The findings from this research project reinforce a number of the key issues raised in the literature and provide further information in support of the positive impacts that can be expected if water services projects were viewed as part of an integrated development programme rather than as one-off projects that are seen as an end in themselves. Improved water supplies can lead to both direct and indirect opportunities for improved productivity. More water, of better quality and provided more reliably, can provide the water needed for productive activities such as irrigation of a backyard or community vegetable garden or for micro-enterprises such as hair salons or brick manufacture. Indirect gains may sometimes be even more important than direct benefits in that they can apply to both water-based and non-water-based activities where saved time and money can be invested in activities that bring positive returns to capital or labour. It is clear that without specific training being provided to rural communities on LED there is unlikely to be a significant shift in the understanding of LED and the improvement of rural economies. It is recommended that community members are exposed to awareness raising and training on the importance and meaning of LED. In addition, community members should be capacitated to understand the IDP process and their roles and responsibilities in relation to the development of the IDP.

Cost: R 300 000 (KSA 3)

Term: 2003 – 2005

## **Thrust 4:** *The Use of Economic Instruments to Promote Equitable and Efficient Water Allocation and Distribution*

### *Principles, approaches and guidelines for participatory revitalisation of smallholder irrigation schemes*

ARCUS GIBB

No 1463

In 2003 the WRC funded a three-year project to develop guidelines for the revitalisation of smallholder irrigation schemes in South Africa. A national database of 317 schemes covering approximately 50 000 ha was compiled. These are located mainly in the former homelands. While most of these schemes have collapsed or are under-utilised they continue to draw substantial funding from the Government for social and economic upliftment, often with limited success. 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.

**'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.

The guidelines present alternative pathways to constructive change on schemes, with full appreciation of the complexity and diversity on and between the schemes. They

are based on meaningful involvement and information exchange between farmers, plot-holders and technical experts and thus ensure co-constructed plans for land-tenure, agricultural, technical, institutional, marketing and financial aspects. Best practice shows that major investment in human capital development is critical and that land-market stimulation can, in many cases, unlock potential. Interventions need to address all aspects of irrigation scheme operation and farm system planning, and avoid single-sector interventions such as infrastructure upgrading, mechanisation or institutional development alone. The **Guidelines** present ways forward to achieve greater success.

Cost: R 1 195 000 (KSA 4)

Term: 2003 - 2006

### *Human rights and equitable access to water*

AWARD

No 1512

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). This concept is an expression in real terms of the constitutional intention to provide water to meet basic human needs (currently taken to be 25 l /person per day) before water can be allocated for use by the various sectors. 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.

### **The objectives were:**

- An exploration of the concept of 'water as a human right' within the context of the South African legal framework
- Enhanced understanding, capacity and competence within Local Government to implement the National Water Act and allocate water resources with consideration for the concept of 'The Reserve'
- To produce and test learning support materials regarding the concept of the Reserve
- To research, understand and document the way that access to water resources as a human right can be implemented in South Africa
- To share findings generated by a research orientation with other catchments and local governments in South Africa.

Cost: R173 000 (KSA1)

Term: 2004-2005

### *Country-wide assessment of non- revenue water throughout South Africa using latest international water association methodology*

WRP Consulting

No 1535

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. The project in partnership with DWAF is the first project in which the water balance methodology has been used to estimate the magnitude of wastage from water reticulation systems throughout the whole of South Africa. While many problems have yet to be resolved, the results from the current study provide the first plausible estimate of the municipal water wastage occurring in South Africa using the standardised water balance

# Impact Areas (continued)

methodology supported by the International Water Association (IWA). Based on the results obtained from the 62 water reticulation systems, the following conclusions were reached:

- The density of connections for the South African systems ranged from a maximum of approximately 135 connections/km mains to 18 connections/km mains. The expected density of connections for a typical first-world system is in the order of 50 connections per km mains.
- The average operating pressure for the South African systems ranged from a minimum of 24 m to 63m. It should be noted that this represents the weighted average pressure for the whole reticulation system and pockets of very high or very low pressure may still exist in various systems. These pressures are typical of most normal systems in first world conditions.
- The average ILI for the South African water reticulation systems was found to be 7.6 (1.0 being very good and greater than 10 being very poor). Excluding one or two small outlier systems, the ILI ranged from approximately 2 (very good) to more than 20 (very poor). The average ILI value places South Africa in the middle of the world data set and indicates that the real losses in the country are high with significant scope for improvement but lower than most other developing countries.

Unfortunately the information available from the various water reticulation systems in the country is either not available or of dubious quality in many cases with the result that any conclusions made regarding the water leakage for the country as a whole must be considered as preliminary estimates that will be revised in future as more reliable data become available.

The National Water Resources Strategy of DWAF states that South Africa's total urban and rural water requirement for 2000 is 3 471 million m<sup>3</sup>/annum. If this value is extrapolated using an assumed growth of 3%, it suggests a total municipal water use in 2005 of approximately 4 000 million m<sup>3</sup>/annum. The total bulk system input volume figure obtained for the 62 systems analysed was 2 149 million m<sup>3</sup>/annum which represents approximately 54% of the total urban/rural water requirement of

the country. Based on these figures and extrapolations, indications were that:

- The losses (real and apparent) for the 62 systems analysed were estimated to be 623 million m<sup>3</sup>/annum or 29% of the total water supplied
- Based on the above figures, the extrapolated water losses from water reticulation systems for the whole of South Africa are likely to be in the order of 1 150 million m<sup>3</sup>/annum (based on the 54% sample size)
- The potential savings that can be achieved from the 62 water reticulation systems analysed are estimated to be 266 million m<sup>3</sup>/annum based on the methodology discussed in this report which includes a combination of real and apparent losses
- If the above figure is extrapolated to the whole country (based on the 54% sample size), the potential savings are estimated to be almost 500 million m<sup>3</sup>/annum, which represents approximately 12.5% of the system input.

Cost: R650 000 (KSA 3)

Term: 2004 - 2006

## Current

### Thrust 1: *The Value of Water to Different Sectors of the Economy*

*Valuing water for South African industries: A production function approach*  
Environmentek, CSIR  
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 proposal 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 water "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 assist existing techniques to ensure sustainable and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge.

Estimated cost: R 549 600 (KSA 3)

Expected term: 2002 - 2005

*Valuation of estuary services in South Africa*  
Nelson Mandela Metropolitan University  
No 1413

Estuaries are delicate systems that are not only in high demand for development, but also deliver important goods and services with a value out of proportion to the geographical area occupied. The continued delivery of these goods and services is dependent on adequate freshwater inflow, and with the high rates of abstraction this is decreasing. The Reserve determination process takes into account ecological process and functions, but does not adequately account for the values placed on estuaries by people.

This follow-up project will build a database of the value of freshwater inflow into estuaries using the contingent valuation method to value the goods and services provided by the freshwater inflow and based on the value attributed to the freshwater inflow by estuary users.

Estimated cost: R2 160 000(KSA 2)  
Expected term: 2004 - 2007

***Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development***  
*Conningarth Economist*  
**No 1570**

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

Estimated cost: R2 000 000 (KSA 1)  
Expected term: 2005-2008

## ***Thrust 2: The Economic Advantages and Disadvantages of Water Resource Development***

***Market risk, water management and the multiplier effects of irrigation agriculture with reference to the Northern Cape***  
*Department of Agricultural Economics,  
University of the Free State*  
**No 1250**

An important aim of the Water Conservation and Demand Management Strategy for the agricultural sector is to provide a regulatory support and incentive framework to improve irrigation efficiency. This can be achieved by firstly ensuring that volumetric water tariffs reflect the financial cost of supply and, secondly, by promoting voluntary reallocation of water resources from lower-valued to higher-valued uses on farms and between farms within agriculture. For irrigation farming this means that farming operations must be restructured. However, production of e.g. high-value perennial crops also involves higher financial and business risks. This is caused by the high capital outlay and the time lag before full production is reached as well as variable export prices and changing consumer preferences over time. Although risk management through e.g. crop diversification or market forecasts and price hedging can be implemented, the question is how far the shift to higher valued crops can be taken. Presently it is not known what the financial boundaries are within which water reallocations can be managed sustainably on a farm level and what the potential impact is on a regional economic level. Knowledge of these issues is of particular importance for irrigation areas in provinces such as the Northern Cape where agriculture is the dominant economic sector. Instability influences not only employment and income on farms, but also processing and input supplying industries through forward and backward linkages. This is emphasised by the recent turmoil in the global deciduous fruit market, which has also affected table-grape production in the lower Orange River. This project will analyse the related production and marketing risks and develop models which link economic activities on a farming level to the regional level. The model will be tested in the particular study

area but will be applicable in any area. The main aim of this project is to quantify the impact of market risk on the efficient use of irrigation water and to determine the multiplier effects of irrigation farming accompanied by a shift in production patterns.

Estimated cost: R1 333 700 (KSA 4)  
Expected term: 2001 - 2005

***Integrating flood-plain agriculture into a diverse rural economy by enhancing co-operative management: A case study of the Pongola***  
*Institute for Natural Resources*  
**No 1299**

The effective management of the Pongola River flood plain has been unsatisfactory ever since the completion of the Pongolapoort Dam. This study aims at promoting effective co-operative management of the river system on a sustainable and democratic basis. Lessons learned here will contribute to formulation of policies and institutions to achieve sustainable use of river systems in rural South Africa. This project is strongly based on the principles of a participative action plan.

### **The aims of the project are to:**

- Learn about promoting effective co-operative management around sustainable use of river systems in rural areas
- Redirect the pattern of resource use on the Pongolo River flood plain towards a shared vision reflecting a diverse and sustainable economy
- Establish a confident and capable team of researchers drawn from previously marginalised sectors

Expected cost: R880 000 (KSA 4)  
Expected term: 2002 - 2005

***Development of a model to assess the costs associated with eutrophication Umgeni Water***  
**No 1568**

Eutrophication and its accompanying effects is one off 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

# Impact Areas (continued)

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. Similar to a study that assessed the cost to users that can be associated to water salinity, a multidisciplinary team will conduct this project to determine the cost associated to eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000 (KSA 1)  
Expected term: 2005-2008

## **Thrust 4:** *The Use of Economic Instruments to Promote Equitable and Efficient Water Allocation and Distribution*

*Water resource management for profitable small-scale farming along the banks of the Orange River*  
Department of Agricultural Economics,  
University of the Free State  
**No 1354**

The establishment of small-scale farmers on the Orange River in the Northern Cape and Western Cape Provinces was identified as a very high priority. The study is motivated by the drive to utilise the water right allocation to establish small-scale irrigated farms and operate them efficiently and sustainably. Formal and appropriate methodologies will be developed to successfully establish small-scale farmers to ensure household food security and enable production of surpluses. Farm size, type of technology, access to markets and financing methods and procedures will be clearly defined. According to the Provincial Department of Agriculture in Kimberley an appropriate economic model is needed to successfully establish small-scale farmers. This project will directly address these issues by providing guidance and developing a model for evaluating the economic performance and efficiency of the farms prior to establishment.

The main aim of this project is to develop an appropriate methodology to successfully establish small-scale irrigation farmers in South Africa.

### **Sub-aims are to:**

- Develop an appropriate land tenure system for small-scale farmers
- Develop an appropriate marketing arrangement for inputs and outputs for small-scale farmers
- Develop a suitable financial arrangement for loan and credit acquisition to facilitate successful establishment of small-scale farmers
- Develop an economic model viable for successful establishment of irrigated farmers
- Determine the social acceptability of the proposed newly developed programme
- Determine the environmental impacts of the establishment of small-scale irrigated farms on undeveloped land.

Estimated cost: R970 000 (KSA 4)  
Expected term: 2002 - 2005

*Development of an appropriate tool: Voice, measure and intervention in ensuring the sustainability of municipal water services to the poor*  
Human Sciences Research Council  
**No 1522**

The main aim of this study is to determine or identify the water handling practices and behaviours which have a negative impact on users. Then use this as the basis to develop a framework for action and guidelines on improving hygiene behaviour. The study could break new ground and lead to new approaches which will lead to benefits in better health and hygiene promotion.

Estimated cost: R1 266 000  
Expected term: 2004 - 2007

*Towards the establishment of water market institutions for effective and efficient water allocation*  
CPH Water  
**No 1569**

The National Water Act provides for the transfer of water use licences through a water market. A recent WRC review of the value of

water to different sectors of the economy has revealed that the market mechanism has proved to be an efficient tool to effect the transfer of water to more efficient users and improve water use efficiency under South African conditions. However, due to high transaction cost, this mechanism is under-utilised. In order to utilise the efficiency of market mechanisms, it would thus be necessary to develop institutions that facilitate transfer and reduce transaction costs. On the other hand, safeguards also need to be instituted to prevent potential negative externalities associated with transfers. This project will focus on three case studies to determine which steps and institutions are required to balance these requirements.

Estimated cost: R1 500 000 (KSA 1)  
Expected term: 2005-2007

*Financial sustainability of sanitation services*  
Partners in Development  
**No 1632**

This programme addresses capital investments in infrastructure for households without access to basic sanitation services and financial requirements for ongoing operation and maintenance including future infrastructure replacement costs. The main objective of research under this programme is to develop models, tools and guidelines that will enable managers to provide financially viable sanitation technology solutions for communities and to make provision for both capital investments and operation and maintenance costs for the different sanitation technology choices.

- Financial models for free basic sanitation service provision and operation and maintenance costs of on-site sanitation services focusing on technology choice, funding arrangements, institutional requirements and household contribution
- Development of an overall costing strategy for meeting the 2010 target of eradication of the sanitation backlog
- Analysis of financial resources of municipalities and their ability to comply with the legislative requirements
- Assessment of the real costs of sanitation subsidy
- Investigation of different models for subsidy allocation and best practice case studies

- Exploration of credit finance options for household sanitation improvement programmes

Estimated cost: R600 000 (KSA 3)  
Expected term: 2005-2007

Herewith a list of the new projects which commenced between 1 April 2005 and 31 March 2006.

## New Projects

### Thrust 1: *Assessing the Value Of Water for the Different Sectors of the Economy*

*Framework and manual for the valuation of goods & services of aquatic ecosystems for resource directed measures*  
Zeta Consulting CC  
No 1644

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

This project aims to develop a framework that will enable decisions to be made based on appropriate definitions of value, aligned with appropriate valuation techniques, based on sound data, within a context where benefit trade-offs are clarified.

Estimated cost: R750 000 (KSA 2)  
Expected term: 2007-2008

*Effective demand for alternative sanitation options in peri-urban settlements*  
Sigodi Marah Martin (Pty) Ltd  
No 1664

This project offers an innovative approach of using tried and tested approaches of contingent evaluation approaches which aim to improve the science and understanding of sanitation demand by exploring and applying existing and tried and tested approaches to sanitation. Through this process it aims to provide knowledge and information as to what people in low-income areas are willing to pay for sanitation. This kind of knowledge and information is lacking. The lack of this information results in unpopular decisions and programmes being made on behalf of recipients. Further, this information could be relevant to informing policy at a national level and local level towards better programmes which are sustainable.

Estimated cost: R 710 000 (KSA 3)  
Expected term: 2006-2008

### Thrust 2: *The Economic Advantages and Disadvantages of Water Resource Development*

*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, 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 bio-physical aspects of in particular infield RWH&C has been done (see WRC Report No 1176/1/03). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC Report No 1267/1/04). This last mentioned study has shown that there are many gaps in knowledge on social, institutional and economic dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge. 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: R 2 800 000 (KSA 4)  
Expected term: 2006-2011

*Productive use of domestic water for sustainable livelihoods*  
Nemai Consulting  
No 1666

Poor communities both in rural and urban areas use water for various purposes, other than just for domestic purposes. The source of this supply can vary from traditional

# Impact Areas (continued)

sources to improved water supplies. It is not well understood what the requirements in terms of quality and quantity of these water supplies are. Current approaches to providing piped water supplies to poor communities do not factor in these additional water requirements of poor communities to be able them to sustain their livelihoods. Further the general approach and thinking with regard to productive uses is limited to small scale agriculture. However, in many cases domestic water is used for many other productive uses. It is not also understood whether these improvements in water supplies accelerate community development or actually inhibit development. The fundamental answer which this study seeks is that whether current levels of basic water supply are adequate to cover the productive use of communities and what levels of supply will be adequate. Secondly, it seeks also to determine whether it would be affordable and economically viable to supply water for productive use through water distribution systems

Estimated cost: R 700 000 (KSA 3)  
Expected term: 2006-2008

*Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa*  
*Johannesburg University of Technology*  
**No 1700**

Over the years, the government has spent billions of rand to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation provision has brought to the communities and the countries. The WHO has over the years 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). Thus, the time is most appropriate to undertake a study of this nature.

Estimated cost: R 1 200 000 (KSA 3)  
Expected term: 2006-2008

**Thrust 3:**  
*The Use of Economic Instruments to Effect Behavioural Change Regarding Water Utilisation*

*A pilot study into upstream cleaner production technologies for the petroleum refining industry to meet the requirements of the Waste Discharge Charge System (WDCS) Process Optimisation and Resource Management*  
**No 1673**

The main objectives of the Waste Discharge Charge System (WDCS), imminently due for implementation by DWAF, are to reduce water pollution by encouraging efficient resource utilisation (incentive objective), recovering the costs of activities aimed at pollution abatement and damage caused by pollution (financial objective), discouraging excessive pollution (deterrent objective) and promoting sustainable water use (social objective). This project aims to develop an understanding of the treatment processes, applicable to various industries, which could be used to meet the requirements of the WDCS. The project will use a petroleum refinery as a case study to investigate the financial impact of the waste discharge charge system on industry and to investigate source-reduction cleaner-production (upstream) options as opposed to an end-of-pipe treatment approach, exploiting a current real-life opportunity where these approaches to pollution prevention can be quantitatively compared. The specific aims of the project are to develop a prioritised list of upstream treatment technologies for the petroleum refining industry, and to quantify the financial implications to the petroleum refining industry of meeting the WDCS requirements.

Estimated cost: R 229 200 (KSA 3)  
Expected term: 2006-2008

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## Water and the Environment



**Dr Renias Dube: Head**

### Scope

The scope of research in this impact area will remain the same following changes introduced at the commencement of the 2004/05 financial year as a result of extensive stakeholder consultation.

Incomplete knowledge and understanding of the linkages between environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) within the hydrological cycle, and between the hydrological cycle and governance systems, hinder sustainable water resources management. This impact area promotes enhanced understanding of whole-ecosystem functioning in the context of the broader environment and its effects on water resources, and supports the development and application of good environmental governance systems. Activities within this impact area contribute to sustainable water resources management that meets the changing needs of society, by combining:

- Our understanding of good governance principles
- Our knowledge of environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) and processes within the hydrological cycle.

The primary focus of the impact area is to integrate existing and new insights generated by research within and between the KSAs and by other institutions working in related fields. In addition, this impact area will stimulate the generation of specific new knowledge and understanding that

will equip the water sector to anticipate and respond appropriately to changes within the biophysical environment. Although this impact area is characterised by integrating research at a high / meta-data analysis level, it is recognised that such research is only possible on the assumption that we have a sound foundation of appropriate basic research (and data) in place.

### Objectives

The objective of the impact area is to contribute to achieving a situation where our governance systems and our understanding of environmental processes and functioning within the hydrological cycle are aligned, to support sustainable water management that meets the needs of society.

### Thrusts

The thrusts, as listed and described below, remain the same as those newly introduced at the start of the 2004/05 financial year.

#### **Thrust 1:** *Environmental Functioning Within the Hydrological Cycle*

All environmental components and processes within the hydrological cycle depend on and are regulated by the structural, functional and compositional aspects of biodiversity. Environmental components and processes also respond to and impact on society's decisions and actions. Historically, research has been narrowly focused on separate environmental components within the hydrological cycle rather than the processes and relationships between them. This thrust focuses on understanding these relationships within the hydrological cycle, their role in maintaining flows of water-related goods and services to society, and their vulnerability to change in the broader environment.

#### **Thrust 2:** *Environmental Governance Systems*

Internationally, good governance is based on principles such as inclusivity, representivity, accountability, efficiency and effectiveness,

as well as social equity and justice. In turn, good environmental governance should reflect our best understanding of the structure, functions, processes and variability that typify natural systems. Although there has been considerable development within the field of public, corporate and natural resource governance, little attention has been paid to the development of good environmental governance systems. This thrust focuses on water-related governance within society and the design of systems that better anticipate, reflect and respond to changes in environmental components and processes within the hydrological cycle.

#### **Thrust 3:** *Integrative Knowledge for Ecosystem-based Water Resource Management*

This thrust focuses on the generation, application and communication of higher-level knowledge and understanding of ecosystem approaches to water resource management, which can recognise and account for natural processes and human-induced impacts that affect water resources. This is achieved by stimulating the generation of new insights and information, through:

- Synthesising outputs from relevant programmes and projects within the WRC's research portfolio
- Combining these with the findings of other relevant national and international research initiatives
- Influencing and initiating appropriate new research to address gaps in current knowledge and deal with emerging new issues.

In order to strengthen the capacity to develop and apply ecosystem approaches to water resource management, the thrust will need to facilitate collaboration with other funding agencies and encourage partnerships between different research initiatives and with resource managers.

The desired outcomes of this thrust are:

- The development of mechanisms and communities of practice that integrate within and between the different disciplines and knowledge bases related to both the biophysical environment and environmental governance systems
- Co-operation between relevant governance sectors, helping to

# Impact Areas (continued)

develop and harmonise environmental governance systems related to water

- Interactions between these groups, in support of good environmental governance practices.

## Research portfolio

The funding for research projects relevant to this impact area and supported by the various KSAs is estimated at R7.86 million for 2006/07. The findings of projects completed during the year under review are given, as well as a summary of current projects and the motivation and objectives for new projects which commenced between 1 April 2006 and 31 March 2007.

## Completed Projects

### Thrust 1: Environmental Functioning Within the Hydrological Cycle

#### *Freshwater requirements of the marine environment: A proposed predictive approach to assessment of potential impacts*

*Environmentek, CSIR  
No K8/509*

The report considers the impact of altered fresh water flows on estuarine and inshore marine systems. Observations indicate that freshwater inputs have a strong influence on the abundance of many aquatic species of socio-economic importance which are supported by these marine environments. An Assessment Framework and methods to assess the potential impacts of the reduction in freshwater flow into South African marine environments, is proposed. Recommendations regarding continued research and predictive assessments are made, such as the need to differentiate between coastal ecosystems (from east to west). Guidelines are given for the extension of Resource Directed Measures (RDM) protocols to include potential freshwater requirements of the marine environment.

Cost: R200 000 (KSA2)  
Term: 2004 – 2006

### *The nature and rehabilitation of alien-invaded riparian zones*

*Dept of Zoology, Freshwater Research Unit,  
University of Cape Town  
No 1407*

Riparian zones are vulnerable to invasion by alien plants and need active management in areas where such species occur. This project was designed to investigate the effects of woody alien invading tree species on the natural vegetation of Western Cape headwater riparian zones, and the recovery of the indigenous vegetation after aliens had been cleared. Six invaded and ten cleared sites were then compared to the reference condition to assess the impacts of invasion and clearance on a number of biotic characteristics. A small study of the possible allelopathic effects of alien invasives was also conducted. All the heavily-invaded areas investigated during this study supported a number of riparian scrub species beneath the dominant alien canopy. In most cases the wet bank was abundantly vegetated with indigenous species whilst the dry bank had a few isolated indigenous shrubs and small trees of either Afromontane forest riparia or scrub riparia affiliation. The results suggest that young alien saplings probably do not exert an interference effect on establishing indigenous seedlings.

Cost: R863 579.47 (KSA2)  
Term: 2003 - 2006

### *Conservation planning for river biodiversity*

*CSIR  
No 1486*

Conservation planning was developed for use on terrestrial systems. Using it on river biodiversity is a new application which started during the planning of the Greater Addo National Park. It worked well, but areas needing refinement were identified. This study formed a pilot study for a broader national initiative, which aimed to develop a policy and planning framework for systematic conservation of inland water biodiversity in South Africa. The pilot was undertaken in the Fish-to-Tsitsikamma Water Management Area, which aims to facilitate testing, refinement and demonstration of the river prioritization and selection tool at a sub-national scale, providing an example of the lessons learnt and best practice for use elsewhere in the country.

Cost: R545 966.79 (KSA2)  
Term: 2004 - 2006

### Thrust 2: Environmental Governance Systems

#### *Integrated development planning for estuaries*

*Institute for Natural Resources  
No 1485*

The Eastern Cape Estuaries research and management programme which was initiated in the late 1990s to empower the communities living beside these estuaries to manage the resource sustainably. The integration of knowledge generated into the Integrated Development Planning (IDP) process is a necessary step towards sustainable management of estuaries and building the capacity in this will entrench this for the future. This sustainable management is also required in terms of existing legislation.

Like other ecosystems, estuaries offer a range of services and attributes that generate value and contribute to human welfare. A suit of methods have been developed to establish economic value and the application of these indicate that estuaries confer significant benefits to society. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas. The course contains modules on economic value, estuary functioning, impacts on estuaries, estuary management and enterprise opportunities that can be derived from estuaries.

Cost: R1 244 337.00 (KSA2)  
Term: 2004 - 2007

## Current

### Thrust 1: Environmental Functioning within the Hydrological Cycle

#### *The impact of urbanisation and industrialisation on the environment*

*Department of Chemistry (Mamelodi Campus), Vista University  
No 717*

Increase in urbanisation results in a dramatic increase in industrial and domestic waste. Of major concern is the generation of toxic chemicals and heavy metals. This study aims to investigate the occurrence of polynuclear aromatic hydrocarbons (PAHs) as an indicator of pollution of urban water catchments. PAHs are potentially carcinogenic and the outputs will provide information on a subject area lacking knowledge.

Estimated cost: R380 000  
Expected term: 1996 - 1997

### **Use of grass species for rehabilitation after wattle control**

*Agricultural Research Council (ARC)*  
**No 1016**

The Working for Water Programme removes alien vegetation from riparian zones. This leaves many river-banks vulnerable to erosion and this project develops guidelines for the establishment of a suitable grass cover after wattle removal. The WRC is a co-funder of the project, together with the National Department of Agriculture and the SA Wattle Growers Union. This project is linked to **Water-Linked Ecosystems**.

Estimated cost: R214 000  
Expected term: 1999 - 2002

### **The assessment of short-, medium- and long-term impacts on groundwater quality associated with the filling of dolomite cavities**

*Metago Environmental Engineering*  
**No 1122**

De-watering of the dolomitic aquifers overlying ore bearing reefs has, since the 1960s, resulted in the formation of large numbers of cavities in the dolomitic compartments on the West Rand. Some of these cavities have in the past been filled with, *inter alia*, various mine waste materials including slimes and waste rock. The State Technical Committee for Sinkholes had raised the alarm about the potential for groundwater contamination as a result of this practice. Filling of cavities is necessary for safety reasons as well as to prevent further inflows of surface water. Slimes material is the most economical material which is available for filling cavities and until its impact is proven to be harmful or irrevers-

ible, the State cannot intervene to prevent this practice. This investigation focused both on the impacts arising from the future filling of cavities as well as an assessment of the effectiveness of alternative fill materials

Estimated cost: R440 000  
Expected term: 2000 - 2002

### **Design and development of an implementation plan for a national eutrophication monitoring programme for South Africa's water resources**

*Environmentek, CSIR*  
**No 1147**

Under the National Water Act, DWAF is required to establish national monitoring networks to collect relevant information on the quality of water resources. The Minister is required to provide guidelines, procedures, standards and methods for monitoring water quality. Data have to be stored in a National Information System where they can be used for the development and implementation of the National Water Resource Strategy and Catchment Management Strategies. This project is providing the required technical and scientific support to design and implement a National Eutrophication Monitoring Programme. It will dovetail with other networks, such as the National Rivers and Reservoir Water Quality Monitoring Network, the National Microbiological Monitoring Programme and the National River Health Programme.

Estimated cost: R724 000  
Expected term: 2001 - 2002

### **Predicting the environmental impact and sustainability of irrigation within gypsiferous mine-water**

*Coaltech 2020*  
**No 1149**

The coalfields in the Highveld of Mpumalanga generate significant quantities of surplus neutralised acid mine-water which is gypsiferous in nature. Because of their high salinity these waters cannot be freely discharged to river systems. However, irrigation with these waters holds much promise to significantly reduce the salt load emanating from mine drainage, while at the same time extracting value from water that would otherwise be a polluting

agent. An initial rough estimate is that up to 10 000 ha of land could potentially be irrigated with coal-mine-waters in the Mpumalanga Highveld. This project is building on successful previous and current field-scale research using gypsiferous water for irrigation, by addressing the following aims:

- Determine the impact of several gypsiferous water/soil combinations on soil conditions and groundwater quality.
- Further develop and refine the soil-water-balance model for use in predicting gypsum precipitation, crop response, water quality and water balance.
- Predict the likely long-term impact of gypsiferous irrigation waters on the groundwater system.
- Determine whether these waters can be used to produce crops on a commercial basis.
- Evaluate the sustainability of irrigation with gypsiferous water

Estimated cost: R1 530 000  
Expected term: 2000 - 2003

### **Regional model development for simulating atmospheric behaviour and rainfall over Southern Africa**

*Department of Earth Sciences, University of Pretoria*  
**No 1261**

There is an increasing demand by hydrologists, the agricultural community, disaster managers and the public for more accurate spatial projections of anomalous rainfall. The complex distribution of surface characteristics over Southern Africa such as topography, coastlines, inland water bodies and vegetation, induces atmospheric circulation and rainfall patterns unique to the region. To better simulate local circulation patterns and rainfall over the Southern African region, it is necessary to develop or adapt a regional atmospheric model to suitably capture the unique surface characteristics of the region. An issue as important as the development of a regional atmospheric model for Southern Africa is the broadening of the skills base needed for continuous refinement and use of such models. It is intended to use this project to create opportunities for interested scientists and students from various institutions to familiarise themselves with atmospheric modelling concepts and practices.

# Impact Areas (continued)

The aims of this project, therefore, are to:

- Modify the dynamical formulation and physical parameterisation schemes of an internationally competitive regional atmospheric circulation model (DARLAM from Australia) in order to improve the simulation of water-related atmospheric variables over Southern Africa
- Equip scientists and prospective students from the Southern African community with the necessary knowledge and skills to develop, maintain and use such regional atmospheric models.

Estimated cost: R678 000

Expected term: 2001 - 2004

## *Development of a system of simplified methods of vegetation water use based on the principle of limits to evapotranspiration*

*Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch  
No 1319*

Water resource managers will increasingly need to assess whether proposed changes in land use within catchments are likely to significantly reduce the quantity and temporal availability of water to downstream users. Such decisions need to be based on the relative annual (and perhaps seasonal) water use of the existing and proposed new crops or vegetation. The National Water Act makes provision for declaring certain land-covers (crops) as SFRA (e.g. commercial afforestation) but it is likely that other land-cover changes may also have a significant impact in some situations. The principle of limits to evapotranspiration will allow for the limiting factors to be identified in particular situations and thus for a screening of land-cover changes based on the likely impacts. It could also provide a useful framework for interpreting the impacts of regional climate change in South African situations.

The aim of this project is to develop a framework of understanding about the major controls of evapotranspiration in different types of vegetation and crops in South Africa. This work will lead to:

- A better understanding of when a change in land-cover may have a significant impact on surface water yields from a land parcel

- Recommendations for simple models to use in assessing these impacts, easing the task of simulating water use in the wide variety of vegetation, indigenous and alien, existing in South Africa.

Estimated cost: R1 013 000

Expected term: 2002 - 2005

## *Analysis of groundwater level time series and the relation to long-term climatic conditions, climate change and recharge*

*Division of Water, Environment and Forestry Technology, CSIR  
No 1323*

DWAF has for many years regularly monitored groundwater levels and water quality in some 400 boreholes country-wide. In most cases at least monthly records are available, although in several cases daily water level recordings are kept. These boreholes are mostly located in undisturbed hydro-geological environments, upstream of major catchment developments or groundwater abstraction schemes.

It is believed that an analysis of this information could give invaluable information pertaining to the cause for this trend, both on a local as well as a regional scale. In particular the possible link to long-term climatic changes is of interest. A possible explanation for this declining trend can be the role or effect of, or the link to longer-term climatic changes over the last few decades, and even centuries. Closely linked to this is the concept of groundwater drought, which may have important management implications, but has not been properly explored. The groundwater drought concept is not new and has previously been addressed in an African context by the British Geological Survey. The decreasing trends that have been recorded in some boreholes may also be explored as part of the longer-term fluctuations established by palaeo-geohydrological studies. Numerous studies have been documented over the last decade on palaeo-climatic conditions (covering the last say 3000 years) in Southern Africa and Africa.

### **The research aims to:**

- Determine whether the long-term declining trends observed in SA

groundwater level data are indicative of a current and/or longer-term groundwater drought cycle(s) or whether other factors are contributing to this trend

- Collate and develop new methods if required, that can be used to correlate long-term water level fluctuations with rainfall and climatic cycles
- Document the analytical techniques available and used to analyse relevant geohydrological information to assist planners in the long-term planning of groundwater utilisation as part of integrated water resource management.

Estimated cost: R233 000

Expected term: 2002 - 2003

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

*CSIR / Umvoto  
No 1327*

There is currently a debate concerning the extent to which groundwater abstraction from TMG aquifers will lead to environmental impacts. This debate will continue and inhibit better understanding of the water resources as well as inhibit development of the groundwater resources. Appropriate investigations are required to adequately inform key players and interested and affected parties, and to move the debate constructively forward.

This project aims to assess the dependency of aquatic and terrestrial TMG ecosystems on groundwater and predict impacts of groundwater abstraction. These ecosystems include wetlands, highland seeps, the riparian zone and spring discharge sites, amongst others.

### **Specific objectives are:**

- The development of predictive tools to assess the impact (or risk) of groundwater abstraction on the environment
- To improve our understanding of groundwater-dependent ecosystems (GDEs) in the TMG and the sensitivity to groundwater level fluctuations
- The use of innovative techniques to determine the impact of groundwater abstraction on the environment
- The development of indicators to monitor the effect of abstraction on sensitive ecosystems

- Coupling time series and spatial databases in order to ascertain the impacts of low flows (groundwater and surface water interaction) on the environmental system
- Improved understanding of the impact of changing low flows on freshwater ecology
- Improved understanding of the relationship between surface flow, event discharge from high-lying TMG unconfined aquifers and deep confined-aquifer discharge in maintaining wetlands or seeps
- Improved understanding of subsurface TMG discharge in maintaining coastal plain wetlands and vleis.

Estimated cost: R2 201 327

Expected term: 2002 - 2005

***Skills comparison of dynamic and empirical down-scaling methods for Southern Africa from a seasonal climate modelling perspective***

*SA Weather Services, Pretoria Office*

**No 1334**

Droughts and floods have long been distinctive features of the climate of Southern Africa. Variability of the climate has been accentuated by the occurrence of the El Niño / Southern Oscillation (ENSO) phenomenon, but is by no means dominated by them. Climate variations have an important impact on agriculture, housing, water supply, industry and tourism. With an ever-increasing population that is putting an associated increase in demand on freshwater resources, effective water management has become essential. The need for providing improved seasonal rainfall forecasts, both temporally and spatially, is becoming more and more necessary in the region.

The main emphasis of the project is to assess the ability of an advanced state-of-the-art, albeit computationally expensive, method as a seasonal rainfall forecasting tool for Southern Africa in order to improve seasonal outlook information for hydrological purposes. Down-scaling the large scale to more localised seasonal rainfall over Southern Africa has been shown to be viable, but further research in down-scaling, with both improved spatial and temporal resolution, is required.

**The main aims of the project are:**

- Compile an appropriate GCM climatology of a sufficiently large ensemble
- Nest dynamic regional climate models in the GCM simulated large-scale fields
- Compare the nested scheme's forecast skill with base-line skill levels
- Set base-line forecast skill levels, using statistical models

Estimated cost: R450 000

Expected term: 2002 - 2005

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

*Department of Chemistry, Technikon*

*Northern Gauteng*

**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 - 2004

***Facilitating the free passage of migratory aquatic biota in South African rivers***

*Consortium; University of Stellenbosch (lead agent)*

**No 1409**

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 prioritising 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 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.

Estimated cost: R 2 000 100

Expected term: 2003 - 2007

***Global climate change and water resources in South Africa: Potential impacts of climate change and mitigation strategies***

*School of BEEH, University of KwaZulu-Natal*

**No 1430**

The need to prepare South Africa to cope with global climate change is of paramount and strategic importance. This project will develop plausible climate change scenarios for Southern Africa; investigate the potential impacts of climate change on hydrological responses and associated water resources; investigate possible water-related socio-economic impacts in a designated water management area; recommend appropriate strategies to adapt to, and cope with, water-related impacts of potential climate change; determine whether effects of climate change can already be detected; and recommend appropriate monitoring systems for its detection.

Estimated cost: R 1 112 000

Expected term: 2003 - 2005

# Impact Areas (continued)

## *Environmental water requirements in non-perennial systems*

*University of the Free State  
No 1414*

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

Estimated cost: R2 000 000 (KSA 2)  
Expected term: 2004 - 2007

## *Habitat use and movement of freshwater fish*

*Freshwater Research Unit, University of Cape Town  
No 1483*

This project presents a unique opportunity to investigate the movements of large fish in an un-impounded river, the Doring River in the Western Cape. This is knowledge which can not be obtained from elsewhere in the country as there are so few un-impounded rivers remaining. The two things making this opportunity unique are that the Doring River, which is one of the last un-impounded rivers in the country, will be impounded within the next decade or so, and that we have a researcher capable of the task. DWAF have asked for information on the movements of fish in a river system for use in their planning of fish-ways, and this research will complement the existing projects researching fish-ways by providing additional information that these projects will not be able to provide.

This work has previously been funded as a consultancy, and progress has been made both in the initial aims of the project, as well as in the sourcing of funds for the radio telemetry tracking of the fish.

Estimated cost: R688 000 (KSA 2)  
Expected term: 2004 - 2007

## *Integrated management of water hyacinth in SA*

*University of the Witwatersrand  
No 1487*

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

Estimated cost: R1 655 600 (KSA 2)  
Expected term: 2004 - 2007

## *Climate change and small town water resources*

*University of Cape Town  
No 1500*

The climate change scientific discourse has revolved around the Intergovernmental Panel on Climate Change (IPCC) through its first, second and third assessments. Bringing development into the third assessment as a cross-cutting theme was attempted, but success was quite limited. In the fourth assessment to be carried out during the period 2003 to 2007, it is proposed that the interaction between sustainable development and climate change be given a priority. The most severe impacts are likely to occur along the western part of South Africa, where small towns and subsistence farmers are most vulnerable. This study intends to investigate the adaptive capacity of small towns and communities in the Western and Northern Provinces to climate variability, specifically drought. By extrapolation of these strategies, planning policies for national and water resource planning and management will be developed to ensure water security against the impacts of climate change. The proposal was considered highly relevant by reviewers. The emphasis on local authorities and providing them with the necessary tools/knowledge to address the possible impacts of climate change are considered critical.

Estimated cost: R261 260 (KSA 1)  
Expected term: 2004 - 2005

## *Field investigations to study the fate and transport of dense-aqueous liquids (DNAPLs) in groundwater*

*University of the Free State  
No 1501*

Studies on the fate and transport of organic pollutants in groundwater have, to date, been done on an *ad hoc* basis. DNAPLs movement in the subsurface is density driven and extremely complex. This project will consolidate knowledge about the fate and transport of DNAPLs in groundwater in a systematic manner.

Estimated cost: R3 058 000 (KSA 1)  
Expected term: 2004 - 2007

## *Land-use impacts on salinity in Western Cape Waters*

*University of Stellenbosch  
No 1503*

Dry-land salinity is widespread throughout semi-arid regions of the world and its occurrence in some of the major catchments of the Western Cape is therefore not surprising. Wheat lands in the Swartland and Overberg regions are widely known to contain "brak kolle" (saline scalds) where the wheat will not germinate. Such saline soils are already recognised as a source of some of the salts affecting the quality of water in major Cape waterways such as the Berg River, where tributaries draining Malmesbury shale-derived soils are known to contribute disproportionately to the salt load. What does not seem to have been addressed yet in the numerous studies of salinisation of major South African rivers is the possibility that changes in land use from extensive pastoral use to intensive cropping over the last century or more may have triggered the same process of salt decantation as that which is so widespread in Australia. This is particularly likely in the semi-arid wheat lands of the Western Cape, which receive most of their rain during the winter months. The key question: is the dry-land salinity in catchments such as that of the Berg River more intense now than it was several decades ago and is it still intensifying? There is already substantial evidence of soil and groundwater salinity in the catchment but more systematic quantification is still needed.

Estimated cost: R1 995 880 (KSA 1)  
Expected term: 2004 - 2009

### **Mine-water irrigation return flow**

*University of the Free State*

**No 1507**

Irrigation with mine water is one of the most promising uses of excess mine water. Currently sufficient detail regarding the sub-surface behaviour and long-term impact of this practice does not exist to the satisfaction of the regulators. Consequently this project will quantify the effects of irrigating with mine water on the surrounding groundwater resources.

Estimated cost: R455 650 (KSA 1)  
Expected term: 2004 - 2007

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

*Univ of Johannesburg (RAU)*

**No 1586**

97% of the world's freshwater is subterranean, and there is an increasing demand for the development of this resource to meet the increasing needs of the population. Little is known about the stygobiont fauna or the interaction between underground and surface water. During this project the following aims will be addressed:

- Formulate a framework to characterize the geological occurrences and geographical distribution of the subterranean amphipods using GIS techniques
- Discussion on the applicability of the sampling protocol
- Identifying microbial composition in association with stygobiont amphipods
- Trace of inorganic macro-elements for water quality
- A primary framework development for the characterization of groundwater systems

Estimated cost: R1 350 000 (KSA 2)  
Expected term: 2005 - 2008

### **Environmental water requirements in non-perennial systems**

*University of the Free State*

**No 1587**

Methods for the determination of environmental flows for the Reserve have been developed and used for rivers with permanent

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

Estimated cost: R3 000 000 (KSA 2)  
Expected term: 2005 - 2007

### **The freshwater requirements of temporarily open/closed estuaries on the South Eastern and South Western Cape coasts**

*SAIAB*

**No 1581**

This project is the result of recommendations of a CERM strategic planning meeting held in March 2004 and is a multifaceted project in order to answer the generic questions routinely posed during DWAF RDM workshops.

Estimated cost: R1 753 000 (KSA 2)  
Expected term: 2005 - 2008

### **Development, testing and installation of a real-time ecological Reserve implementation method for the Thukela River**

*Rhodes University (IWR)*

**No 1582**

Previous work on implementing the Reserve has identified the need for suitable hydrological triggers to be used to specify the Reserve flows required in real time. It has also identified some of the limitations of the Regional Offices of DWAF to deal with, and make use of, the reserve information supplied by the DWAF RDM Office. During the recent reserve determination on the Thukela River some concepts were developed on how this could be done.

During the project the researchers will develop and test a real time Reserve implementation method, and install the system in the KZN DWAF Regional Office, for application to the Thukela River. A manual for the method and training of KZN DWAF Regional Office staff will also be developed. The model will be based on a standard model for which initial calibrations are available for all the quaternary catchments country-wide, so the model will be widely applicable.

The development and application of a real-time reserve implementation method will assist in the implementation of the NWA on the ground. The outcome of this research will deepen knowledge on the functioning of temporarily open and closed estuaries. The results will be worked into estuary management as the work progresses as the team are involved with DWAF and MCM initiatives in estuary management, including the determination of the reserve.

Estimated cost: R 690 800 (KSA1)  
Expected term: 2005-2007

### **Development of a diatom protocol for river health assessment**

*DH Environmental Consulting*

**No 1588**

Increasingly, diatoms are finding their place in the suite of water quality assessment tools available elsewhere in the world. The collection on which this project will be based spans a half-century, and the information that may be gleaned is potentially very valuable. A diatom assessment protocol (DAP) for river health assessment will be developed during this project, and this process will happen in three distinct phases.

In phase 1 a South African diatom taxonomic identification key will be developed, and diatom images will be transferred from the SA Diatom Collection onto electronic format. In Phase II the DAP protocol will be comprehensively tested to compare it with SASS indices within the River Health Programme, and there will be user training. It will also be linked to a central reporting database by means of a software resource centre before being calibrated, refined and released for wider use. Phase III will involve the continuing extraction of historical water quality and information on ecosystem condition from the SA Diatom Collection.

Estimated cost: R292 000(KSA1)  
Expected term: 2005-2006

### **Secondary and tertiary impacts on water resources due to primary changes in temperature and precipitation**

*University of Cape Town*

**No 1562**

The WRC is currently funding a project to investigate the potential impact of global and

# Impact Areas (continued)

regional changes in climate and climate variability on water resources, but this focuses only on hydrology at present. There are likely to be secondary effects on water resources arising through changes in flow regimes and ambient temperature – these include changes in nutrient cycling, changes in processes affecting sequestration of toxic substances such as metals, changes in chemical and biochemical oxidation and reduction processes, and changes in background concentrations of dissolved salts. The complex changes in water quality, water quantity and temperature due to climate change will in turn have effects on aquatic ecosystem structure and function, with further implications for the quantity, quality, reliability and availability of water resources. This project will build on recent and current research within the WRC and other organisations, to generate potential scenarios for the secondary and tertiary impacts of climate change on water resources, with the aim of supporting the development of policy responses and coping mechanisms.

Estimated cost: R2 500 000(KSA1)  
Expected term: 2005-2008

## **Persistent organic pollutants (POPs) in the water environment** *University of the North West* **No 1561**

South Africa is a signatory to the recent 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:

- Better identify and quantify the fate and effect of selected POPs in the hydrological cycle
- Assess with higher confidence the scale and significance of the occurrence of POPs in the environment in South Africa, and the potential short-term and long-term impacts on water resources and water-linked ecosystems
- Support the development of appropriate policy and regulatory measures to ensure implementation of the requirements of the Stockholm Convention

Estimated cost: R1 500 000(KSA1)  
Expected term: 2005-2008

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

*SRK*  
**No 1565**

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

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

Estimated cost: R3 400 000(KSA1)  
Expected term: 2005-2009

## **Refining tools for evaporation monitoring in support of water resource management**

*CSIR*  
**No 1567**

Evaporation, after precipitation, is the largest component of the hydrological cycle at the land surface. It includes evaporation from open water surfaces, moist soil and wet foliage, as well as the transpiration of plants. There are many compelling water-resource related reasons (among them demands created by recent water legislation) for being able to measure/estimate and monitor evaporation with sufficient accuracy and precision. While many potentially suitable techniques and methods exist, there is a lack of knowledge regarding their appropriate use and capacity in applying them. Consequently, this project will aim to:

- Classify and characterise land uses/units and water-resource management

applications for which evaporation measurements/estimates are needed

- Assess accuracy and precision requirements relating to evaporation measurement/estimation for various water resources

Estimated cost: R1 600 000(KSA1)  
Expected term: 2005-2008

## **Thrust 2: Environmental Governance Systems**

### **Industry-government partnerships for the development, setting and implementation of standards for the water environment**

*PBAI Associates*  
**No 1416**

The aim of this project would be to develop a partnership approach between industry and government for setting of agreed environmental standards, based on the Dutch "covenant" model and utilising the provisions of the National Water Act for setting minimum standards for water uses which impact on the water environment, and implementing these through the use of provisions for Environmental co-operation agreements which are contained in the National Environmental Management Act. The approach would be to work at pilot scale for one industrial sector and one aspect of the water environment, in order to develop a generically applicable model.

Estimated cost: R200 000 (KSA1)  
Expected term: 2004 - 2006

### **Integration of indigenous knowledge systems in the conservation and protection of wetlands in communal areas of South Africa**

*CN Maqwa Consultants*  
**No 1417**

This project aims to identify and describe the indigenous knowledge systems contributing to the conservation of wetlands in communal areas, and to provide guidelines on how this knowledge can be integrated into current systems to enhance sustainable management.

Estimated cost: R 300 000(KSA2)  
Expected term: 2003 - 2004

**Review and evaluation of all relevant governance elements which directly relate to or potentially impact upon water in all phases of the hydrological cycle**

*Pegasus Strategic Management*  
**No 1514**

Review and evaluation of all relevant governance elements (principles, policy, legislation, regulation and practice) at international, national and provincial level that are presently in place and which directly relate to or potentially impact upon water in all phases of the hydrological cycle.

Estimated cost: R500 000(KSA2)  
Expected term: 2003 - 2004

**Industry-government partnerships for development and implementation of sector-based standards for the water environment**

*Karin Bowler Enterprises*  
**No 1511**

The aim of this project is to develop a partnership approach between industry and government for setting of agreed environmental standards, based on the Dutch "covenant" model and utilising the provisions of the NWA for setting minimum standards for water uses which impact on the water environment, and implementing these through the use of provisions for environmental co-operation agreements which are contained in the National Environmental Management Act. The approach is to work at pilot scale for one industrial sector and one aspect of the water environment, in order to develop a generically applicable model.

Estimated cost: R400 000 (KSA 1)  
Expected term: 2004 - 2005

**Strategic review of governance systems**  
*Pegasus Strategic Management*  
**No 1514**

This project will review and evaluate all relevant governance elements (principles, policy, legislation, regulation and practice)

at international, national and provincial level that are presently in place and which directly relate to or potentially impact upon water in all phases of the hydrological cycle.

Estimated cost: R500 000 (KSA 1)  
Expected term: 2004 - 2005

**International freshwater agreements**  
*CSIR*  
**No 1515**

South Africa shares four rivers with its five neighbours – the Incomati, Orange, Limpopo and Maputo. The quantity and quality of the water in these international rivers is increasingly under pressure due to increased water demands in South Africa as well as in the neighbouring states. These pressures will increase as the region develops, possibly leading to a clash of interests between the basin states. South Africa has signed and ratified the UN Convention on the Law of the Non-Navigational Uses of International Watercourses (UNCSW 1997), which promotes the principles of equitable and reasonable utilisation and the obligation not to cause significant harm (to downstream states). Additionally, the convention calls for the establishment of a framework for the exchange of data and information, the protection and preservation of shared water bodies, the creation of joint management mechanisms, and the settlement of disputes (UNEP, 2002). Essential tools in the pursuit of the objectives of the UN Convention are the various treaties, protocols, memoranda and agreements entered into between basin states (collectively referred to as agreements in this project). South Africa is also a signatory to a range of bilateral, multilateral and regional agreements guiding issues of quantity, quality, infrastructure and management of shared freshwater resources (e.g. SADC, 2001). These include agreements entered into as a colony of Britain with various other colonial powers as well as those agreed recently with neighbouring states. Currently, there is no central repository of these agreements; some are housed at DWAF's offices and others at the Department of Foreign Affairs.

Estimated cost: R370 000 (KSA 1)  
Expected term: 2004 - 2005

**Trade policies and water management**  
*University of Pretoria*  
**K5/1564**

The primary aims of this project are:

- To develop strategic understanding of the linkages between trade policies and water policy in South Africa, and the implications of trade policies for water resources and water management
- To identify points or issues for future related research to support policy development, analysis and implementation in the water sector and linked economic sectors.

The outcomes of this research will be used to guide South Africa's position in regional and international trade negotiations, and to guide future research which supports improved quantitative understanding of linkages between trade and water policies.

Estimated cost: R500 000 (KSA 1)  
Expected term: 2004 - 2005

**Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development**  
*Conningarth Economists*  
**No 1570**

With 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 (KSA1)  
Expected term: 2005-2008

# Impact Areas (continued)

## New Projects

### **Thrust 1:** *Environmental Functioning Within the Hydrological Cycle*

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

*Univ of Pretoria*  
**No 1686**

The adverse effects of endocrine disrupting chemicals (EDCs) in the water environment have been widely recognised. The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. According to the feedlot association of SA, 75% of all bovine produced in SA stems from the feedlot production system. Most of the excretions of natural hormones from both human and animal origin are degraded in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. The excretions from animals are recycled into other production systems such as fertilisers for soil or agricultural land. In SA no data is available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal. In this study the presence/absence of veterinary drugs in the effluent of a number of feedlots would be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources close to identified feedlots in South Africa screened for estrogenic and anti-androgenic activity, using a battery of bio-assays.

Estimated cost: R1 900 000 (KSA1)  
Expected term: 2006-2010

#### *The determination of annual phosphorus loading limits and land use-based phosphorus loading models for 30 key South African dams in relation to their present and likely future trophic status*

*W Harding (Private Consultant)*  
**No 1687**

South Africa is near-totally reliant on storage in dams for water supply, with in many cases a large proportion of the flows to these dams

being comprised of polluted return flows and wastewater effluents from urban developments. These return flows are characterised in the main by elevated concentrations of phosphorus. Ideally the management (reduction/prevention) of eutrophication focuses on phosphorus attenuation. However, in South Africa phosphorus elimination from wastewater and other effluents is not targeted as a priority. With eutrophication as the cause, the most common impact (effect) is the increasing, both in extent and duration, development of noxious cyanobacterial aggregations, with the associated risks of cyanotoxin production. Cyanotoxins are notoriously difficult and costly to remove from raw potable waters. The threats posed by cyanotoxins have recently been exacerbated by the discovery that all known species of commonly-occurring cyanobacteria possess the propensity to produce beta-N-methylamino alanine, a non-protein amino acid now linked to the occurrence of Parkinson's Disease (Parkinson's Dementia). The project aims to categorise a suite of key South African dams in terms of:

- Their current trophic status
- The current matrix of phosphorus sources contributing to the total annual phosphorus loads to each of these dams (based on land use)
- Setting total maximum annual phosphorus load (TMAPLs) for each
- Identifying from the land-use-based loading profile where nutrient attenuation management practices should be focused.

Estimated cost: R243 750 (KSA1)  
Expected term: 2006-2007

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

*Geological Sciences, UCT*  
**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 (KSA2)  
Expected term: 2006-2008

#### *National Wetland Rehab Programme Phase II: Wetland Health & Integrity* *Zoology Department, UCT* **No 1584**

This solicited project is Phase 2 of the 3-phase National Wetland Research Programme and it focuses on the development of methods to assess the health and integrity of wetlands. The assessment of wetland health and integrity lags behind that for rivers and estuaries and this poses a problem in the environmental water determination process. There is also growing recognition of the important role of the ecosystem services provided by wetlands. A suite of assessment techniques is required not only to assess the ecological condition of the wetland but also the state of the services delivered. To that end, research undertaken during this project will address the development of tools to assess the ecological condition as well as the state of the services delivered, and to develop a protocol to gauge the loss of wetland function through degradation. Training courses and a communication programme will be developed to assist in the transfer of the technologies developed.

Estimated cost: R3 450 000 (KSA2)  
Expected term: 2006-2010

### **Conservation model for threatened fish species**

*School of Agricultural & Environmental Sciences, Aquaculture Unit, Limpopo University*  
**No 1677**

Freshwater ecosystems are recognised as the most threatened ecosystems worldwide, and in an inherently water-short situation this threat is increased. Fish, being fairly large and requiring larger units of habitat, are generally more sensitive to disturbance than invertebrates. The three main threats are from habitat loss, impact of aliens and exploitation.

The objective of this project is to develop a conservation model for threatened fish species using *Opsaridium peringueyi* as a reference species, and the study will examine the population status, threats to the population and rehabilitation.

Estimated cost: R1 078 170 (KSA2)  
Expected term: 2006-2008

## **Thrust 2: Environmental Governance Systems**

### **A philosophy and strategy enabling learning for good ecosystem governance**

*CSIR*  
**No 1689**

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

Estimated cost: R639 200 (KSA1)  
Expected term: 2006-2009

### **Enriching freshwater conservation planning and management**

*CSIR, Environmentek*  
**No 1678**

The pressures from social-economic aspirations have resulted in a progressive degradation of freshwater habitats in recent decades. As in other countries, this country's rivers have deteriorated faster than terrestrial habitats. *Ad hoc* conservation efforts are not effective in the face of this pressure, a strategic and systematic approach is needed if the initiative is to be effective.

This project is part of a suite of initiatives (funded by WRC, DWAF and CSIR) which include the development of cross-sectoral policy and planning tools for conservation planning, and aims to advance our understanding of the relationships between freshwater conservation planning and the socio-economic and political processes that govern freshwater conservation at international, national and sub-national levels. This will be done through engaging the broader socio-economic and political discourse to identify the issues that are important for the successful implementation of the conservation planning process, and incorporating these into the overall process. This will be tested in a specific geographic context.

Estimated cost: R450 000 (KSA2)  
Expected term: 2006-2008

## **Thrust 3: Integrative Knowledge for Ecosystem-based Water Resource Management**

**Periphyton flow dynamics**  
*Zoology Department, UCT*  
**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 rendering 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, and 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 (KSA2)  
Expected term: 2006-2009

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

*School for Environmental Sciences, University of the North-West, Potchefstroom*  
**No 1675**

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

The objective of this project is to develop a cyanobacterial toxin prediction tool for South African use based on the technologies used in Australia for use by water resource managers and water treatment works.

Estimated cost: R 225 000  
Expected term: 2006-2008

### **Contact person**

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# Impact Areas (continued)

## Water and Health



**Dr Gerhard Offringa: Head**

### Scope

Water-related health forms a crucial and integral component of our daily quality of life. Health-related water research is undertaken with the aim of improving water quality and hygiene practices in order to save lives and reduce the cost and effort in treating diseases and their symptoms.

This impact area continues to play an essential role in providing an integrating framework for all the WRC's health-related research and development initiatives, identifying gaps and negotiating the initiation of gap-filling research in crucial areas. In fulfilling this role, the impact area assumes the responsibility for the structuring of a co-ordinated, needs-driven, dynamic health-related water research portfolio on behalf of the WRC, with contributing projects being funded and managed in the appropriate KSAs.

The focus is on water-linked health impacts associated with microbial or chemical contamination or transferred via water-associated vectors. The impact area aims to improve knowledge regarding the origin, survival and persistence of microbial, biological and chemical agents that may pollute water and may affect human health. The impact area supports the development and utilisation of methodologies to identify and quantify the occurrence of pathogens and contaminants in water, as well as risk assessment and epidemiological studies.

A holistic, multidisciplinary approach is followed in order to develop a comprehensive understanding of the origin/sources and spatial extent of pollution; water usage patterns; the effects of degraded water quality on human and animal health and the need for, and efficiency of, various water treatment options. The development of guidelines, protocols, manuals and pamphlets as tools to disseminate research findings is supported. The emphasis is on a proactive approach to identify and address causes, rather than on a passive response to addressing symptoms. This approach should ensure research products that are relevant, user-friendly, practical and scientifically valid.

### Objectives

The objectives of this impact area have been reviewed and reformulated since the drafting of the previous review. The revised primary objective is to contribute to the protection of human health by investigating the sources, occurrence, persistence and control of water-related diseases and other water related health problems.

#### Revised secondary objectives are to:

- Develop appropriate techniques, technologies and systems for monitoring of potentially harmful pollutants in water
- Obtain adequate understanding of the origin, survival and persistence of, and inter-relationships between, microbial, chemical and other biological and toxic pollutants in water
- Assess the impacts (actual and potential) of pollutants on human health by performing epidemiological investigations and developing health-risk assessment tools
- Investigate the effects of the environmental change on health (e.g. the impact of global warming on the spread of malaria; the link between climate variability and epidemics caused by water-borne diseases)
- Develop scientifically sound educational material on health, hygiene, the effects of pollution and the prevention of pollution, and the relationship between these
- Provide guidance for appropriate communication, awareness-building and management strategies
- Also contribute to the general health of animals and of the environment in pursuing all of the above objectives.

### Thrusts

The thrusts which define the structure of this impact area's research portfolio have been changed following the completion of the new Strategic Framework for Water Related Human Health Research, completed at the end of 2005 (see background below). Previously, the three thrusts were 1) Microbial Water Quality and Associated Health Impact, 2) Chemical Quality of Water and Associated Impact on Health, and 3) Safeguarding Public Health. The 6 new thrusts are the following:

#### Thrust 1: Resource Protection

The focus of research under this thrust is on the safeguarding of human health through the protection of both surface and ground water resources from impacts that compromise the quality of water and add to the economic burden of treating water to the national water quality norms and standards. Point and diffuse sources of pollution are addressed through pollution prevention interventions and remediation where water quality has already deteriorated. The focus is on the detection, prevention and management of all contaminants that pose a threat to human health. Development of health risk assessment and management tools for protecting human health from water-related health hazards is addressed under this thrust.

Research under this thrust is addressed under the following programmes:

**Programme 1:**  
Detection, prevention and management of water-related microbial agents.

**Programme 2:**  
Detection, prevention and management of chemicals and radioactive contaminants in water resources.

**Programme 3:**  
Management of eutrophication and algal toxins.

**Programme 4:**  
Management of impacts of land use activities on surface and groundwater at a catchment level

## **Thrust 2:** **Drinking Water**

This thrust focuses on research addressing all health impacts of drinking water quality, risk assessment and risk management approaches such as water safety plans and development of water quality monitoring systems. Research is contributing to ensuring that drinking water is safe, i.e. it does not cause any harm to human health, and it is free from pathogens and chemical contaminants that can potentially induce pathological and physiological damage to humans. This is achieved through the development of rapid and sensitive technologies for detecting contaminants in drinking water and innovative treatment technologies for removing contaminants from water. Research also contributes to the development of effective governance systems which are necessary to facilitate the regulation of drinking water quality.

Research is addressed under the following programmes

- Programme 1:**  
Drinking water quality management.
- Programme 2:**  
Water treatment technologies and reticulation systems

## **Thrust 3:** **Public Health and Hygiene Issues**

This thrust focuses on proximal factors such as water quantity, health and hygiene education that have a direct link to disease transmission. It also addresses the distal causal factors such as socio-economic factors that have an impact on both the health of a society and the individual through the linkages to the proximal factors. Public health protection has the following components:

- Surveillance to measure risk associated with specific water uses;
- Comparisons of measured risk and predefined acceptable risk thus leading to the development of control strategies;
- Public awareness campaigns and promotion of sanitation, health and hygiene education.

The main focus of this research thrust is on the development of tools for the identification of conditions that are conducive to water-borne disease outbreaks and appropriate precautionary and preventive measures that can be taken to protect public health.

Examples of tools include water quality monitoring systems, early warning systems, disease surveillance systems and health and hygiene awareness and education materials. The impact of sanitation, water quality and quantity on the health of HIV/AIDS patients is also addressed with a view to developing strategies for reducing their exposure to microbial agents associated with contaminated water. Capacity building and training of sector professionals is further receiving attention under this thrust because the availability of skilled personnel is critical to public health protection.

Research is addressed under the following programmes:

- Programme 1:**  
Public health and hygiene awareness and educational materials
- Programme 2:**  
Capacity building and training programmes for public health professionals and practitioners.
- Programme 3:**  
HIV/AIDS linkage with water quality and quantity and access to adequate sanitation services.
- Programme 4:**  
Impact of water quantity and service levels on human health

## **Thrust 4:** **Sanitation and waste management**

This thrust focuses on health aspects of the different sanitation technologies and waste management practices, with special reference to health implications of using waste as a resource. Promotion of ecological sanitation technology is leading to a growing interest in the use of human excrement and grey water in crop production. There is a need to find a balance between increasing food security for poor households and the protection of public and environmental health. Research provides scientific information and health risk management strategies for guiding decision-makers in setting minimum quality standards for use of wastewater in crop production in order to protect human health. Research addresses safe treatment and disposal of sludge from on-site sanitation systems, for example, pit latrines, septic tanks and urine diversion systems. Health implications of malfunctioning waterborne sewerage and poor storm drainage systems are also addressed under this thrust.

Research is funded under the following programmes:

- Programme 1:**  
On-site sanitation treatment technologies
- Programme 2:**  
Use of waste as a resource
- Programme 3:**  
Management of waterborne sewerage and stormwater systems

## **Thrust 5:** **Health Implications of Water Uses other than Domestic Use**

Research under this thrust focuses on the health implications of other water uses such as health risks associated with the irrigation of crops with water of poor quality; polluted recreational waters and occupational exposure to water of poor quality. Irrigation of crops with water of poor quality can have both direct and indirect effects on human health. Health risk assessment studies for the different use categories should be undertaken and appropriate management strategies should be developed to mitigate negative health impacts of exposure to water of poor quality.

Research is addressed under the following programmes:

- Programme 1:**  
Impacts of quality of irrigation water on human health
- Programme 2:**  
Ensuring safe water for recreation
- Programme 3:**  
Management of health impacts associated with occupational exposure to water of poor quality

## **Thrust 6:** **Governance Systems for Safeguarding Human Health**

This thrust focuses on research that supports the implementation of the basic principles of effective governance (stakeholder participation, transparency, equity, accountability, coherence, responsiveness and integration) within the context of water and human health. The research contributes to the development of a regulatory framework for the protection of public health from all water related health impacts. It also develops tools and guidelines for the implementation of comprehensive risk management strategies for managing drinking water quality from

# Impact Areas (continued)

the catchment to the end-users. Research necessary to evaluate and guide the policy formulation process is addressed under this thrust. Models for appropriate governance systems necessary to support effective regulation of water quality are addressed. These models should be flexible enough to accommodate the challenges faced by small water service authorities with regards to water quality aspects.

Research is undertaken under the following programmes:

**Programme 1:**  
*Governance system for the protection of public health from water related impacts on human health*

This programme focuses on governance issues that should be addressed to safeguard public health from water related impacts on human health.

**Programme 2:**  
*Regulatory framework for an integrated water quality management approach*  
*This programme addresses governance issues pertaining to the protection of the resource, focusing on the development of appropriate instruments and tools for regulating integrated water quality management and enforcing compliance.*

## Research portfolio

The funding for research projects relevant to this impact area and supported by the various KSAs, is estimated at R10.7 million for 2006/07.

## Completed

### Thrust 1: Resource Protection

**Programme 2:**  
*Detection, prevention and management of chemicals and radio-active contaminants in water resources*  
*Monitoring environmental water on the East Rand for the presence of toxic agents: A pilot study*  
*Highveld Biological Association*  
**No 1397**

Environmental monitoring is normally only carried out by institutions with substantial resources, which in South Africa has tended to create a top-down approach to water quality problems. Previously, the project leader has developed a rapid low-cost (Human Cell Test, HCT) method of monitoring the toxicity of water prior to and after human use. This project was a pilot study intended to demonstrate the effectiveness of the method developed, but with the co-operation of disadvantaged communities. It was shown that HCT analysis does provide a practical approach for rapidly screening large numbers of environmental samples for human health risks. The results of HCT assays carried out on water samples from 127 sites in the Vaal Barrage catchment provided supporting evidence that the Vaal Barrage catchment is adversely affected by a variety of effluents resulting from human activities. However, the extent of this adverse impact cannot be quantified until reliable data is available regarding flow rates throughout the catchment. Subject to spatial considerations, the natural remediation processes of the catchment still appear to be functioning.

Cost: R250 000 (KSA 1)  
Term: 2002 - 2006

**Chemical and biological assays and sentinel species for EDCs**  
*University of Pretoria / Consortium*  
**No 1505**

The objective of this study was to determine whether sufficiently high levels of EDCs exist in the general environment to exert adverse health effects on aquatic or terrestrial animals or humans in the Rietvlei Nature Reserve (RNR). This report summarizes the scientific background relevant to the study with emphasis on chemical residue analyses, endocrine disruptive metals (EDMs) and bio-assays for oestrogenicity and dioxin and dioxin-like PCBs. It also reviews the use of possible biosentinel aquatic and terrestrial animals. General information on the RNR and the outcomes of previous projects are discussed. This is followed by separate chapters on analytical chemistry and *in vitro* bio-assays. *Clarias gariepinus* (sharp-tooth catfish), *Xenopus laevis* (African clawed frog), *Bulinus tropica* (freshwater snail) and *Rhabdomys pumilio* (striped mouse) were evaluated as possible biomarker species for EDC exposure.

The impact of active biomonitoring (ABM) on fish and snail species in the RVD, the effect on macro-invertebrates (SASS5) and the possible role of plants in the wetlands were addressed separately. All the information gathered was integrated in a qualitative scenario-based health risk analysis and a toolkit recommended for future use.

Cost: R2 000 000 (KSA1)  
Term: 2004-2007

**Programme 4:**  
*Management of impacts of land use activities on surface and ground water at catchment level*  
*Modelling non-point source pollution in agriculture from field to catchment scale – a scoping study*  
*Sigma Beta*  
**No 1467**

Agriculture has been implicated as a major source of non-point source (NPS) pollution because most of the land area is utilised for agricultural activities. 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. This project aimed to involve major players active in this field in a scoping exercise and knowledge gap analysis in order to develop the terms of reference for a longer term project that would establish an integrated model for the prediction of agricultural NPS pollution from field to catchment scales for the major agricultural NPS pollutants. The project compiled a first order estimate of the contribution that agricultural activities make towards NPS pollution in South Africa. The large-scale national databases of point discharges, return flows and agricultural land and water use that underlie DWAF's National Water Resources Strategy and the Internal Strategic Perspective Projects were used to partition aggregated observed water quality loadings into point and non-point components for selected constituents at selected sites in three representative river systems.

Cost: R644 400 (KSA 4)  
Term: 2003 - 2006

## **Thrust 2: Drinking Water**

### **Programme 1:**

#### **Drinking water quality management**

*Develop and apply an innovative assay system to provide direct and reliable assessments of the role of domestic water supply in causing diarrhoea in rural households*

*Technikon Witwatersrand*

**No 1444**

This project revolved around linking water quality to health. It became necessary to investigate supplementary water-assessment tools that can link the quality of water (for consumption) more directly to potential human health effects. The aim was to develop an assessment methodology that combines measurements of inflammatory potential of, as well as the potential occurrence of bacterial pathogens in, water that people consume in order to assess whether such water have the potential to cause inflammation that could lead to water-borne infection. Water samples were collected from the Nwanedi River Basin in the Vhembe district of Limpopo. In this area, substantial numbers of people in several villages still source untreated river water for domestic use, however, some villages having access to tap water of a good microbiological quality. The common risk factor among these villages was containers that people used for collecting water from whatever source they accessed and transporting it to their homes where it was stored and used over time. This study showed that most of the waters tested were inflammatory. The team, however, failed to associate this with the potential bacterial pathogenesis of the test waters. This meant that there were some other constituents that caused the inflammatory reactivity. Further research may therefore be required.

Cost: R424 400 (KSA 3)

Term: 2003-2006

#### **On-line real-time enzyme diagnostic system for the detection and monitoring of sewage levels in drinking water**

*Dept of Biochemistry and Microbiology,  
Rhodes University*

**No 1446**

The ultimate aim of this work was to develop an on-line real-time enzyme diagnostic system for the detection and monitoring of sewage levels in drinking water, using suitable marker enzymes. Furthermore, proof of concept was established for the design of a suitable electrochemical biosensor for the rapid detection of faecal matter in water intended for drinking purpose. One of the most promising alternative approaches to faecal microbial detection (by performing direct assays for marker enzymes of these indicator micro-organisms) was selected. Detection via marker enzymes was successfully achieved within 24 h although the aim is to reduce this time to less than 9 hours. Attempts to immobilise the substrates on a solid support were successful with modified nylon providing the best support. However, the use of the strips had limitations in the environmental samples due to substrate desorption with prolonged times of immersion in samples with low enzyme concentration. To implement real-time assaying, electrochemical detection of the enzyme breakdown products was investigated and proof of concept was established. Real time monitoring of faecal pollution proved promising though direct electrochemical detection and development of a sequential flow injection analysis (SFIA) system. This design constitutes a high priority for future research and is based on the proof of concept that was established during the course of this study. At this point, a provisional patent is being applied for, based on results obtained in this and the follow-on study.

Cost: R500 000

Term: 2003 – 2006

## **Thrust 3: Public Health and Hygiene Issues**

### **Programme 1:**

#### **Public health and hygiene awareness and education material**

*The effectiveness of water and sanitation awareness programmes in informal areas*  
*Nemai Consulting*

**No 1523**

The objective of this study was to investigate the effectiveness of sanitation awareness and education programmes (SEAPs) in informal

settlements in reducing the incidence of disease. The project focused on a range of awareness creation and education techniques that may be utilized in SEAPs, and the effectiveness of these techniques. It was found that sustainability is a major problem. Most SEAPs are run as part of a larger sanitation service provision project and when the construction of toilets is complete the SEAP ends too. People from the area where the project was implemented and who have been trained and employed as health promoters are no longer active as educators after the implementing agent has left. However, given information and imbued with knowledge, the people in informal settlements have the capacity to organise themselves to change their own situations. A high level of commitment and initiative is shown in areas where people have been empowered with knowledge about hygiene and sanitation issues.

Cost: R200 000

Term: 2004 - 2006

## **Thrust 4: Sanitation and Waste Management**

### **Programme 2:**

#### **Use of waste as a resource**

*A scoping study to evaluate the fitness-for-use of greywater in urban and peri-urban agriculture*

*CSIR-NRE*

**No 1479**

Household and urban food gardens can contribute to food security and is therefore supported by government. However, their application potential is limited by a shortage of water to supplement rainfall. Greywater (used household water that is not toilet water) presents a potentially suitable water resource that is under the control of the household gardener. This scoping investigation was undertaken to obtain a balanced evaluation of the opportunities and threats presented by grey-water use and the research needs to address them.

Cost: R490 000

Term: 2004 - 2006

# Impact Areas (continued)

## Current

### Thrust 1: Resource Protection

#### Programme 1: Detection, prevention and management of water related microbial agents

Refinement of protocols for the National  
Microbial Monitoring Programme for  
Groundwater  
CSIR  
No 1494

A project to develop a prototype implementation manual for the national microbial monitoring programme (NMMP) for groundwater has recently been completed. This desktop study produced a general framework for the design of the monitoring programme. Before this can be formally adopted the core design must be tested and researched in the field. This project aims to monitor the microbial quality of groundwater that reflects the degree of faecal pollution in a manner that will support strategic management decisions in the context of sustainable fitness for use.

Estimated cost: R500 000 (KSA 1)  
Expected term: 2004 -2006

#### Programme 2: Detection, prevention and management of chemicals and radioactive contaminants in water resources.

Programme for endocrine disruption  
contaminants (EDC)  
Consortium Members: US; UFH; MEDUNSA;  
Technikon Free State; Technikon Pretoria;  
SABS; Environmentek, CSIR; ARC-PPRI;  
Consultant manager  
No 1402

This is a follow-up of the preliminary studies of the EDC programme. This programme will focus on the present status of EDC pollution in the aquatic systems of the country and will address the wide variety of chemicals involved to determine those crucial for the SA environment and the special techniques and skills needed for the detection thereof. It will be a combined effort between laboratories country-wide with specific capabilities and skilled researchers to develop a battery of bio-assays and chemical analyses that could be used to determine the extent of the

EDC pollutions in SA. Each laboratory will be expanding on their special capabilities and building capacity to form a centre of expertise, but not working in isolation, to the benefit of this research in SA.

Estimated cost: R3 000 000  
Expected term: 2002 - 2007

#### To calibrate and verify a predictive model for the occurrence of naturally occurring hazardous trace constituents in groundwater

Council for Geoscience  
No 1431

The South African groundwater database does not support identification of areas with high concentrations of trace metals that may form a potential hazard due to incomplete data and difficulties in detecting these trace metals. In this project geochemical modelling will be adopted to determine the presence of trace metals in groundwater. The objectives of the project are: Verification of prediction of naturally occurring trace constituents in groundwater by field sampling at appropriate sites; setting up of leaching tests; verification of geochemical and geological models; and development of a GIS map that identifies areas of special concern.

Estimated cost: R3 500 000  
Expected term: 2003 -2005

#### Application of the CHEMPROP Model for South African conditions to predict the environmental fate of toxic organic chemicals in the aquatic environment (as a contribution to the National Toxicant Monitoring Programme (NTMP)

Rand Water  
No 1475

The software CHEMPROP was developed in Germany and facilitates the prediction of physiochemical properties and associated environmental fate of organic compounds, as well as the baseline toxicity to aquatic organisms and is based on the structural composition of compounds. It was designed as a research tool for developers and experts. It will be tailored as a specific prediction tool for the local conditions that could be used to govern the selection and optimization of subsequent analytical procedures.

#### The aims of this project are to:

- Develop and evaluate a specific fate prediction tool that is tailored for the local geographical conditions in South Africa
- Train students in the application of CHEMPROP and ensure that this technology is transferred to South Africa
- Use CHEMPROP to assist in determining sampling strategies and frequencies for the NTMP.

Estimated cost: R254 820 (KSA 1)  
Expected term: 2004 -2006

#### Occurrence and fate of EDCs in drinking water

CSIR  
No 1532

It is of high priority that the fate of EDCs be determined to minimize the effect thereof on humans and animals. The project aims to investigate the occurrence and fate of EDCs in raw and treated drinking water using biological/biochemical techniques and chemical tests. Recommendations will be made on the most effective water treatment technologies for the removal of EDCs and the most appropriate combination of tests for the detection of EDCs in drinking water.

Estimated cost: R830 000 (KSA3)  
Expected term: 2004 -2006

#### New detection methods for EDCs

University of Stellenbosch  
No 1534

The project will aim to produce and test an endocrine disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand binding domain (LBDER) into a suitable yeast (*Pichia pastoris*) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotinylation of LBDER and preparation of biotinylated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors

- Development of specialized 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 – 2007

***An investigation into the occurrence of endocrine disrupting chemicals, organochlorine pesticides and heavy metals (Cd, Zn, Ca and Pb) in surface waters of the Northern Province***

*University of Venda*  
**No 1557**

Organochlorine pesticides (OCPs) and heavy metals have been implicated in endocrine disrupting activities. In studies done in the Northern Province DDT was detected in the streams and rivers, thus pointing to pesticide pollution of water sources. It is important to widen the scope of the studies done to get a clearer picture of the pollution profile of the source waters that could be detrimental to human, animal and ecosystem health.

Estimated cost: R60 000  
 Expected term: 2004-2007

***Persistent organic pollutants (POPs) in the water environment***

*North West University*  
**No 1561**

Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research will now be taken further in order to:

- Better identify and quantify the fate and effect of selected POPs in the hydrological cycle
- Assess with higher confidence the scale and significance of the occurrence of POPs in the environment in South Africa, and the potential short-term and long-term impacts on water resources and water-linked ecosystems
- Support the development of appropriate policy and regulatory measures to ensure implementation of the requirements of the Stockholm Convention.

Estimated cost: R1 500 000 (KSA1)  
 Expected term: 2005-2008

***Osmoregulation in freshwater invertebrates in response to exposure to salt solution***

*Rhodes University*  
**No 1585**

The project aims to undertake acute and chronic toxicity tests using selected salts and indigenous macro-invertebrates as well as oxygen consumption and osmolarity tests to evaluate the salt boundary values for application in environmental water quality in setting resource quality objectives.

Estimated cost: R209 000 (KSA2)  
 Expected term: 2005-2007

***Programme 3: Management of eutrophication and algal toxins***

*Cyanobacteria programme: Toxin blooms and toxin promotion*  
*Consortium members: PU for CHE; University of Port Elizabeth; Technikon Pretoria*  
**No 1401**

The first part of this programme will investigate, *in vitro*, algal physiological aspects concerning phosphorus and nitrogen nutrition as part of an ongoing study as to why problem algae form harmful blooms. A model for the prediction of toxic bloom events based on the cellular mechanisms of the modulation of toxin production by nutritional environmental parameters will also be developed. The third part will be an investigation of algal blooms and release of decomposition products and cellular material with consequent effect on water quality during lysis of the bloom in the Hartbeespoort Dam.

Estimated cost: R630 000  
 Expected term: 2002 - 2005

***Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers***

*Rand Water*  
**No 1445**

An increase in the eutrophication of surface water resources is leading to an increased incidence of toxic blue-green algae growth – thereby increasing health risks for drinking water from a treatment plant which does not use activated carbon adsorption in its

process train. No structured framework exists yet in South Africa to manage the supply of safe drinking water during a persistent blue-green algae bloom in source water. This project aims to establish a pro-active approach by means of a generic algal bloom incident management framework to effectively manage potable water supplies when toxic algal blooms are present. Such a system will be widely applicable to water service providers and will reduce the risk of human health-related incidents related to blue-green toxins by providing this framework for informed and appropriate pro-active management measures.

Estimated cost: R 236 000 (KSA3)  
 Expected term: 2003 – 2004

***PCR-based marker for identification of toxic cyanobacteria strains***

*University of Pretoria*  
**No 1502**

Current cyanobacterial taxonomy does not provide an unequivocal system for the identification of toxigenic and bloom-forming genus *Microcystis*. The ambiguities that exist in the cyanobacterial taxonomy are due to the expressed variability, minor morphological and developmental characteristics used for identification and classification of the genus or species level. The increasing occurrence of toxic *Microcystis aeruginosa* blooms in major water resources make identification and prediction of these toxic blooms very important. This research will contribute to the development of techniques that will aid in the rapid identification of toxic cyanobacterial strains and in assessing the potential toxicity of the strains.

Estimated cost: R668 500 (KSA 1)  
 Expected term: 2004 - 2007

***Methods manual for monitoring phytoplankton and cyanobacteria***

*Rand Water*  
**No 1533**

There is no uniformity in the manner in which water suppliers approach the monitoring of phytoplankton and algal blooms, with the result that incompatibility of data makes it difficult to draw conclusions regarding the extent of the problem. The aims of the proposed project are to:

# Impact Areas (continued)

- Synthesise current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis and geosmin and MIB analysis nationally and internationally
- Compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins and geosmin and MIB for South African freshwaters
- Compile a summarised reference document

Estimated cost: R403 600 (KSA 3)  
Expected term: 2004 - 2006

## **Programme 4:** **Management of impacts of land use activities on surface and groundwater at a catchment level**

*Modelling non-point source pollution in agriculture from field to catchment scale*  
*Sigma Beta Consulting*  
**No 1516**

It is increasingly recognised that non-point source, 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. This further results in a negative impact on plant, animal and human health. The project will address those issues that require priority attention, with regard to non-point source pollution.

Estimated cost: R5 000 000  
Expected term: 2004 - 2009

## **Thrust 2:** **Drinking Water**

**Programme 1:**  
**Drinking water quality management. Determination of the specific origin of contaminating bacteria in drinking water of rural households by elucidating the contamination pathway using amplified fragment length polymorphism (AFLP)**  
*CSIR*  
**No 1602**

Method development at the DNA level has made the identification of the exact origin of specific contaminating and other organisms

possible. This ability may have a profound impact on our understanding of exactly where contaminating organisms originate from and where in the contamination pathway introduction of these organisms into drinking water supplies takes place. Understanding the latter will in turn allow identification of the specific human behaviours and practices that contribute to contamination of drinking water. The information will enable the design of preventative measures aimed at the very core of the problem and in doing so minimize health impacts and direct resources optimally. Using the amplified fragment length polymorphism (AFLP) methodology, the project therefore aims to identify those human behavioural factors and practices that are directly associated with the identified contamination pathway and identify the exact point where bacterial contamination of drinking water takes place in rural households without access to in-house piped water. Recommendations will be made that would address those behaviours or practices associated with the identified pathway so that contamination can be prevented or minimized in future

Estimated cost: R371 320  
Expected term: 2005 - 2007

**Programme 2:**  
**Water treatment technologies and reticulation systems**  
*Enabling water fluoridation in small drinking water treatment plants*  
*Umgeni Water*  
**No 1530**

The project aims to investigate and suggest ways to ensure that the implementation and operation of fluoridation in small and rural plants may be done in a safe and sustainable fashion. Available equipment and instrumentation will be evaluated and guidelines provided for the choice and operation of suitable equipment. Suggestions will be made on the optimal ways to install and operate such equipment and instrumentation. Innovative ways will further be suggested in which to implement and operate such equipment and instrumentation in order to ensure safe and sustainable fluoridation on small and rural water treatment plants.

Estimated cost: R1 200 000  
Expected term: 2004 - 2007

**Improving the efficiency of disinfection in small drinking water treatment plants**  
*University of Fort Hare*  
**No 1531**

Inefficient disinfection was shown to be a major weak point in the provision of safe water by small and rural drinking water treatment plants to rural communities. The project aims to investigate the reasons for these existing problems and suggest both technical and social remedies to overcome the problems and to ensure the provision of efficiently disinfected and safe drinking water to these communities.

Estimated cost: R1 000 000  
Expected term: 2004 - 2006

**Assessment of the occurrence and key causes of drinking-water quality failures within non-metropolitan distribution networks in South Africa, and guidelines for the practical management thereof**  
*Emanti Management*  
**No 1597**

Small water service providers are having problems in proactively managing drinking water quality within their distribution networks. This project aims to analyse the relatively high percentage of water quality failure in two provinces of South Africa and in particular contrast the water quality at the water treatment plant with that at point of use. Guidelines will then be developed for the management of drinking-water quality in non-metropolitan distribution systems. The guidelines will include legislative compliance requirements, technical inputs (e.g. optimum free chlorine residual levels), best practices (e.g. pro-active maintenance requirements), monitoring and management protocols and reporting protocols to consumers, provincial and national government. These guidelines will then be used in a 'road show' to make the appropriate officials aware of the need for effective monitoring and management.

Estimated cost: R452 300  
Expected term: 2005 - 2007

### **Thrust 3:** **Public Health and Hygiene Issues**

#### **Programme 1:** **Public health and hygiene awareness and education material**

*Involving traditional healers and myths and stories in hand-washing/hygiene education / sanitation promotion initiatives*  
*Sigodi Marah Martin*  
**No 1521**

This study will examine the myths and traditional practices around WSS and hygiene, with the intention of developing strategies to involve traditional healers and the practices in promotion of health and hygiene activities and messages. The project offers a fresh approach at using local resources and systems to promote good sanitation and hygiene.

Estimated cost: R326 000  
Expected term: 2004 - 2006

#### **Health and hygiene education** *Mvula Trust* **No 1634**

The main objective of this programme is to support 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.

The following research topics will be addressed under this programme:

- Investigation of the linkage between poor sanitation and HIV/AIDS and also possible linkage between the high incidence of cholera outbreaks and prevalence of HIV/AIDS infection
- Investigate modes for the spread of cholera in South Africa and recurrence of cholera outbreaks
- Development of indicators for measuring health improvement and assessing the use of proxy indicators; this should include evaluation of the impact of health and hygiene in the creation of a demand for sanitation

Guideline: **Education and Awareness Building on the Detrimental Effects of Pollution**

Estimated cost: R 800 000 (KSA3)  
Expected term: 2005 -2007

#### **Programme 2:** **Capacity building and training programmes for public health professionals and practitioners** **A Guideline Document for the Implementation of Sanitation, Health and Hygiene Education Programmes in Informal Settlements** *Nemai Consulting* **No 1656**

The provision of a guideline/tool for promotion of HHE in informal areas is a gap identified by current research.

Where environmental health workers are appointed, their services are usually not directed at sanitation-related health & hygiene promotion. Very few WSAs have a sanitation department/unit that deals with low-cost sanitation. Where such sanitation departments/units exist, and there are sanitation managers, a limited number of these managers understand the specific requirements posed by alternative sanitation delivery. This study is a small step in assisting water services to engage with informal areas in the promotion of HHE and sanitation. The tool is aimed at empowering them on how to address the situation and provide a sustainable service. The current typhoid outbreak is a good example of the lack of education in informal areas, alleviated by poor management of water and sanitation services.

Estimated cost: R 570 000 (KSA3)  
Expected term: 2006-2008

#### **Programme 3:** **HIV/AIDS linkage with water quality and quantity and access to adequate sanitation service** **Molecular relatedness of enteric pathogens isolated from water sources and HIV/AIDS patients with diarrhoea in rural communities in the Limpopo and Eastern Cape Provinces Univ. of Venda** **No 1633**

The project aims to establish any epidemiological linkage between enteropathogens from water sources and those in infected patients, to isolate and characterise bacterial and protozoan enteropathogens and to determine its antimicrobial susceptibility. The study will address the issues of scientific and technical links to other aspects such as hygiene practices, water quality and type

of service rendered, all aspects of storage in containers, identification of water-borne opportunistic bacteria specifically of concern to the HIV compromised and the rate of infection.

Estimated cost: R900 000(KSA3)  
Expected term: 2005-2008

### **Thrust 4:** **Sanitation and Waste Management**

#### **Programme 1:** **On-site sanitation treatment technologies and waste management Strategy for the furtherance of knowledge and good practice of ecological sanitation (Ecosan) technology in South Africa** *Boutek, CSIR* **No 1439**

VIP toilets, correctly engineered and implemented, are a good means of providing a dry sanitation service, but these systems are not without their problems. 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 ecological sanitation (Ecosan) systems address the above problems. They 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. 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. This study aims to develop strategies and guidelines, through monitoring and evaluating existing schemes, which would provide fundamental answers in the sustainable management of this technology.

# Impact Areas (continued)

Estimated cost: R 820 000  
Expected term: 2003 – 2006 (KSA 3)

## **Drainage in rural and peri-urban townships**

*Water Systems Research Group, University of the Witwatersrand*  
**No 1440**

It is well known that drainage in low-income areas is lacking, leading to increased risks of flooding and environmental health. South Africa suffers from a backlog and inadequacy in drainage services, particularly in peri-urban and rural areas. The differentiation between sewage, grey water or sullage and stormwater is often unclear. In fact, in low-income areas, the paths are often merged. Sewage and solid waste enter surface drains, and pose health threats, are not aesthetic and degrade the environment. In high density, informal settlements, these services are often non-existent or at the most are inadequate and dangerous. Stormwater runoff from low cost townships is polluted by waste and overflows from toilets and goes untreated to watercourses. In some cases, the water is re-used posing a health hazard. There is no separate disposal mechanism for sullage. Even where pit latrines or chemical closets are provided, the sullage is discharged onto the surface. This study aims to investigate and pilot alternative methods of drainage systems for low-income areas. The output will be a user guide and software that would assist decision makers in the field.

Estimated cost: R 520 000  
Expected term: 2003 – 2005 (KSA 3)

## **Understanding the disposal and use of grey-water in the non-sewered areas in South Africa**

*University of Cape Town*  
**No 1524**

There is a strong drive from the South African government to attain basic water and sanitation coverage. The level of service to meet this requirement being applied by the majority of authorities in urban and rural areas relate in most cases to on-site dry latrines (VIPs or equivalent) and 25 l/cap-d of drinking water. As water and sanitation services are attained and improved, the potential for problems related to the disposal and management of grey-water will emerge. Solutions are required to circumvent or minimise these

problems. The study aims to undertake a complete scoping exercise to identify current and historic grey-water management initiatives in urban and rural areas, and to identify problem areas / challenges. Determine and assess existing management and disposal practices within South Africa.

Estimated cost: R800 000  
Expected term: 2004 – 2006 (KSA 3)

## **Research into urine diversion toilets in eThekweni**

*University of KwaZulu-Natal*  
**No 1629**

The study aims to provide a scientific basis for the design and operation of urine diversion (UD) toilets, evaluate their effectiveness and determine the fate of *Ascaris* eggs in the toilets. The study puts forward a problem that is emerging around service delivery issues related to the use of urine diversion toilets. Ethekeweni has taken on the championing of the technology and has modified its design. Success of Ethekeweni's initiative will be of relevance to the rest of the country in the use of the technology. This research is a direct outcome of a strategy workshop hosted by Ethekeweni and WRC. The fate of pathogens in UD toilets is not clear, that is what happens to pathogens in a dehydration process that is the basis of the operation of UD systems. This lack of understanding is an inhibitory factor in the use of pit contents, as well safe handling of faecal sludge. Thus, the management and operation of the UD provide greater challenges than just the sanitation convenience. The study intends to find answers to these challenges which would make the option of UD more acceptable and improve the management aspects.

Estimated cost: R 600 000  
Expected term: 2005 – 2007

## **Scientific support for the design and operation of ventilated improved pit-latrines (VIPs)**

*University of KwaZulu-Natal*  
**No 1630**

The project aims to investigate and determine the fate of different pit-latrines additives and their performance, using newly developed testing procedures in wastewater treatment. The project is very important in light of previous attempts by the WRC to evaluate

pit additives that did not live up to promise. The sector is continuously in demand for this information.

Estimated cost: R 600 000  
Expected term: 2005 – 2007

## **Thrust 5: Health Implications of Water Uses other than Domestic Use**

### **Programme 1: Impacts of quality of irrigation water on human health**

*Assessment of the interaction between aquaculture and water quality in on-farm irrigation dams*

*Division of Aquaculture, University of Stellenbosch*  
**No 1461**

Most irrigation areas make use of on-farm storage dams to store water until it is required for the irrigation of crops. The existence of these dams presents an opportunity to utilise them also for fish production. Benefits associated with this dual use of farm dams include the additional income associated with such an enterprise, the supply of fresh fish as protein source for local communities, the creation of additional employment opportunities and a potential reduction in fertiliser requirements for crop production, as a result of the enrichment of the irrigation water by fish food and excrement. Although dual use is practiced in many countries, it is not common in South Africa. In the light of the potential benefits associated with the integration of aquaculture production with irrigation practice, it is proposed that the interaction between these two practices, the benefits and disadvantages associated with such integration and ways to maximise the benefits, be investigated for two case studies. Specific attention will be given to water quality effects and the precautionary measures that are required in order to maintain fitness-for-use.

Estimated cost: R 1 000 000  
Estimated term: 2003 – 2007

### **Development of a strategic research programme for toxic algal blooms**

*Targeted consultancy*  
**No K8/576/7**

There are various possible products on the market that could potentially be used to control toxic algae blooms. The aims of this consultancy will be to conduct a literature study on existing and possibly available methods and develop a ToR of a research programme, for using these methods in SA conditions to evaluate their performance under field conditions; and determine the economic viability and commercialisation of the product(s).

Estimated cost: R200 000 (Impact area- WATER and HEALTH)

Expected term: 2004 - 2006

Herewith a list of the new projects which commenced between 1 April 2005 and 31 March 2006

## New Projects

### Thrust 1: Resource Protection

#### Programme 1: Detection, prevention and management of water related microbial agents

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

*Inst for Natural Resources  
No 1589*

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

Estimated cost: R400 000 (KSA2)

Expected term: 2006-2009

#### *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 concordantly 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 (KSA2)

Expected term: 2006-2010

#### *Determine the applicability of Ecological Informatics Modelling Approaches for South African conditions with preliminary testing on the occurrence of algal blooms in eutrophic impoundments*

*Univ of the North-West  
No 1675*

Algal blooms are not only nuisance-causing in water bodies, but are able to, under certain circumstances, form toxins which affect both humans and animals – with specific reference to hepato-toxicity. The project will research methods to predict algal blooms and the application of these tools; collect and collate an extensive dataset of five eutrophic impoundments in South Africa containing climatological data, physical and chemical data; adapt the deterministic SALMO model for application as an algal bloom prediction

tool for use by local water resource managers and potable water treatment works; apply ecological informatics in the field of algal bloom prediction; and organise an Ecological Informatics Workshop to make known the cyanobacterial toxin prediction tool and to expand South African knowledge on the application of artificial neural network modelling and evolutionary algorithm approaches in ecosystem research

Estimated cost: R225 000 (KSA2)

Expected term: 2006-2008

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

*Dept of Zoology, University of Stellenbosch  
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 waterborne 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 (KSA2)

Expected term: 2006-2007

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

*Univ of Pretoria  
No 1686*

The impact of livestock wastes as a source of endocrine disruption in aquatic environments is not well known. Approximately 75% of all bovine wastes produced in SA stem from the feedlot production system. Most of the excretions of natural hormones from both human and animal origin are degraded

# Impact Areas (continued)

in the environment, but the synthetic ones are relatively stable in liquid manure and solid dung. In SA no data are available on the contamination of the environmental water as a direct result of the usage and excretion of synthetic hormones during the production cycle of the animal.

In this study the presence /absence of veterinary drugs in the effluent of a number of feedlots will be obtained. The veterinary compounds, growth promoters and animal dips used in South Africa will be identified and tested and water sources close to identified feedlots screened for estrogenic and anti-androgenic activity. A reproductive toxicology study will further be executed, inter alia on the sharptooth catfish.

Estimated cost: R1 900 000 (KSA1)  
Expected term: 2006-2009

**Programme 2:**  
**Detection, prevention and management of chemicals and radioactive contaminants in water resources**  
*Production of Microcystin standards and evaluation of cyanobacterial hepatotoxin quantification methods and their relative suitability for screening and quantification*  
NMMU  
No 1695

This project intends to produce cyanobacterial hepatotoxin variants and to assess the feasibility of maintaining a supply to researchers and water-testing laboratories. It is also aimed at rectifying gaps in the current knowledge of cyanobacterial hepatotoxin screening, and testing the feasibility of production of the toxin standards necessary for continued research in this field. The study will further include the development and testing of an analytical method to screen for BMAA (beta /methyl amino alanine) a cyanobacterial neurotoxin suggested to have detrimental implications on human health.

Estimated cost: R250 000 (KSA1)  
Expected term: 2006-2007

**Thrust 2:**  
**Drinking Water**

**Programme 1:**  
**Drinking water quality management**  
*Compilation of a generic water safety plan for small community water supply*  
Umgeni Water  
No K8/649

The objective of this project is to develop a model water safety plan for South Africa that will consider water supply from the catchment to the consumer, including treatment processes and piped distribution systems. The model water safety plan will incorporate existing systems as well as new systems and will yield a comprehensive checklist and guidance manual for the evaluation of water supply. The model plan will mainly be aimed at small and rural water supply, but will also be usable by larger suppliers. This project ties in with the WRC's Rural Water Management activities in conjunction with the WHO.

Estimated cost: R196 000 (KSA3)  
Expected term: 2006-2007

**Compliance of non-metropolitan South African potable water providers with accepted drinking water quality and management guidelines and norms**  
Univ Fort Hare  
No 1668

The project aims to establish the compliance of a representative cross-section of South African potable water providers with drinking-water quality related requirements (including SANS 241 guidelines) and a set of other, operational and management norms. It will further determine key reasons for non-compliance, suggest solutions to the barriers which are preventing compliance to these guidelines and norms, and communicate these solutions to the Municipal Management. The accent will be on the smaller and non-metropolitan water supplier, and includes the whole water supply chain, from source to tap.

Estimated cost: R1 200 000 (KSA3)  
Expected term: 2006-2007

**Thrust 3:**  
**Public Health and Hygiene Issues**

**Programme 1:**  
**Public health and hygiene awareness and education material**  
*Programme: Development of health-related guidelines: Vol. 3 How Great Is the Problem? – Health Impact Assessment*  
Ian Bailey  
K8/683

This guide forms part of a series of educational material to train the upcoming generation in the basic principles of how water is involved in the spread of disease and how to control water-related diseases. This guide should lead to the development of a culture intent on keeping water supplies free of contamination and thus safe for use. The aims of this guideline are to illustrate the key principles of Health Impact Assessment (HIA) and how these may be applied to water-related interventions.

Estimated cost: R 200 000 (KSA3)  
Expected term: 2006-2007

**Programme:**  
**Development of Health-Related Guidelines: Vol. 5 What We and Our Children Need to Know - Health and Hygiene Awareness**  
University of Venda  
No 1672

This is the last guide in the series and will address the management of water-related microbial diseases in the household. The guide will be developed by women for women. The aims of this document will be to provide basic information on the causes of diseases and the pathways of infection to provide an understanding of the management of such diseases at household level.

Estimated cost: R 200 000 (KSA3)  
Expected term: 2006

### **Programme 3:**

#### ***HIV/AIDS linkage with water quality and quantity and access to adequate sanitation service***

*Molecular relatedness of enteric pathogens isolated from water sources and HIV/AIDS patients with diarrhoea in rural communities in the Limpopo and Eastern Cape Provinces*  
University of Venda

**No 1633**

The project aims to isolate and characterise bacterial enteropathogens from water sources and from HIV/AIDS patients with diarrhoea and controls in rural communities in the Limpopo Province. It will also establish any epidemiologic linkage between bacterial enteropathogens from water sources and those from HIV/AIDS patients with diarrhoea in rural communities in the Limpopo Province. The antimicrobial susceptibility profiles of enteric isolates from water sources in comparison with diarrhoeagenic pathogens from HIV/AIDS patients will further be determined in order to guide clinicians on the empiric treatment of diarrhoea cases requiring antibiotic therapy in HIV/AIDS patients.

Estimated cost: R 300 000 (KSA3)  
Expected term: 2006-2007

#### ***Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS***

University of Venda  
**No 1653**

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 waterborne 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 qual-

ity and health indicators (such as diarrhoeal morbidity and mortality).

Estimated cost: R 800 300 (KSA3)  
Expected term: 2006-2008

### **Thrust 4: Sanitation and Waste Management**

#### **Programme 2:**

##### ***Use of waste as a resource***

*Adopting internationally acceptable methods and building capacity to measure Helminth Ova in wastewater and sludge samples*

Zitholele Consulting (Pty) Ltd  
**No 1662**

The WRC has funded the development of the South African Wastewater Sludge Guidelines. **Volume 1** (*Selection of Management Options*) details a new classification system according to the microbiological class, stability class and pollutant class and total viable helminth ova has 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 waste water and waste water 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.

Estimated cost: R 273 000 (KSA3)  
Expected term: 2006-2007

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# Catalogue of Available TT Reports

## **KSA 1:**

**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 criteria for selecting dredging techniques which emphasise on cost cutting measures is presented.

Report No: TT 110/99  
ISBN: 1 86845 493 2  
Overseas price: \$60-00 excl postage

**A Global Overview of Inter-Basin Water Transfer Schemes, Socio-Economic and Socio-Political Implications, and Recommendations for their Management**

*Snaddon CD, Davies BR & Wishart MJ*

This report combines two source documents. The first is the report on the research done during the project and the second is a worldwide synthesis of information on inter-basin transfer (IBTs) with contributions from scientists in the USA and Australia.

Report No: TT 120/00  
ISBN: 1 8645 583 1  
Overseas price: \$20-00 excl postage

- **Groundwater Development in South Africa and an introduction to the Hydrogeology of Groundwater Regions**

*Vegter JR*

This report presents a historical overview from the introduction of the first drill in 1880 -a manually powered diamond rig - up to the present. The following topics are covered:

- groundwater exploration and exploitation
- Investigation and research; and
- the evaluation of groundwater legislation

Report No: TT134/00  
ISBN: 1 86845 642 0  
Overseas price: \$25-00 excl postage

- **Hydrogeology of Groundwater: Region 1 - Makoppa Dome**

*by 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: TT137/00  
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

**Estimation of streamflow reductions resulting from commercial afforestation in South Africa**

Gush MB, Scott DF, Jewitt GPW, Schulze RE; Lumsden TG, Hallowes LA & Gørgens AHM

The main objective of this report is to present the verification of the ACRU model on available streamflow data from experimental or research afforested catchments and thereafter to apply the model to all regions with economically viable afforestation potential.

Report No: TT 173/02  
ISBN: 1 86845 845 8  
Overseas price: \$30-00 excl postage

**A manual for cost benefit analysis in South Africa with special references to water resource development**

Conningarth Economist

This document entails the guidelines in the format of a manual for conducting Cost Benefit Analysis (CBA) in South Africa with specific references 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. This manual is specifically aimed at the decision maker in the public sector, but can be used outside the public sector too.

Report No: TT 177/02  
ISBN: 1 86845 851 2  
Overseas price: \$30-00 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**

Guy Pegram; Gugu Mazibuko

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

# Catalogue of Available TT Reports (continued)

- ***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 ongoing 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

- ***An introduction to Aquifer dependent Ecosystem in South Africa***

Aquifer Dependent Ecosystems (ADE), ecosystems which require groundwater occur throughout the South African landscape in areas where aquifer flows and discharge influence ecological patterns and processes. The identification of ADEs is often difficult, often requiring multi-disciplinary input, but needs to be focused initially at a catchment scale, the most 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. It is also possible to assess aquifer vulnerability to disturbance of discharge regimes, but both ADE occurrence and risk should be verified at a local scale. 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, enabled by new legislation and a transforming water sector and ADEs need to be considered in the context of IWRM. Successful protection of ADEs require cooperative governance of land, water and the environment. The main custodians are DEAT and DWAF but management needs to happen at the grass-roots level of farmers, mines and municipalities who manage aquifers on a day to day basis.

It will be important to raise the public's awareness of the role aquifers play in sustaining the surface environment.

Report No: TT 301/07  
ISBN: 978-1-77005-532-2  
Overseas price: \$ 25-00 excl postage

### ***Water as a human right, made easy! Workbook 1 and 2***

*Derij du Toit, Teresa Sguazzin*

Water as a human right made easy! A framework for understanding a rights-based approach to water.

Report No: TT 296/07  
ISBN: 78 1 77005 513 1  
Overseas price: \$ 15-00 excl postage

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).*

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. They introduce the necessary social tools and scientific knowledge to enable communities to participate as envisioned by the legislative framework. The Participatory Guidelines are concerned with good Integrated Water Resource Management (IWRM) practice, applying the philosophy of participatory IWRM and describing methodologies and case studies for community participation. Good IWRM entails capacity building, networking and conflict resolution, all of which require consistent work over time. The practitioner's responsibility is to help participating stakeholders to become knowledgeable about catchment issues and to build well-organised groups who can sustain the IWRM work when the project comes to an end. The Environmental Guidelines describe the legislative and ecological context within which integrated water resource management practice takes place. They give the reader/practitioner guidance in three ways - they outline national policy for water resource protection, they describe the environmental principles that inform good catchment management and IWRM, and they list some of the IWRM procedures and partnerships currently in operation. The Planning and Economic Guidelines present tools and conceptual models for participatory financial planning and decision-making, and outline the economics of IWRM. The tools

allow project priorities to be quantified and rationally assessed. This is the first time that many of these tools have been introduced in South Africa, but they have been tried and tested elsewhere in the world and constitute international best practice.

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*

The development of guidelines for implementing volunteer water quality monitoring in South Africa was undertaken to:

- Identify and investigate different volunteer monitoring models in use nationally and internationally, their strengths and weaknesses, and good practices to enable water resource managers to identify opportunities where volunteer monitoring can support monitoring efforts.
- Document good practices in volunteer monitoring to enable water resource managers to plan and implement volunteer monitoring.
- Identify training requirements for volunteer monitors at different levels of competency to enable water resource managers to implement volunteer monitoring.
- Investigate the legal and health and safety implications for volunteer monitors that will identify legal and other constraints on the use of volunteer monitors.

Create awareness amongst forums and other interested and affected parties on how they can contribute to water resource management by getting involved in volunteer monitoring.

Report No: TT 279/06  
ISBN: 1 77005 469 3  
Overseas price: \$20-00 excl postage

# Catalogue of Available TT Reports (continued)

## *Hydrogeology of groundwater region 26 Bushmanland*

*Vegter Johannes Roelf*

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 497 0  
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 hydrogeological research projects completed to date. It was developed after widespread consultation that included officials from the Department of Water Affairs and Forestry (DWAF) in the Eastern Cape Province, and a number of locally-based groundwater and engineering consultants.

Report No: TT 286/06  
ISBN: 1 77005 497 0  
Overseas price: \$25-00 excl postage

## *Integrated water resource management plan guidelines for local authorities (IWRMP)*

*Burke J*

From a groundwater perspective, Groundwater Resource Directed Measures (GRDM) is more important than the Reserve on its own. While the Reserve only addresses the role groundwater plays in meeting basic human needs and sustaining aquatic ecosystems such as rivers and wetlands, GRDM allows the use and protection of the entire groundwater resource to be addressed holistically. Four levels of GRDM assessments are recognised – desktop, rapid, intermediate and comprehensive – each providing an increased level of confidence.

The objectives of this project were:

1. To review and implement methods developed to set RDM for groundwater through an appropriate case study;
2. To refine and adapt methods as a result of lessons learnt during the pilot study; and
3. 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 hydrocensus, 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 hydrogeochemical conditions

Report No: TT 303/07  
ISBN: 978 1 7005 545 2  
Overseas price: \$2-00 excl postage

## **KSA 2:**

### *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 subcatchments 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 lowland 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**
- **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 incl postage

- **Guides to the freshwater Invertebrates of Southern Africa. Volume 4: 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 incl postage

- **Guides to the freshwater Invertebrates of Southern Africa. Volume 3: 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 incl postage

- **Guides to the freshwater invertebrates of Southern Africa Vol 5: Non-Arthropods (SA Price: R114-00)**

*Day JA & IJ deMoor*

Report No: TT 167/02  
 ISBN: 1 86845 827 X  
 Overseas price: \$50-00 incl postage

- **Guides to the freshwater invertebrates of Southern Africa Vol 6: 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 incl postage

- **Guides to the freshwater invertebrates of Southern Africa Vol 7: 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 incl postage

- **Volume 8: Guides to the freshwater invertebrates of Southern Africa: Volume 8 (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 incl postage

- **Guides to the freshwater invertebrates of Southern Africa Vol 9: 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 incl postage

- **Volme 10: In preparation**

### **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.

# Catalogue of Available TT Reports (continued)

## 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 WF, 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

*RC Maree, AK Whitfield and NW Quinn*

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 licence 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: \$25-00 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 217/04  
ISBN: 1 77005 083 3  
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Report No: TT 224/04  
ISBN: 1 77005 131 7  
Overseas price: \$30-00 excl postage

### *Towards the conservation and sustainable use of Eastern Cape estuaries.*

*Breen C; et al*

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 subcatchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 237/04  
ISBN: 1 77005 235 6  
Overseas price: \$20-00 excl postage

### *Spatsim, an integrated framework for ecological reserve determination and implementation.*

*Hughes DA; Palmer CG*

Water quality is currently trailing water quantity in the ecological Reserve methodology. Further development of the methods used is necessary to enable the water quality component to be considered adequately. The aims of this project are to develop acceptable time-series data for selected water quality variables, encapsulate the expert water quality knowledge in an organised way and encode these for inclusion into the DSS currently being developed as part of a parallel project, and co-ordinate this with other water quality projects working on the Reserve. This will ensure that decisions taken on water quality in the Reserve determination process are done in a standard way and in parallel with those on water quantity.

Report No: TT 245/04  
ISBN: 1 77005 296 8  
Overseas price: \$25-00 excl postage

### *Managing sedimentary processes in SA Estuaries: A guide*

*Hay D; Huizinga P; Mitchell S*

Ingress of marine sediments into estuaries was the single most important issue in estuary management identified in the western part of the Eastern Cape during the early stages of the EC Management Programme. The local authority for the Port Alfred / Boesmans River area has committed funds to develop the predictions of the effect of interventions on the problem. If the predictions indicate that an intervention may be successful, then the EIA around the planned intervention will be undertaken within this project. Thereafter, the implementation of any technology will be for the expense of the local authority.

Report No: TT 241/05  
ISBN: 1 77005 272 0  
Overseas price: \$20-00 excl postage

# Catalogue of Available TT Reports (continued)

## **The SA diatom collection:**

### **1. An appraisal and overview of needs and opportunities**

*Harding WR; Archibald CGM; Taylor JC; Mundree S*

The South African Diatom Collection (which extends beyond South Africa's borders) was established over the period 1950 to 1995 by a number of collectors and is amongst the larger collections worldwide. A number of case studies were carried out which showed the relevance of the OMNIDIA software package (use of diatom-based water quality indices) for South African conditions. The general conclusion is that the data and information contained in this collection will add value to, and have a place in, the current suite of assessment tools currently being used for the management of the surface water resource in South and Southern Africa.

Report No: TT 242/04  
ISBN: 1 77005 275 5  
Overseas price: \$25-00 excl postage

### **2. Benthic diatoms in the rivers and estuaries of South Africa**

*Bate GC; Smailes PA; Adams JB*

This follow-on project (from the project entitled Identification of diatoms and their use in the assessment of water quality) will address 3 aspects of the use of diatoms in monitoring for water quality. The determination of the relationship between dominant diatom assemblages and freshwater quality will continue. The same will be done for estuarine diatoms, where the relationship between water quality and dominant assemblages will be defined. Thirdly, a manual of South African diatoms will be produced. The product of this project will enable the use of diatoms, long recognised as being sensitive indicators, in water quality management at the technician level, not achieved elsewhere before.

Report No: TT 234/04  
ISBN: 1 77005 182  
Overseas price: \$35-00 excl postage

### **3. A methods manual for the collection, preparation and analysis of diatom samples.**

*Taylor JC; Harding WR; Archibald CGM*

Report No: TT 281/07  
ISBN: 1 77005 483 9  
Overseas price: \$20-00 excl postage

### **4. An illustrated guide to some common diatom species from South Africa.**

*Taylor JC; Harding WR; Archibald CGM*

Report No: TT 282/07  
ISBN: 1 77005 484 7  
Overseas price: \$30-00 excl postage

### **The state of yellowfish report in South Africa: (SA price R50-00)**

*Wolhuter LE; Impson ND*

Report No: TT 302/07  
ISBN: 978 1 77005 543 8  
Overseas price: \$30-00 excl postage

### **Cross-sector policy objectives for conserving South Africa's inland water biodiversity.**

*Roux D; Nel JL; MacKay HM; Ashton PJ*

Report No: TT 276/06 ISBN: 1 77005 459 6  
Overseas price: \$25-00  
excl postage

### **Conservation planning for river and estuarine biodiversity in the Fish to Tsitsikamma water management area.**

*Lindsay NJ, Smith-Adao L, Roux DJ, Adams J, Cambray JA, de Moor FC, 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 Tsitsikamma Water Management Area, and provides a process for implementing biodiversity conservation in practice.

Report No: TT 280/06  
ISBN: 1 77005 473 1  
Overseas price: \$30-00 excl postage

### **Watermark: The lasting impression of the ecological reserve.**

*Mmbofheni Stanley Liphadz*

The lasting impression of the Ecological Reserve Watermark, the Ecological Reserve educational booklet, explains what this Ecological Reserve is, where it fits into the National Water Act of 1998, and how it will help to provide "a little for all, forever". South Africa has a dry climate compared with the world average and the physical challenges at ground level affect the water cycle as well as our economy. The Ecological Reserve determinations take these conditions into account so that the management of the total water resource is adjusted to suit South African-specific conditions. Water is central to our economy and the preservation of this resource is part of the fine balancing act needed to maintain economic growth. The aim of the Ecological Reserve is to maintain the total water resource so that this never happens. The Reserve determination is made in a manner that is mindful of the entire system and future and current usage. This determination takes into account social and economic impacts of the decision before the Reserve is classified. In homes and industry, the Ecological Reserve is important as the scarcity of usable water will hike up prices and adversely affect the various economic sectors. The booklet explains the link between the Reserve and resource management as well as the need to classify the resource before it can be allocated. Because no water may be allocated until the Reserve has been determined for human needs and for protecting the ecosystem – in effect, the people and sustainability come first.

Report No: TT 307/07  
ISBN: 978 1 77005 555 1  
Overseas price: \$20-00 excl postage

### ***Estuaries and Integrated Development Planning: A Managers' Guide***

*Duncan Hay*

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07  
ISBN: 978 1 77005 541 4  
Overseas price: \$15-00 excl postage

### **KSA 3:**

#### ***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 minimisation 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; Kasselmann G; Steyn CE; Wilken JW*

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 261/05  
ISBN: 1 77005 422 7  
Overseas price: \$20-00 excl postage

#### ***Guidelines for the utilisation and disposal of wastewater sludge: Volume 2 of 5: Requirements for the agricultural use of wastewater sludge***

*Snyman HG; Herselman JE; Kasselmann G; Steyn CE; Wilken JW*

Report No: TT 262/05  
ISBN: 1 77005 423 5  
Overseas price: \$20-00 excl postage

#### ***Water purification works design: (SA Price R150-00)***

*Van Duuren FA*

This project was aimed at facilitating the optimal, most economical water purification and treatment works by providing a design guide based on water quality considerations, processes and operations. This guide indicates water quality requirements, control and management of procedures, and water demands in all sectors. It also categorises water purification and treatment processes and operations

Report No: TT 92/97  
ISBN: 1 86845 345 6  
Overseas price: \$50-00 excl postage

#### ***Information transfer extraction management systems (ITEMS) (SA Price R114-00)***

*Howard MR; Perkins M*

This project developed a computerised Information Transfer, Extraction and Management System (ITEMS) which enables users to gain access to local and international information on mine-water quality, management, treatment and research. The six modules incorporated in ITEMS, viz. literature, water quality guidelines, contaminant properties, research results, an impact assessment manual and a mine-water management manual, and the options available in each of the modules, render 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

# Catalogue of Available TT Reports (continued)

## ***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***

*Ramothhola 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 IV: 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 – Vol V: 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 was 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 KO'H*

Effluents and soils were identified as factors which help in the process of making decisions on the applicability of a specific effluent on a specific land. The identification of the effluent takes into account health-related aspects, the risk of pollution to the water source and the effects of it on plants. The identification of the soil relates to the ability of soils to attenuate the contaminants in the effluents.

The user guide takes one through the process in order to be able to determine whether the combination is acceptable or not and whether it conforms to health guidelines. If this is acceptable, it is indicative of restrictions or protective measures. ELADS Effluents to land - application decision-support software is the expert systems-based decision-support software developed. It could be used not only for sewage effluents, but also for organic effluents, to some extent for nitrogenous effluents and effluents containing potentially toxic trace elements. It could be modified to accommodate any site, soil or effluent-related limits specified by new regulations. (WRC Report No TT 125/00).

Report No: TT 125/00  
ISBN: 1 86845 551 3  
Overseas price: \$20-00 excl postage

### **The level of communication between communities and engineers in the provision of engineering services**

*Pybus P; Schoeman G; Hart T*

The purpose of this research was to test the hypothesis above and to establish how engineering information, for example, concerning the level of service, can best be given so that the community leaders can make a decision based on sound knowledge of the technicalities of the situation. In an analysis of the major factors that negatively affect communication between consultants (specifically engineering) and communities, it was found that the majority of factors stemmed from a lack of integrated and comprehensive project planning. The findings from this study are supported by an excellent set of guidelines, aimed at improving communication processes between practitioners and communities in water and sanitation development projects

Report No: TT 133/00  
ISBN: 1 86845 630 7  
Overseas price: \$20-00 excl postage

### **Waste minimisation guide for the textile industry: A step towards cleaner production: Vol I**

*Barclay S; Buckley C*

The Waste Minimisation Guide for the Textile Industry has been found to be a useful tool for assisting the RSA textile industry to improve its environmental performance in the following areas of application:

- The textile industry can use the Guide to self-assess and improve its implementation of waste minimisation practices and, hence, its aquatic environmental performance
- Similarly, use of the Guide will assist factories in achieving compliance with environmental management standards e.g. ISO 14000, and, thereby, improving their international competitiveness
- Local regulatory authorities can use the Guide both as a training tool and as a management tool for monitoring and assessing the performance of textile manufacturers in their area of jurisdiction.

# Catalogue of Available TT Reports (continued)

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

## Hygiene awareness workshop

Duncker LC

The study showed that the level of general knowledge regarding hygiene practices was high in all case study areas. However, the practice of appropriate hygienic lifestyle was hampered by poverty and a lack of access to basic water supply and sanitation services. It was found that rural communities lacked a specific knowledge regarding causes, transmission and prevention of water-related and faeces-related diseases. The level of knowledge on the treatment of these diseases was high because of their prevalence in these communities. This research has produced the following manuals:

- A Manual on Knowledge, Attitude and Practice (KAP) Study for Hygiene Awareness in the Rural Areas of South Africa (K5/819)
- Hygiene Awareness Programme (TT144/00)

Report No: TT 145/00  
ISBN: 1 86845 633 1  
Overseas price: \$25-00 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 identified 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

Philip Pybus

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 Peter*

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 focussed 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 168/02  
ISBN: 1 86845 842 3  
Overseas price: \$20-00 excl postage

### ***A manual for cost benefit analysis in South Africa with special references to water resource development***

*Conningarth Economist*

This document entails the guidelines in the format of a manual for conducting Cost Benefit Analysis (CBA) in South Africa with specific references 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. This manual is specifically aimed at the decision maker in the public sector, but can be used outside the public sector too.

Report No: TT 170/04  
ISBN: 1 86845 833  
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 m<sup>3</sup>/t and re-refining SWIs were found to vary widely (0.06 to 7.2 m<sup>3</sup>/t), depending on the type of process used. The results obtained present a snapshot of the water and wastewater characteristics of the industry in which crude oil refining (at four refineries) is around 20 million t/a, syn-fuel refining (at two refineries) is around 9 million t/a and oil re-refining is around 120 000 t/a. In addition to the water and effluent survey data, the Guide produced contains a number of specific recommendations for reducing water use and effluent generation in the industry.

Report No: TT 180/05  
ISBN: 1 86845 508 4  
Overseas Price: \$15-00 excl postage

### ***Elementary handbook of water disinfection***

*FHH Carlsson*

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 incl postage

### ***An assessment of the trickle feed system as a tool for implementing the free basic water policy***

*AM Lenehan; L Abelitis*

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 stormwater drainage systems***

*Mark Marais; Neil Armitage*

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

# Catalogue of Available TT Reports (continued)

- 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 exl postage

## *Making Water work for villages*

*C Moat; C van den Voorden; I Wilson*

Evaluation studies of new water projects show that poor operation and maintenance (O&M) of water supply schemes is responsible for the high failure rate of water projects. These studies have also shown that the O&M systems that were implemented were generally unresponsive to user needs. This highlights the importance of basing the development of O&M guidelines on local knowledge. This study captured the different methods that communities have used to manage their water supply schemes prior to the implementation of new water projects. The study has also documented local knowledge and experience that has formed the basis for the development of O&M guidelines.

Report No: TT 216/03  
ISBN: 1 77005 073 6  
Overseas price: \$20-00 exl 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 exl postage

## *Feasibility of water fluoridation for South Africa*

*B Genthe; CE Herold; J Haarhoff; Hosking S; G Syke*

A team, consisting of five experts in their fields, was requested to perform a desk study to identify both the positive and negative consequences which could be expected to arise following the fluoridation of potable water supplies in South Africa.. Results from the study for the first time summarize and bring together a whole spectrum of aspects to take into consideration when potable water supplies are fluoridated. The results show that further actions, including further research, are required before fluoridation can be effected with full safety and confidence in a developing country such as South Africa.

Report No: TT 222/04  
ISBN: 1 77005 108 2  
Overseas price: \$24-00 exl postage

## *A summary of lessons and experiences from the Ethekewini 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 Pitlatrines (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 exl 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 exl 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 ground-water infiltration into the sewer facilities cannot be left anymore to ad hoc solutions and there is an urgency for a strategic approach to these problems. This report based on identifying and quantifying the problem of ingress, provides the necessary strategy and answers to these problems.

Report No: TT 239/05  
ISBN: 1 77005 264 X  
Overseas Price: \$20-00 excl postage

### **Benchmarking of leakage from water reticulation systems in South Africa**

*McKenzie RS; Seago C*

In the attempt to get a better handle on the level of leakage at a municipal and national level, this study was undertaken in order to assess the levels of leakage in various water utilities throughout South Africa. The standard water auditing model BENCHLEAK, previously developed through a WRC study was used for the analyses since it is relatively simple to use and follows the standard IWA and BABE leakage benchmarking methodology. Benchleak introduces the concept of Infrastructure Leakage Index (ILI) as a standard method for the purpose of leakage evaluation, as it has been found to be the most reliable and meaningful indicator.

Report No: TT 244/05  
ISBN: 1 77005 282 8  
Overseas Price: \$25-00 excl postage

### **Water and waste-water management in the power generating industry (NATSURV 16)**

*Van Zyl HD; 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 biofilm regrowth 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.

# Catalogue of Available TT Reports (continued)

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***

*Onabolu Bolu; Ndlovu Maliti*

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)***

*Susan Barclay and Chris Buckley*

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. The better quantification and identification of these factors required investigation, reviewing the available literature, conducting experimental investigations, perform field investigations and develop software that will assist designers in evaluating a pipeline system over its full life cycle. Findings from the literature review 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.

Finding from field and experimental work to quantify some of these sub-factors and the influence energy loss in pipelines revealed the following noteworthy affects:

- The field work indicated roughness parameters as well as the annual rate of increase in roughness parameter were all significantly higher than that prescribed in theoretical references.
- Biofilm exists on all piping surfaces in a potable water distribution system and that there is an increase of biofilm with time.
- Biofilm has an effect on the hydraulic capacity of a pipe system but the quantification thereof is difficult due to the fluctuating growth pattern thereof.
- The current measures of trying to remove or destroy biofilm (velocity or disinfectants) have limited success.
- Experimental tests and numerical modelling confirmed that the pipe couplings result in additional energy loss.
- The roughness parameters that are normally quoted by manufacturers tend to be 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. (i) the need to create a management and support infrastructure and (ii) 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*

In many areas of our country, fresh water may already be at short supply, but adequate quantities of saline water may be readily available. The cost of treating water is a fraction of the total cost of making water available to the consumer. Further, the cost of desalinating water has been steadily decreasing. Therefore, 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 project produced a guideline to assist Municipalities and consultants to identify and select the technologies which may currently be commercially implemented in South Africa to treat saline water to drinking water standards and thereby augment their fresh water supplies.

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

# Catalogue of Available TT Reports (continued)

widely applicable to water services providers and will reduce the risk of human incidents related to bluegreen 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

## ***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 261/06  
ISBN: 1 77005 422 7  
Overseas price: \$20-00 excl postage

## ***Guidelines for the utilisation and disposal of wastewater sludge: Volume 2 of 5: Requirements for the agricultural use of wastewater sludge***

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 262/06  
ISBN: 1 77005 423 5  
Overseas price: \$20-00 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. From the analyses of the water balances for each of the water reticulation systems, the following conclusions were drawn:

- 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. This can be compared to an expected value of approximately 12 kl per property per month which is considered to be a realistic value for monthly water use per property in low income areas.
- The average monthly water use per property in the medium to high income areas was estimated to be in the order of 46 kl per property per month.
- In the middle and high income areas, the greatest source of water loss is through physical leakage rather than any unauthorised use or unbilled use.

Based on these figures the following assumptions and extrapolations were made:

- The losses (real and apparent) for the 62 systems analysed was estimated to be 623 million m<sup>3</sup>/annum or 29% of the total water supplied.
- Based on the above figures, the extrapolated water losses from water reticulation systems for the whole of South Africa are likely to be in the order of 1 150 million m<sup>3</sup>/annum (based on the 54% sample size).
- The potential savings that can be achieved from the 62 water reticulation systems analysed are estimated to be 266 million m<sup>3</sup>/annum based on the methodology discussed in this report which includes a combination of real and apparent losses.
- If the above figure is extrapolated to the whole country (based on the 54% sample

size), the potential savings are estimated to be almost 500 million m<sup>3</sup>/annum, which represents approximately 12.5% of the system input.

Report No: TT 300/07  
ISBN: 978 1 77005 529 2  
Overseas price: \$20-00 excl postage

## ***KSA 4***

### ***Using SAPWAT to estimate water requirements of crops in selected irrigation areas managed by the Orange - Vaal and Orange - Riet water users association***

*Van Heerden PS, Crosby CT & Crosby CP*

This report serves as a user manual for the application of SAPWAT. Furthermore, it demonstrates that the estimation of irrigation requirements can be credible and that the requirements that the National Water Act (36 of 1998) sets for future water management can be met.

Report No: TT 163/01  
ISBN: 1 86845 812 1  
Overseas price: \$30-00 excl postage

### ***Micro-irrigation for smallholders - Guidelines for funders, planners, designers and support staff in SA***

*Du Plessis FJ; Van Averbek W; Van der Stoep I*

The objective of this project was to assess how small-scale farmers experience the concept of micro-irrigation systems and how they cope with problems. The aim was to identify those aspects that eventually determine the success or failure of small-scale crop production, utilising these systems. During the course of the project it became apparent that external factors, generic to any small-scale farming system and seemingly unrelated to micro-irrigation, had a significant influence, and that it would, therefore, be almost impossible to evaluate the former without taking the latter into account. The aim of the guideline report is to help prevent mistakes of the past and, hopefully, it will contribute to policy-making on a small scale regarding the utilisation of micro-irrigation. Thus, the successful use of the systems is ensured.

Report No: TT 164/01  
ISBN: 1 86845 824 5  
Overseas price: \$15-00 excl postage

### ***Contribution of aquaculture to rural livelihoods in South Africa: A baseline study***

*Rouhani QA; Britz PJ*

At present there is a lack of information on the importance of fish production systems in agricultural activities, the contribution it makes to household food security and constraints or opportunities which exist for expansion. This study should highlight specific topics for research projects that need attention. Particular emphasis will be placed on research of water-related issues that will lead to an improvement of rural livelihoods.

Report No: TT 235/05  
ISBN: 1 77005 186 4  
Overseas price: \$25-00 excl postage

### ***Guidelines for irrigation water measurement in practice.***

*Vd Stoep I; Benade N; Smal HS; Reinders FB*

Effective management of water resources can be vastly improved if water use is measured accurately. This applies in particular to efforts to influence the quantity of water demanded by levying tariffs on the volume of water actually consumed. However, on most irrigation schemes water flow is not measured and water tariffs are presently still levied on an area and not a volumetric basis. This report is as a result of a comprehensive study of water measurement in irrigation.

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### ***Irrigation scheduling using the Soil Water Balance (SWB) model as a user-friendly irrigation scheduling tool.***

*John George Annandale; Joachem Marthinus Steyn; Nico Benade; Nebojsa Zarko Jovanovic; Puffy Soundy*

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.

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ISBN: 1 77005 339 5  
Overseas price: \$20-00 excl postage

### ***Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: A rough guide of irrigation development practitioners: Vol 1***

*Jonathan Denison; Siyabu Manona*

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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ISBN: 978 1 77005 568 1  
Overseas price: \$25-00 excl postage

### ***Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: Concepts and cases: Vol 2***

*Jonathan Denison; Siyabu Manona*

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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