

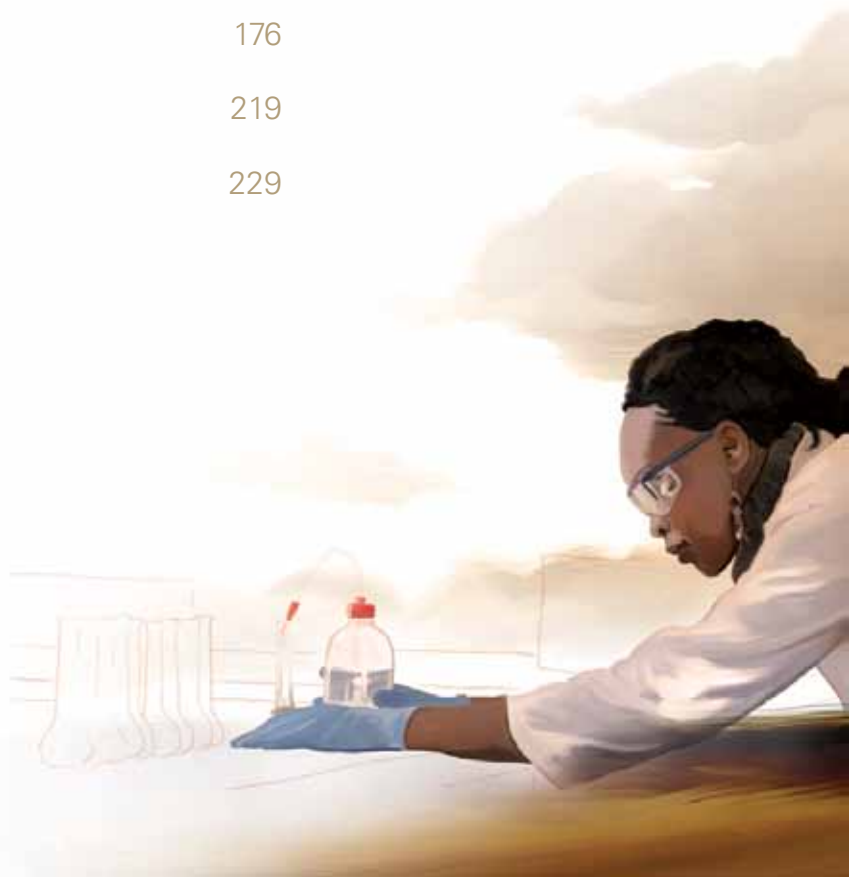


WATER
RESEARCH
COMMISSION

WRC KNOWLEDGE REVIEW 2011/12

CONTENTS

| | |
|---|-----|
| Introduction | 3 |
| KSA 1: Water Resource Management | 12 |
| KSA 2: Water-Linked Ecosystems | 68 |
| KSA 3: Water Use and Waste Management | 102 |
| KSA 4: Water Utilisation in Agriculture | 176 |
| KSA 5: Water-Centred Knowledge | 219 |
| Catalogue of Available TT Reports | 229 |



INTRODUCTION



*Dhesigen Naidoo:
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INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2011/12, the WRC fulfilled its mandate to contribute positively to South Africa's ability to address its water challenges through research and development solutions. The WRC supported the sector with research products aimed at informed decision-making, improving monitoring and assessment tools, and making available a range of new and improved technologies related to water resource management, improved use of water in agriculture and the provision of water and sanitation services. The WRC continued to address the challenges posed by climate change and the linked phenomena of extreme weather events. Research steered and funded by the WRC continues to support the development of adaptive and mitigating strategies which will ensure the future sustainability of the country's water resources and services, in order to continue the economic growth trajectory and the improvement of quality of life within a sustainable development paradigm.

Water Resource Management

- Water Resource Assessment and Planning
- Water Quality Management
- Water Resource Protection
- Water Resources and Climate
- Water Resource Institutional Arrangements

Water-Linked Ecosystems

- Ecosystem Processes
- Ecosystem Management and Utilisation
- Ecosystem Rehabilitation

Water Use and Waste Management

- Water Services – Institutional and Management Issues
- Water Supply and Treatment Technology
- Sustainable Municipal Wastewater and Sanitation
- Sustainable and Integrated Industrial Water Management
- Mine-water Treatment and Management
- WaterSmart Fund

Water Utilisation in Agriculture

- Water Utilisation for Food and Fibre Production
- Water Utilisation for Fuelwood and Timber Production
- Water Utilisation for Poverty Reduction and Wealth Creation in Agriculture
- Water Resource Protection and Reclamation in Agriculture

Figure 1: The key strategic research areas and thrusts

The research portfolio for 2011/12 was set on the basis of the WRC's strategic plan. The schematic presentation above (Figure 1) provided the frame for the research addressed during the year under review. The WRC continued to invest in the creation of knowledge via its four main key strategic areas (KSAs). These areas include: **Water Resource Management, Water-Linked Ecosystems, Water Use and Waste Management, and Water Utilisation in Agriculture**. In general, the portfolio as planned for the year under review was well-received by the various stakeholders. These research KSAs were supported by the **Water-Centred Knowledge KSA**. This structure continued to form the core operating framework for WRC-funded R&D and was further consolidated during the year.

Water Resource Management – The objectives of the Key Strategic Area (KSA) were closely aligned with various Government outcomes, particularly Outcome 10 relating to 'environmental assets and natural resources that are well-protected and continually enhanced'. The impact of the KSA at national level also reached both regional and international levels through partnerships and collaboration. The KSA continued to play a prominent role in addressing many challenging water resource issues within the sector. This ranged from investigating appropriate forms of water governance for South Africa to development of improved water resource assessment tools, development of appropriate conceptual frameworks for regulation of water quality, revision of groundwater Reserve methodologies, and developing projection scenarios for potential impact of climate change on Karoo aquifers. The KSA also participated in the development of South Africa's Green Paper and subsequent White Paper on the National Climate Change Response, and made significant inputs to the National Water Resource Strategy review process. In a particularly integrative initiative, it has recently played a leading role in mobilising groundwater specialists to work collaboratively with surface water hydrologists through the Groundwater Division of the Geological Society of South Africa.

Water-Linked Ecosystems – Research in this KSA put strong emphasis on the creation of knowledge aimed at protection, and ensuring the utilisation and sustainable management, of water-linked ecosystems in our water-scarce country during a time of demographic and climate change. Research portfolios within this KSA promoted critical issues about conservation of aquatic ecosystems in order to provide the knowledge required for their sustainable functioning, in terms of national legislation, commitments to international conventions, and the ongoing provision of goods and services which ecosystems deliver. The research in this KSA develops the understanding of the ecological processes underlying the delivery of goods and services and provides the knowledge to sustainably manage, protect, utilise and rehabilitate aquatic ecosystems. Three main research areas were addressed during 2011/12: ecosystem processes, i.e., the biophysical process, form and function of ecosystems; ecosystem management and utilisation, including issues such as the ecological Reserve, socio-economic considerations, ecosystem governance and ecosystem health; and ecosystem rehabilitation, including rehabilitation and restoration of process, form and function of estuaries, rivers and wetlands. The research addressed national priorities and Government outcomes relating to the KSA's portfolio.

Water Use and Waste Management – During the year under review, this KSA focused mainly on research for the domestic, industrial and mining water sectors. The aim was to proactively and effectively lead and support the advancement of technology, science, management and policy relevant to water supply, waste and effluent management, for these sectors. The KSA continued to support studies on appropriate technologies for improving the quality and quantity of our water supplies for domestic use, with a focus on water supply and treatment technologies serving urban, rural, large and small systems. Greater emphasis has been put on aspects related to water footprints, energy-efficiency and generation in the supply of services, water conservation and demand management, reuse and beneficiation from water supply and wastewater treatment, treatment of AMD, and adaptation

and mitigation strategies at a water services level to deal with future challenges associated with climate change. Waste and effluent, as well as reuse technologies that can support and improve management in the municipal, mining and industrial sectors, were also addressed, and innovative, integrated solutions for water and waste management in the industrial and mining sectors were studied. The research areas included water services (institutional and management issues); water supply and treatment technology; sustainable municipal wastewater and sanitation, industrial and mine-water management; sanitation and hygiene education, and the WaterSmart Fund which supports the demonstration and development of innovative solutions.

Water Utilisation in Agriculture – Research carried out in this KSA aimed at increasing household food security and improving the livelihoods of people at farming, community and regional levels, through efficient and sustainable utilisation and development of water resources in agriculture. More specifically, this research focused on increased biological, technical and economic efficiency of water use, the reduction of poverty through water-based agricultural activities, increases in profitability of water-based farming systems, and the sustainable use of water resources through protection and restoration practices. All agricultural sub-sectors were addressed, including irrigated and dryland agriculture; woodlands and forestry; grasslands and livestock watering; aquaculture and inland freshwater fisheries. During 2011/12 emphasis was placed, through new projects, on determination of water use of irrigated crops through satellite imagery; improved water use efficiency and reduced canopy management inputs through deficit irrigation of wine grapes; rehabilitation of catchments invaded with alien plants and measurement of the water use of indigenous trees; empowerment of women through water use security, land use security and knowledge generation for skills development to achieve household food security and sustainable rural livelihoods in selected areas of Limpopo and Eastern Cape Provinces; and indigenous coping strategies for drought adaptation with scenarios for agriculture in the

Southern Cape. This research output will support development and application of approaches, models, techniques, practices and guidelines for efficient and beneficial agricultural water management.

Supporting research projects

During 2011/12 the WRC managed 322 research projects at various stages of project life cycle (Table 1), of which about 79% (259 projects) were active projects; the balance were mostly projects that have been finalised and are in the process of being financially closed.

Table 1:
Overview of research project activity for the year under review and the previous financial year

| Financial year | 2011/12 | 2010/11 |
|---------------------------|---------|---------|
| Total no. of projects | 322 | 328 |
| No. of active projects | 258 | 259 |
| No. of new projects | 74 | 77 |
| No. of finalised projects | 96 | 76 |
| No. of solicited projects | 101 | 109 |

The WRC initiated a total of 74 projects at the beginning of the 2011/12 financial year, with the key strategic area focusing on **Water Resource Management** initiating 31, **Water-Linked Ecosystems** initiating 7, **Water Use and Waste Management** initiating 30, and **Water Use in Agriculture** initiating 6 of these projects.

In 2011/12 the WRC finalised 96 projects: The key strategic area focusing on **Water Resource Management** finalised 32 projects, **Water-Linked Ecosystems** finalised 14 projects, **Water Use and Waste Management** finalised 38 projects, and **Water Use in Agriculture** finalised 12 projects.

The WRC published 133 research reports and products in this period. This included 103 printed reports, 12 electronically-published reports, 15 posters and 3 DVDs.

The various funding streams included both non-solicited projects, accommodating projects within the broad research strategy of each KSA, and solicited projects, where research projects are developed in accordance with clear terms of reference, aimed at solving specific problems. Solicited research projects are mostly long-term, consortia-based, and address multifaceted issues, often calling for more than one research discipline and a substantial budget. About 31% of the total number of projects were solicited projects.

Figure 2 provides a schematic representation of the total number of research projects per annum for the past five years. The average number of projects remained around 300.

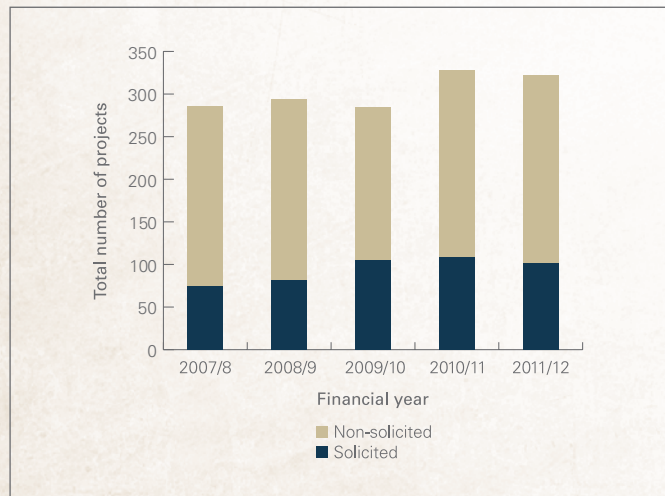


Figure 2:
Total number of non-solicited and solicited research projects per annum for the past five years

Over the past 5 years the WRC has finalised 363 research projects (Fig. 3) indicating a significant contribution to knowledge in the water sector. An average number of 73 projects were finalised per year, for the past 5 years. Over the same 5-year period 342 new projects (Fig. 4) were initiated, ensuring the continuous contribution of new knowledge to the sector. An average number of 68 new projects were started per year, for the past 5 years.

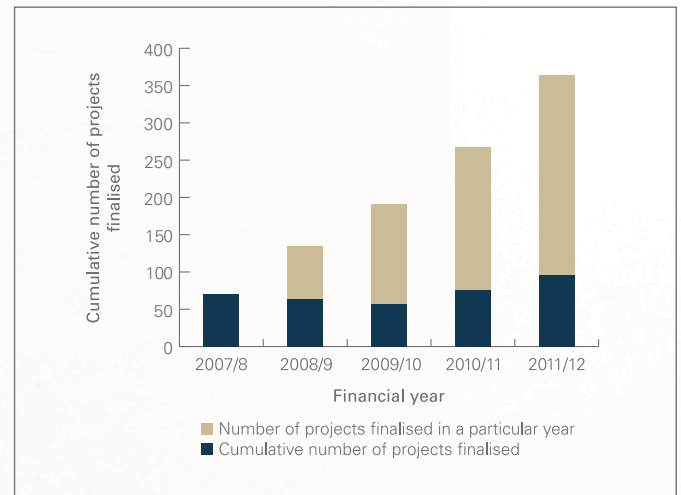


Figure 3:
Annual and cumulative number of projects finalised over the past 5 years

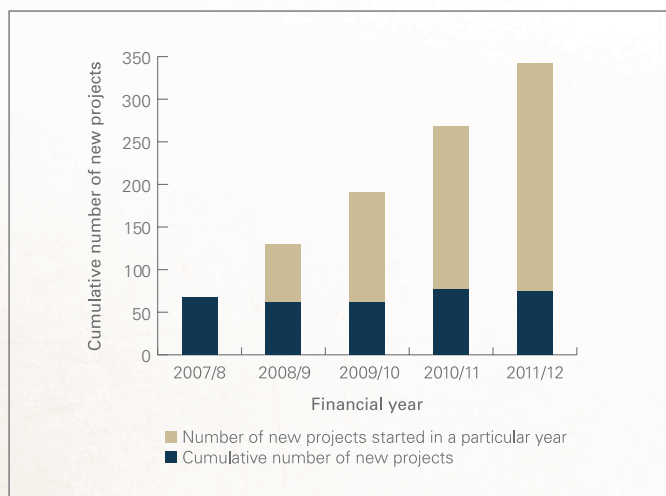


Figure 4:
Annual and cumulative number of projects initiated over the past 5 years

Total investment in the support of knowledge creation, sharing and dissemination amounted to R140.9 m. This represents an increase of 27% from the previous year (R110.7 m. total investment was reported in 2010/11). This investment included about R3.2 m. for the Water Information Network (WIN-SA), R1.7 m. for the Framework for Education and Training in Water (FETWater), as well as other income leveraged for projects during the year under review. The investment in research projects expressed as a percentage of total expenditure was 67%, higher than the budgeted ratio (63%) and also higher than that of the previous year (62%). The investment in research support expressed as a percentage of total expenditure was 75%, slightly higher than the budgeted ratio (74%) and also slightly higher than that of the previous year (73%). The ratio addressing funding of the creation of new knowledge (research projects only) was 67%, 5% higher than that for 2010/11 and 4% higher than the planned ratio of 63%. The ratio for research support was 75%, compared to 73% in 2010/11, and was higher than the planned ratio of 74%.

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

During the year under review the WRC continued to leverage levy income by striving to obtain funds from other sources to support water research. During 2011/12 this drive was fairly successful, but substantial amounts were rolled over into 2012/13. The WRC income originating from sources other than the levy for 2011/12 amounted to R23.6 m. Leveraged income included funds allocated to a number of KSAs for direct support of research projects and funds provided for capacity building, knowledge sharing and dissemination (e.g. WIN-SA and FETWater). Leveraged income was obtained from both local and international sources, where the main source of income was due to support by various Government departments for specific research and for other knowledge-sharing projects. Sources of income other than the levy for 2011/12 amounted to about 17% of the total income.

BUILDING CAPACITY

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

Capacity building by lead organisations in 2011/12

Table 2 reflects the number of students involved in WRC-funded projects, as reported for the various lead organisations contracted by the WRC, in the 2011/12 financial year.

Table 2:
Number of students and number of previously-disadvantaged students (PDI) involved in WRC-funded projects per lead organisation in 2011/12

| Institution name | Total PDI | Total students |
|---|------------|----------------|
| Higher-education institutions | | |
| Cape Peninsula University of Technology | 8 | 15 |
| Nelson Mandela Metropolitan University | 2 | 8 |
| North-West University | 3 | 9 |
| Rhodes University | 19 | 32 |
| Tshwane University of Technology | 12 | 12 |
| University of Cape Town | 11 | 35 |
| University of Johannesburg | 4 | 6 |
| University of Limpopo | 0 | 2 |
| University of Pretoria | 19 | 34 |
| University of South Africa | 6 | 7 |
| University of Stellenbosch | 14 | 46 |
| University of the Free State | 12 | 30 |
| University of the Western Cape | 31 | 34 |
| University of the Witwatersrand | 5 | 15 |
| University of Venda | 1 | 2 |
| University of KwaZulu-Natal | 31 | 66 |
| Subtotal | 178 | 353 |

| | | |
|---|-----------|-----------|
| Science councils and state agencies | | |
| Agricultural Research Council | 6 | 14 |
| Council for Scientific and Industrial Research | 16 | 28 |
| Council for Geoscience | 2 | 5 |
| South African Weather Service | 1 | 1 |
| Umgeni Water | 4 | 4 |
| Subtotal | 29 | 52 |
| Non-Governmental and private institutions | | |
| Africa Remediation Technology | 1 | 1 |
| Aquagreen Consulting | 1 | 2 |
| ASSET Research | 3 | 10 |
| ATL-HYDRO | 1 | 1 |
| Aurecon Group | 1 | 2 |
| BioAssets | 0 | 1 |
| Blue-Green Technologies cc | 1 | 1 |
| Centre for Environmental Economics and Policy in Africa | 3 | 3 |
| Counterpoint Development | 1 | 2 |
| DH Environmental Consulting | 0 | 1 |
| Duncan Hay and Associates | 1 | 1 |
| Emanti Management | 1 | 3 |
| Golder Associates Africa | 4 | 9 |
| GroundTruth | 0 | 1 |
| Hydrosoft Institute | 17 | 18 |
| Institute of Natural Resources | 2 | 2 |
| Muondli Consulting and Projects | 1 | 1 |
| National Institute of Occupational Health | 0 | 2 |
| PDG | 1 | 2 |
| Pegasys International | 0 | 3 |
| Pegram and Associates | 1 | 2 |
| Prime Africa Consultants (previously CIC International) | 5 | 7 |
| Sigma Beta | 5 | 8 |

| | | |
|--|------------|------------|
| Sinelwati Scientific Research & Management | 1 | 1 |
| The Freshwater Consulting Group | 0 | 1 |
| The Narrative Lab | 0 | 1 |
| Umhlaba Consulting Group | 7 | 8 |
| Umvoto Africa | 0 | 1 |
| Virtual Consulting | 0 | 1 |
| Water for Africa | 3 | 4 |
| WSM Leshika Consulting | 0 | 1 |
| Subtotal | 61 | 101 |
| TOTAL | 268 | 506 |

Capacity-building initiatives

In addition to its support for the training of students, the WRC initiated and supported a number of national capacity-building initiatives. These included support to national and local Government as well as the development of new training material for different levels of learners and for academic institutions. The WRC continued to support the South African Youth Water Prize Competition and the Aqua Enduro Schools Competition. Career guides were distributed to secondary schools such as the Mamolemane Secondary School situated in Polokwane, Limpopo Province. The WRC assisted the Tshwane University of Technology (TUT) to review its Water Care programme. Other significant interventions included:

Water sector skills. The WRC managed a project entitled 'Integrated water sector skills intervention map based on a sector skills gap analysis' on behalf of the DWA. To date, no comprehensive, integrated plan exists that strategically outlines ways in which to build capacity and grow skills for both water services and water resource management. This project is aimed at developing an integrated water sector skills intervention map based on the findings of a quantitative and qualitative sector-wide skills audit.

Occupational qualifications for water-process controllers. The WRC participated in the first LGSETA pre-scoping meeting for the occupational qualification related to water on 5 October 2011. The purpose was to determine and define the curriculum scope for water-related occupational qualifications for the local Government sector in the context of the Quality Council for Trades and Occupations (QCTO), which was established in terms of revised implementation of the National Qualifications Framework. The WRC also participated in a three-day workshop, held from 6 to 8 December 2011, entitled: 'Understanding occupational profiles as the basis for skills planning and development in the water and wastewater treatment sector'. WISA, together with the Tshwane University of Technology and UNESCO-IHE, hosted a workshop which focused on the development of specific occupational profiles and related training requirements which can form the basis for improved skills planning, career paths and course development.

Techno Girls programme. The WRC is pleased to be one of the institutions participating in the Techno Girls programme, which was set up by President Jacob Zuma in 2009, through the Department for Women, Children and People with Disabilities, as a way of speeding up the achievement of gender equality and empowerment of women in South Africa. The WRC participated in the launch of the Techno Girls programme on 4 November 2011 at the Sandton Convention Centre. During the launch the WRC pledged to support at least four girl learners with access to the world of work, to enable them to take up scarce-skills careers required by the South African economy. The programme maintains an exclusive focus on careers in the science-related fields. During their tenure at the WRC, during the school holidays, the girls will be exposed to various career paths and options through job shadowing of role models.

WRC 101 for project leaders. In the 2009/10 financial year the WRC developed an informative one-day course/workshop for aspiring and new project leaders to understand the WRC research cycle. The course shows participants the research priorities of the WRC and the fund allocation for each of the priorities; how to prepare a comprehensive proposal, with tips provided to improve the chances of success; and how to manage the technical, administrative and financial aspects of a WRC project. It also provides an understanding of the contractual and financial audit requirements and also the resources available to enhance the success of the project. Four regional courses were held in the year under review: Gauteng (26 May 2011 – approximately 80 people attended), Eastern Cape (30 May 2011 – approximately 40 people attended), KwaZulu-Natal (6 June 2010 – 30 people attended) and Western Cape (15 June 2010 – approximately 50 people attended).

Regional Southern African Young Water Professionals initiative. The WRC supports this joint initiative of the International Water Association (IWA) and the Water Institute of Southern Africa (WISA). The 2nd Regional Conference of the Southern African Young Water Professionals (SA YWP) was held at the CSIR International Convention Centre, Pretoria, and was the largest YWP conference held by the IWA to date, with over 400 registrations representing 10 countries. Research managers from the WRC were involved in planning the event and the technical programme. A WRC director delivered a plenary address on 4 July 2011 at the opening session. A WRC research manager currently serves as the Vice-President of the Southern African Young Water Professionals and will take up the position of President in May 2012.

KNOWLEDGE REVIEW 2011/12

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2011/12 financial year. This reflects the organisation's strategic focus based on assessment and integration of the needs, opportunities and priorities presented by the current context and challenges facing the water sector in South Africa, and globally.

KSA 1: WATER RESOURCE MANAGEMENT



*Ms Eiman Karar:
Director*

SCOPE

Nothing is more fundamental to life than water. Not only is water a basic need, but adequate safe water underpins the nation's health, economy, security, and ecology. The strategic challenge for the future is to ensure adequate quantity and quality of water to meet human and ecological needs in the face of social inequities, competition among domestic, industrial-commercial, agricultural, and environmental uses.

In the 2011/12 plan, numerous interactions with stakeholders resulted in effecting the following new aspects:

- Water resource challenges are not necessarily new but can be viewed in different combinations each year and with newly-defined priorities towards the achievement of the new 'Measurable Performance and Accountable Government Delivery Outcomes'. Competition over scarce or inequitably allocated resources can lead to tension and insecurities.
- Strategies for reducing demand, increasing efficiency, and creating new sources of water resources from desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., can be viewed as part of Outcome 6: 'An efficient, competitive and responsive economic infrastructure network', which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', relates to these pertinent aspects.

- The fully-fledged thrust on water quality has been necessitated by the increasing challenges for ecological functioning and biodiversity of these resources, potentially threatening public health, agricultural and industrial production and ultimately quality of life.
- Water Resources and Climate Change is a new thrust which is aimed at dedicating financial and human resources to coordinating and promoting research in this pertinent and increasingly growing portfolio. This thrust was envisaged to make substantial contributions to the Conference of the Parties (COP) 17 in South Africa in 2011.
- The thrust dealing with water resource protection has redesigned its programmes to be complementary to the new Water Quality thrust.

As South Africa progresses into the 21st century, its water resources are likely to be subjected to much greater pressures than in the past. Projections of population increases mostly in urban areas, aging of the national water resource infrastructure, significant water quality problems in our estuaries and surface water resources and groundwater can have a significant impact. An example of one of the national issues of concern is acid mine drainage (AMD). Moreover, global environmental change, including climate change, will have further potential deleterious effects on systems, resources and society. Ensuring that the appropriate policies and overall institutional arrangements are in place will be essential in the passage to better environmental and public health, sustainable economic growth and ultimately quality of life.

The bulk of the research in this KSA is in support of Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 1, 2 and 3. Thrust 4 is in support of Output 2: 'Reduced greenhouse-gas emissions, climate change impacts and improved air/atmospheric quality'.

The implementation of policies guiding related interventions has thus far yielded variable successes. This could be attributed to a number of reasons: the lack of appropriate capacity; the decline and fragmentation of data to be used in decision making supported by intelligent information systems (in support of the imminent decentralisation of decision making); and the increased impacts on ecosystems and their functioning due to the need for economic growth with limited capabilities for enforcement of penalties and incentives for compliance. The need for leadership in defining feasible organisational arrangements to ensure effective implementation of policies is heightened. There are specific roles for research in addressing the above challenges, mainly in commissioning relevant and appropriate research of an applied and fundamental nature in support of the above strategic outcomes.

In this KSA, it is acknowledged that the categorising of water issues in narrow thematic domains has the danger of not reflecting the inherent complexity of managing water resources in an integrated manner. The kinds of challenges mentioned above are typically not solved by narrowly-focused solutions. This is reflected in the research portfolio which aimed to reflect a considerable degree of integration between the different thrusts, without duplication.

People-centred policies that govern the management of water resources reflect the need to explore innovations based on social theory and practice, in order to better understand stakeholders' collective role in better managing our water resources. The related research dealing with social sciences will need its fair

share of investment in coordination with other related and specialised institutions.

Integration of sectors, disciplines and institutions must go hand-in-hand with coordination for action. Integration in water resource management requires, for example, integrating surface water and groundwater resources in assessment, planning, decision making, upstream and downstream issues, local, regional and international scales, water quantity and water quality, and data and information systems, at the appropriate temporal and spatial scales. The fundamental research challenge is that this is much easier said than done.

OBJECTIVES

The main objective of research in this KSA is to provide the water resource management tools for addressing the above challenges, fundamentally driven by increasing water scarcity in the face of increasing and competing demands, all of which have social, economic and environmental consequences. This therefore necessitates proactive, innovative, scientific, technological and institutional experientially-based solutions. A better understanding of water resources and their management requires a more holistic conceptual framework encompassing regional-scale hydrologic systems, land-atmosphere interactions and the biogeochemical cycles that control contaminant transport. This unit operates in five thrusts, the management of which is specifically designed to meet this need. These thrusts inevitably have areas of overlap, which are described below in their respective scopes. Holistic approaches to water resource management are particularly pertinent in this area of research and must take account of all sources of water from quality, quantity and accessibility perspectives.

These objectives are achieved in support of the desired impacts on the lives and health of people, on the economy and on the environment, as articulated through the new Government performance outcomes.

In view of the above, the thrusts have been revised to allow for full articulation of water quality issues as well as climate change aspects.

Thrust 1: Water Resource Assessment and Planning

Thrust 2: Water Quality Management

Thrust 3: Water Resource Protection

Thrust 4: Water Resources and Climate

Thrust 5: Water Resource Institutional Arrangements

THRUSTS AND PROGRAMMES

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

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

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

THRUST 2: WATER QUALITY MANAGEMENT

Scope: This thrust acknowledges the significant water quality problems in our estuaries, inland surface water resources and groundwater. The deteriorating state of water quality has many

negative impacts. Ecological functioning and biodiversity can be severely impacted. This, and the inadequate water quality itself, can directly threaten public health, agricultural and industrial production, and ultimately quality of life. Water quality is reflected in concentrations of substances and microorganisms, physico-chemical attributes, radioactivity, and biological responses to these. While some water quality problems arise naturally, many are caused by human activities. These are worsened by fundamental drivers such as population increases, urbanisation, and climate change. These increase immediate pressures on water quality, such as those arising from point and non-point sources. Research in this thrust will focus on water quality issues in our natural water resources affected by fundamental driving forces and the pressures on water quality they create, the state of water quality in water resources, and water quality impacts. Better knowledge and management of water quality must support effective water resource management and hence sustainable environmental management in general. Programmes that will support improved and sustainable water quality management, including integrated planning, in the interests of social upliftment, economic enhancement and ecosystem integrity, are reflected below:

- Water quality monitoring
- Water quality modelling
- Impacts on and of water quality

THRUST 3: WATER RESOURCE PROTECTION

Scope: Reliable supply of good quality water is required for the health, environmental, social and economic wellbeing of the country. The National Water Act of 1998 recognises that protection in relation to a water resource means: (1) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecological sustainable way; (2) prevention of the degradation of the water resource, and (3) the rehabilitation of the water resource. There are significant gaps in our knowledge on how to protect our water resources in an integrated manner. While Thrust 2 will look mainly at

the quality of the water within our systems Thrust 3 focuses on protecting the water resources, by reducing the quantity of harmful materials reaching the water resources, within a broader framework for all uses. Broadly, research in this thrust focuses on the generation of knowledge and understanding of the catchment processes and land-use activities that influence the quality and quantity, negatively or positively, of the water resources. Scientific, technological and institutional approaches that will help to characterise and address these problems include: (1) assessment, monitoring and prediction; (2) tools and control strategies; (3) innovation to assist with prediction and control; and (4) implementation and technology transfer options. The following programmes support this thrust:

- Water sources protection
- Land-water linkages

THRUST 4: WATER RESOURCES AND CLIMATE

Scope: Global environmental change, including climate change, has potential deleterious effects on systems, resources and society. These also superimpose on existing stressors such as unsustainable use of water, deteriorating water quality, land use and demographic changes in time and space. The resultant lack of access to water of acceptable quality is also likely to have undesirable impacts on economic growth, food security, health, ecosystem goods and services, as well as community livelihoods. South Africa is vulnerable to these effects. Adaptation that reduces this vulnerability is critical. Accordingly, this thrust focuses on developing understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales. Research will also include 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. These aim to support the development of policy responses, at regional, national or catchment scale, to existing and emerging problems.

This includes, but is not limited to, development of tools and systems (e.g. weather forecasts, model scenario projections or early preparedness). These should be for, among others, managing floods and droughts and the effects thereof on the resources and the people who rely on those resources, with special emphasis on water quality (e.g. trophic waters) and quantity (due to increased evaporation rates and other) impacts. The following programmes support this thrust:

- Predictive tools
- Climate change risk, vulnerability and adaptation
- Integrated flood and drought management

THRUST 5: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

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

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

RESEARCH PORTFOLIO FOR 2011/12

From the rigorous interaction with the stakeholders, the KSA continued to actively pursue the full articulation of the coming new challenges in water resource management. These challenges are not necessarily new but can be viewed in different combinations each year, and with newly defined priorities towards the achievement of the 'Measurable Performance and Accountable Government Delivery Outcomes'. Competition over scarce or inequitably allocated resources can lead to tension and insecurities. Strategies for reducing demand, increasing efficiency, and creating new sources of water resources from desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., can be viewed as part of Outcome 6: 'An efficient, competitive and responsive economic infrastructure network' which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', relates to these pertinent aspects.

During the previous funding cycle the research community was given an opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. The 2011/12 plan was informed by the needs expressed by the Minister of Water and Environmental Affairs and the broad stakeholder inputs shared earlier, as well as the continuous interactions with various researchers and community members. New solicited calls were prompted by stakeholder inputs and some strategic partnerships, saving a sufficient amount for non-solicited inputs which normally bring about interesting and innovative topics, considered according to importance, relevance (alignment to the new Government-wide outcomes), and budgetary allocations to each thrust.

BUDGET FOR 2011/12

The approved funding of the research portfolio for 2011/12 led to a committed and approved funding budget, inclusive of roll-over, of R30 280 126. Available funding to support new projects within the five thrusts in 2011/12 was R9 817 333. The actual committed budget for new projects was R9 373 333. The consolidated budget for the research portfolio is presented below:

| Research portfolio | Approved 2011/12 (R) |
|--------------------|----------------------|
| Current projects | 20 462 793 |
| New projects | 9 817 333 |
| Total | 30 280 126 |

CORE STRATEGY

Strategic context

To address water resource challenges which are likely to emerge in the next 10 to 15 years, decision-makers at all levels of Government will need to make informed choices among often conflicting and uncertain alternative actions. These choices are best made with the full benefit of research and analysis. It is therefore of great importance that the nation will continue to invest not only in applied research but also in fundamental research that will form the basis for national implementation of water sector projects.

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological measurements and how these are interpreted in water resource simulations and other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes can only suffice if real, reliable data are available at reasonable spatial and temporal resolutions

for verifications. The KSA has invested vastly in enhancing the estimates for quantifying water use and water availability. In 2011/12 the KSA aimed to contribute to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the National Information System. Furthermore, the need for integrating surface water and groundwater models was highlighted. Concerted effort was made to bridge this gap and to create a continuum starting from improving evapotranspiration estimates, which take into account the unsaturated zone informed by groundwater dynamics.

At a national level the recent momentum towards establishing research needs based on outcomes and Government-defined outputs is included. The main outcomes pertaining to this KSA are Outcomes 6, 7, 9 and 10.

Competition over scarce or inequitably allocated resources can lead to tension and insecurities. Strategies for reducing demand, increasing efficiency, and creating new sources of water resources from desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., can be viewed as part of Outcome 6: 'An efficient, competitive and responsive economic infrastructure network' which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', relates to these pertinent aspects.

Water is an economic and a social good according to the South African policies. The marked inequities in the physical, social, as well as institutional, access to this important resource remain a challenge, mainly to the poor and the disempowered majority whose ability to pay for water is limited. Delivering water services to this majority and ensuring that there are adequate water resources for new productive users, such as emerging farmers in rural areas, is a main target of Outcome 7: 'Vibrant and sustainable rural communities and food security for all'. Output 1: 'Sustainable agrarian reform' is a major focus for the KSA dealing

with Water and Agriculture, but in this KSA the main focus is from the perspectives of climate change, resource assessment and the institutional arrangements pertaining to addressing equity aspects. In all of the above, the need to safeguard society and the economy through early warning systems has been identified. Research results need to be shared and communicated effectively to be optimally used for the benefit of South Africa and further afield. Finally, water governance, which has received a lot of attention recently, continues to occupy centre stage in the water sector, bringing with it tremendous uncertainty and optimism from a continued desire for improvement and self-reflection. This KSA will continue to be willing to support these processes for a more locally suitable and resilient institutional landscape in the water sector.

The bulk of the research in this KSA is in support of Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 1, 2 and 3. Thrust 4 is in support of Output 2: 'Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality'.

The KSA's contribution to the national service delivery-based outcomes is through conducting research that can yield impacts on society, economy, health and environment, as defined in the strategy and the WRC's impact areas.

Water and society

The National Water Act (NWA) places emphasis on stakeholder participation in water resource management, which forms a blend between decentralisation and democratisation for decision making. Vast resources have been used in ensuring that adequate consultation takes place, without necessarily reflecting much value from those investments. International literature confirms that empowerment is a long path which is progressive in nature and highly non-linear. Since the primary focus is to make an

impact on the lives of people, the KSA has commissioned studies to establish the lowest appropriate level for decision making in water management in South Africa, the benefits from such engagements and their impact on the lives of women and the poor. The role of local Government as the democratic representative in water-related decision making in South Africa is an area that needs further investigation. A benchmarking exercise is currently under way to document international experience in regulation of the sector. With the numerous restructuring efforts undertaken in the sector, it is not easy to establish how the sector will look in the future. In response, scenarios are currently developed to map out the institutional landscape by the year 2025, in order to ensure that current efforts are indeed in support of growing the South African economy by 6% of GDP per annum.

Water and health

The deteriorating quality of water resources, including water in some of the major rivers, dams and aquifers, has continued to threaten the efficient and sustainable supply of reliable water to various sectors. Previous research has identified a number of water quality challenges. The KSA has sought to support research that addresses the challenges surrounding the provision of suitable and sustainable solutions for water quality issues at the resource level. Special focus is needed on the impacts on water resources from some Government policies such as rainwater harvesting and biofuels. The impacts on the health of society, especially those members with compromised immune systems, from land-use practices such as agriculture and mining, and from endocrine disruptive compounds found in the ecosystem, will need to be further understood. The potential for the creation of 'new' water through water recycling, grey-water use and reuse, artificial aquifer recharging, etc., can assist in meeting growing demands for a healthier society.

Similarly, and in close association with the recent energy crisis, water infrastructure failings can be one major area that may affect water quality and hence create health issues, and this requires

attention. An investigation aimed at quantifying and classifying all national water resource infrastructure is underway. Non-compliant wastewater and water treatment plants prompted a more focused study on the water infrastructure development financial allocation pathways in municipalities, aiming to understand the reasons behind lack of maintenance and upgrades of consistently failing infrastructure in some municipal locations.

Water and the economy

The evidence of global climate change, largely as a result of human activities, has now been documented. There is a growing consensus among global climate model projections regarding the nature and extent of the change. The main climate change consequences which are related to water resources have been identified as increases in temperature, shifts in precipitation patterns, increased frequency and intensity of floods and drought events, and sea-level rise.

The KSA has initiated a comprehensive research programme on climate change impacts on water resources, with a view to gaining insight into the magnitude of the impacts and subsequently the consequential adaptation needs for the economy; the first steps to incorporate research on vulnerability, mitigation and adaptation have already been taken. The success of this research relies on the outcomes of considerable prior investment by the WRC in water-related climate, atmosphere and ocean-atmosphere research, as well as hydrological modelling research, done over a period of more than 15 years. The KSA will seek to drive further research on climate change to deal with regionalisation of climate change knowledge as well as improving the modelling processes to account for conditions that are consistent with the Southern African region. In this cycle, the KSA has strategically allocated all the solicited funding for the purpose of furthering the studies relating to climate change impacts on society, economy, health and the environment, and on majority water uses such as urban water supply, agriculture, mining, etc.

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

Water and the environment

A recent review of relative investments in the different impact areas revealed the need for new research in the area of environmental degradation and mitigation, especially from a water use perspective such as agriculture, mining, etc. Environmental functioning within the hydrological cycle and the integrative knowledge for ecosystem-based water resource management is another area of interest. For example, the crocodile deaths in the Olifants River have created collaborative efforts between this KSA, dealing with water resources, and the KSA dealing with ecosystems.

The impact on the environment from the release of energy and the resulting impact thereof on water resources have formed part of a long-term discussion between WRC and Eskom, and an agreement has been signed between the two parties to conduct joint research into alternative energies and the international benchmarking of the latest technologies.

Needs analysis

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

- An effective alliance with, and active participation of, water resource research stakeholders
- A systematic, strategic, and balanced agenda of both core- and problem-driven research priorities set to meet short- and long-term needs

- The national water resource research effort should be coordinated to reduce needless duplication and to ensure that gaps do not occur
- Research should be multidisciplinary and interdisciplinary
- Research should be proactive and anticipate the nation's water needs and the environmental impacts of management options
- Research should be accountable to the public to assure that the water resource research investment has been appropriately utilised to meet the nation's needs

In continuation from the previous business plan and based on the needs analysis, the research focus of this KSA continued to support policy making by: developing tools and technologies for overall water resource management, supporting decision making by reviewing existing policies and strategies, providing quick responses to immediate and specific research questions in support of national initiatives, providing platforms for debate, building capacity in project teams and steering committees disseminating resultant information as widely as possible and encouraging partnerships through joint projects with key stakeholders. During its formal and informal consultation with the various stakeholders, the KSA defined the following as research areas needing further attention in the business plan cycle from 2011/12 to 2013/14:

Research needs/issues

The KSA deals with freshwater resources and their management. The strategic intent of this KSA continues to be informed by the regular interaction with numerous stakeholders. During its formal and informal consultation with the various stakeholders, the KSA in its previous business plan has defined the following as research areas needing further attention. Additional aspects are included from interactions in 2010/11, such as SALGA (26 August 2010, 9 September 2010 and 26 January 2011), DWA strategic planning (2 September 2010), WRC Strategic Planning (3 September 2010), internal KSA discussion (October 2010; new

thrust constellations), Groundwater Governance Workshop (8 November 2010) and the WRC Board (November 2010), etc. It seems that areas already defined are adequately addressing the current needs.

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

Water and business: At a global scale business has begun to seriously consider risk around water availability and quality, with some of the more proactive multinationals having formulated the CEO Water Mandate under the auspices of the UN Global Compact. The CEO Mandate commits signatories to action in the following six areas: direct operations; supply chain and watershed management; collective action; public policy; community engagement; and transparency. The World Economic Forum (WEF), World Business Council for Sustainable Development (WBCSD) and World Wide Fund for Nature (WWF) are each driving initiatives to understand corporate risk and responsibility around water, including focuses on supply chains

and water footprints. Some of the exciting new developments relate to enhanced awareness of the importance of water in development, resulting in enhanced participation from large end-users. SABMiller has developed a position statement on water use, analysing risks surrounding water security and scarcity at its regional operations. The company analyses its water use using an industry metric, the amount of water used to brew a hectolitre of beer, and it recognises that in addition to saving costs water is a material risk factor for the company, as some of its operations are located in watersheds facing water stress. The company accordingly recognises that it has a part to play in water efficiency in order to protect its resource base. Competition is around security issues which directly relates to allocations and transparency of decision making, i.e., governance aspects. The significant role of the end-users in ensuring good management of water resources is heightened since the realisation of the immediacy of water scarcity is amplified.

Another example of how a common interest of large users to protect water can steer water development is the pilot implementation of BHP Billiton of their eMalahleni Water Reclamation Plant (EWRP). The long-term water management approach for the mine closure at the South Witbank Colliery of BHP Billiton has resulted in the EWRP, a permanent infrastructure put in place to abstract decant mine-water from the deepest point in the underground workings, for treatment to potable standards and reuse in the local municipality as a new source of drinking water.

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

Water pollution and regulation: The previous Minister of Water and Environmental Affairs, Minister B Sonjica, stated that South Africa needs both technology-based solutions and a change in public attitude which can be achieved through education and awareness. Creative programmes are needed to address this at community level, and compliance and enforcement are critical. Wetland protection is also of utmost importance as the wetlands play a major role in sustaining the resource and combating pollution.

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

Water scarcity with regards to future water supply options; new water such as water reuse, return flows, desalination; and the implications for water resource allocation options require further research. Support methodologies for water resource planning options such as recharge, retention and recycling need to be addressed in a consolidated fashion to satisfy increased demands sustainably. Augmentation options versus new water

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

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

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

Uncertainty and climate change go hand in hand. Small uncertainties in the physical processes are amplified into large uncertainties in the climate response. The challenge for policy-makers, planners and environmental decision-makers is to understand how the timing and magnitude of impacts may be affected by changes in climate and sea level rise associated with differing amounts and rates of change in global average temperature. The challenge for climate change research is to develop monitoring and observation systems; refine models to determine the impacts of climate change in a specific area; identify measures to enhance our capacity to adapt (building adaptive capacity) and take advantage of the opportunities presented by climate change; and make information available for those responsible for policy, planning and environmental decision making.

Sectoral and political cooperation: The realisation that water is an embedded sector and needs to be outward-focused emphasises that many decisions around water lie outside the water sector and hence expansion of the stakeholder base is important to affect decisions made around water. Alignment of powers and functions between the three spheres of Government is defined in the respective laws and legislation. However, the complexity in the management of water and other resources in an integrated manner is proving to be a challenge. This requires a cooperative Government functioning seamlessly

between national, provincial and local Government. However, the delineation, coordination and support in this value chain have created some blind spots, mainly from a planning and financial point of view. The reform of water allocations can only be successful if there is complete alignment between the responsible departments. The new Planning Commission calls for futuristic studies which are able to project alternatives in future scenarios. This KSA aims to invest in research efforts to further define available options in support of national sustainable growth and development.

Public participation: The move towards a common goal for use of the water resource involves identifying conflicting needs for use of the resource, and resolving or negotiating these conflicts. This process uses IWRM tools like water demand management, water quality management, or the conjunctive use of surface water and groundwater resources. This process would also rely on water resource assessment techniques such as water resource yield models or water quality modelling. It is an iterative process of interaction with stakeholders, and of bringing conflicting stakeholders together to resolve potential conflicts.

There is a need to balance current challenges and forecast future research needs. More partnerships with other sectors; local Government, private sector and other public sector agencies are needed. There is a need to continue translating research into implementation through pilot implementation where possible. More focus on repurposing existing research information aimed at a specific target audience was identified as a crucial undertaking, especially given that the size of the knowledge repository which already exists is substantial. Based on the above, the following areas/issues were thought to be important to repackage for targeted stakeholders: water assessments such as WR2005 published in 2009; the state of the water infrastructure; monitoring technologies for infrastructure assessment; drinking water quality; regulation, compliance and enforcement manual; raw water quality; demand for water; shortage of skills; and councillor support tools.

Overview of technological trends

The National Climate Change Committee (NCCC) mandated DST to lead a Technology Needs Assessment (TNA) in relation to climate change in 2007. The TNA shows that, despite remaining uncertainties regarding the exact nature, magnitude and pattern of future rainfall changes in South Africa, it appears that water resources, already under pressure as a result of growing water demand in relation to a finite and limited supply, will be under even greater pressure in the future as a result of climate change.

According to the IPCC Technical Paper on Climate Change and Water of June 2008, major gaps in observations of climate change related to freshwater and hydrological cycles were identified as follows:

- There are difficulties in the measurement calculated from parameters such as solar radiation, relative humidity and wind speed. Records are often very short, and available for only a few regions, which impedes complete analysis of changes in droughts.
- There may be opportunities for river flow data rescue in some regions. Where no observations are available, the construction of new observing networks should be considered.
- Groundwater is not well monitored, and the processes of groundwater depletion and recharge are not well-modelled in many regions.
- Monitoring data are needed on water quality, water use and sediment transport.
- There is a general lack of data from the Southern Hemisphere.
- More information is needed on plant evapotranspiration responses to the combined effects of rising atmospheric CO₂, rising temperature and rising atmospheric water vapour concentration, in order to better understand the relationship between the direct effects of atmospheric CO₂ enrichment and changes in the hydrological cycle.

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

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

Data monitoring using remote sensing is undergoing a revolution in terms of technical monitoring capabilities through the advances in spatial and spectral resolution of new sensors. The continuing improvements to the analysis are also expanding the level of detail that can be extracted from imagery. One of

our research projects is now applying hyperspectral imagery to accurately estimate evapotranspiration, plant water content, water stress and plant- or soil-water availability. Unlike low-spectral resolution imagery which covers only selected regions of the electromagnetic spectrum, thus giving more generalised products, high-spectral resolution imagery covers a wide region of the electromagnetic spectrum (approximately 400 to 2 500 nm). This gives more spectral bands with finer bandwidths (generally less than 10 nm). The finer spectral resolution allows for detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

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

Water accounting: Accurate information on and understanding of the quantity of water that South Africa has available are important for making decisions regarding sustainable and effective water use. Just as financial accounting is essential for the successful operation of a business; standard water accounting practice is needed to provide support, security and confidence in water planning and water allocations, and in support of cost-effective investments in water infrastructure. To manage our water resources effectively and sustainably we need to know how much water there is, where it is, who is using it, and what it is being used for. This will be done by building on the water resource measurement, monitoring and reporting activities already undertaken such as the National Water Resource Strategy (2004) and assessments such as WR2005 as well as other planning instruments already in existence. There is always a

need to improve measurements and methodologies adopted for measurements from a quality and a quantity point of view. Having and applying national standards for measurement and metering – including knowing the degree of accuracy of each measurements system – will be a crucial step in developing nationally-compatible water accounting systems.

Key stakeholders

The major stakeholders remain to be the following five groups:

- The Minister of Water and Environmental Affairs
- The Parliamentary Portfolio Committee on Water and Environmental Affairs
- Government departments representing a major group that has a large stake in the research conducted, especially the Department of Water Affairs (DWA) which represents the water resource managers and planners, i.e., all those entrusted with developing and allocating water resources to meet the needs of the environment and various users according to the National Water Act
- Other departments such as the Department of Minerals and Energy, the Department of Science and Technology, the Department of Cooperative Governance and Traditional Affairs, the Department of Agriculture, Forestry and Fisheries, the Department of Health, the Department of Rural Development and Land Reform, Working for Water, the Planning Commission in the Presidency and the related Portfolio Committees of Parliament represent the other stakeholder groups
- Major water users including farmers, mines, industries, energy, water service providers and civil society
- South Africa shares many rivers with its neighbouring countries; therefore, the Governments and major water-user groups from these countries constitute the fifth group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.
- Water use communities at large

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

Other stakeholders

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

International players

As in previous years, the WRC maintains its peer review and best practice through continuous interactions with international role-players. Other role-players include: CapNet, an established capacity-building organisation hosted in the WRC building and a number of their extended networks such as the Philippines CapNet; SaciWATERs, South Asia Consortium for Interdisciplinary Water Resources Studies; the World Water Council, of which the WRC is a member; and United Nations Agencies such as the UN Environment Programme, which was a partner to the WRC in two completed studies and in facilitating the hosting of ministerial delegations from Darfur/Sudan showcasing IWRM implementation in South Africa. The WRC was involved in chairing the review of the Rivers Working Group responsible for reviewing the value of science in the research funded by the Global Environment Facility in partnership with the United Nations University. Numerous partnerships, at a project level, exist with the World Bank, the UNESCO IHE, University of Osnabrück, United States Geological Survey, the French International Research and Development Agency and the Department of Science and Technology and the local and African Academies of Sciences. Partnerships exist with Waternet in support of regional capacity building, and GWP in support of IWRM implementation and benchmarking.

The KSA members are invited internationally to make technical contributions in many fields, mainly institutional governance, climate change, water quality, water resource protection, groundwater and hydrology research.

IMPLEMENTATION PLAN

Research portfolio for 2011/12

The primary objective of the research in this KSA continues to be 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 2011/12 addressed this primary objective through the Government delivery Outcomes 6, 7, 9 and 10, and as reflected by the following secondary aims to:

- Improve water resource information systems and access to data
- Achieve integration between surface water and groundwater research – a programmatic approach will be designed addressing the need for joint studies
- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impacts on humans)
- Broaden the scope for policy and institutional studies to deal holistically with the legal, economic, compliance and implementation aspects

The research portfolio for 2011/12 is presented in Table 1, which provides an overview and description of research thrusts and programmes.

TABLE 1**Overview and description of thrusts and programmes****THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING**

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

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| <p>Programme 1: <i>Catchment data and information systems</i></p> | <p>Scope: This programme will support the provisions of Chapter 14 of the National Water Act, especially Part 2: National Information Systems on Water Resources. This programme is focused on supporting the national initiative for improving the available water resource information, better management of the information and improved information dissemination to stakeholders. It will establish direct linkages to the national information systems as well as identifying and resolving water resource information gaps. In this programme researched water resource information will be integrated into the national information system that is being established by DWA. The programme will also support the process of decentralising identified water resource data and information from broader national perspectives to detailed and highly-resolved local and catchment scales.</p> |
| <p>Programme 2: <i>Surface water/ groundwater hydrology</i></p> | <p>Scope: This programme focuses on developing and utilising integrated hydrological approaches in surface water and groundwater assessments, water resource explorations, planning and management. It will take advantage of gains made in improved understanding of groundwater and surface water hydrological processes as well as the availability of better hydrological data, especially the various forms of more accurate remotely-sensed data with better coverage. Through this programme, strategic partnerships with international expertise in both groundwater and surface water hydrological research will be encouraged to flourish. Hydrological tools that have been developed in the past are expected to be upgraded, redeveloped or replaced by tools that are more suited to the current data availability, the improved knowledge and the recent technological advances in hydrological modelling. In this programme, the continued deterioration of hydrological gauging processes and other installed earth measurement devices will be addressed through the intensive use of new data sources from remote sensing coupled with the limited earth-based measurements.</p> |

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| <p>Programme 3: Water resource planning</p> | <p>Scope: This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps such as the absence of reliable information in ungauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water system plans that will benefit from real-time, historic and stochastic data on a countrywide basis. Impacts of climate change on water resources and the planning processes will be accounted for so as to ensure a proactive approach and allow for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs as expressed in the objectives of <i>Water for Growth and Development</i> as well as through accounting for other factors, which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals. Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water uses will be investigated and included as part of future water resource plans.</p> |
| <p>Programme 4: Water resource infrastructure</p> | <p>Scope: There is an increasing need to develop systems for the efficient maintenance of the aging water infrastructure as the demand for the development of new and expensive water resource infrastructure is increasing due to the growing economy and population growth. This programme will seek to develop strategies and priorities for water resource infrastructure development and management to address the uncertainties and risks associated with climate change. While built infrastructure development such as dams, reservoirs, irrigation and flood barriers, are important options for addressing these issues, this programme will also explore the potential use of natural infrastructure such as wetlands, floodplains, artificial recharge (to aquifers), etc., to complement built infrastructure (but with an added advantage of healthy ecosystems).</p> |
| <p>Programme 5: New water</p> | <p>Scope: This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges and economic growth target of 6% of GDP per year will require thorough understanding and assessments of alternative sources of water. Such sources could be built into future projections for new water, virtual water and water transfers, be they national or international, from desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. The initial development of research under the new theme of Water and Energy will be initiated through this programme. Within this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention, to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.</p> |

THRUST 2: WATER QUALITY MANAGEMENT

Scope: This thrust acknowledges the significant water quality problems in our estuaries, inland surface water resources and groundwater. The deteriorating state of water quality has many negative impacts. Ecological functioning and biodiversity can be severely impacted. This, and the inadequate water quality itself, can directly threaten public health, agricultural and industrial production, and ultimately quality of life. Water quality is reflected in concentrations of substances and microorganisms, physico-chemical attributes, radioactivity, and biological responses to these. While some water quality problems arise naturally, many are caused by human activities. These are worsened by fundamental drivers such as population increases, urbanisation, and climate change. These increase immediate pressures on water quality, such as those arising from point and non-point sources. Research in this thrust will focus on water quality issues in our natural water resources affected by fundamental driving forces and the pressures on water quality they create, the state of water quality in water resources, and water quality impacts. Better knowledge and management of water quality must support effective water resource management and hence sustainable environmental management in general. Programmes that will support improved and sustainable water quality management, including integrated planning, in the interests of social upliftment, economic enhancement and ecosystem integrity, are reflected below.

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| Programme 1: Water quality monitoring | Scope: Sound water quality monitoring data are crucial to sustainable management because they provide information on the current state and trends. However, many data and information gaps exist. Monitoring is often relatively expensive. Creative yet soundly scientific approaches to monitoring are required that optimise information and minimise costs. Particular attention needs to be given to the relationship between costs, uncertainty in the generated data and the requirements of the users of the monitoring information. All phases of monitoring design need careful consideration, from data acquisition, data storage and management, information generation and dissemination, to realistic implementation strategies. Special attention will be given to the public availability of the acquired data because accessibility to water depends on accessibility to data and information. |
| Programme 2: Water quality modelling | Scope: There is a world-wide movement towards the development and application of integrated open-source modelling platforms for water resource management. Managed correctly, these have the potential to provide a powerful mix of modularity and integrative power that (a) allows individual module developers to retain control of their modules and (b) allows a wide variety of other modules, including spatial (e.g. GIS) data systems, to interface to provide a powerful and versatile integrated information generation system. Water quality modelling capabilities will be critical components of such systems. Such systems can improve data and information accessibility and be as much in the economic interests of users of such information (e.g. catchment management agencies) as the service providers and modellers. This programme aims to ultimately support decision making and planning with state-of-the-art, scientifically defensible data and integrated information on water resources. |

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| <p>Programme 3: Impacts on and of water quality</p> | <p>Scope: The ever-changing nature and increasing intensity of the wide variety of land and water uses can compromise water quality in our water resources. Current priorities include acid mine drainage and inadequate wastewater treatment. These in turn create new threats or increase existing risks to humans and ecosystems. This programme will focus on identifying, characterising, and understanding (a) the associated changes in the state of water quality, either from point or non-point sources, and (b) the associated impacts of such compromised water quality. This must provide knowledge that will effectively inform water quality management in particular, and hence water resource management in general.</p> |
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THRUST 3: WATER RESOURCE PROTECTION

Scope: Reliable supply of good quality water is required for the environmental, health, social and economic wellbeing of the country. The National Water Act of 1998 recognises that protection in relation to a water resource means: (1) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecological sustainable way; (2) prevention of the degradation of the water resource and (3) the rehabilitation of the water resource. There are significant gaps in our knowledge on how to protect our water resources in an integrated manner. While Thrust 2 will look mainly at the quality of the water within our systems this thrust focuses on protecting the water resources, by reducing the quantity of harmful materials reaching the water resources, within a broader framework for all uses. Broadly, research in this thrust focuses on the generation of knowledge and understanding of the catchment processes and land use activities that influence the quality and quantity, negatively or positively, of the water resources. Scientific, technological and institutional approaches that will help characterise and address these problems include: (1) assessment, monitoring and prediction; (2) tools and control strategies; (3) innovation to assist with prediction and control; and (4) implementation and technology transfer options.

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| <p>Programme 1: Source water protection</p> | <p>Scope: Source water protection refers to protecting source water (water from dams, wetlands, rivers, aquifers, etc.) from contamination and overuse. Specific driving forces, or a combination thereof, which have an impact on water resources will be researched. Integrated protection strategies and approaches will be researched and tested. The development of source water planning, control and response strategies, to minimise adverse impacts on source waters by reducing pollution risks and securing water availability, is a key component of this programme. The source water protection approach will look at, among others, land use (see Programme 2 below), vulnerability assessments and catchment plans and strategies (for both surface and groundwater).</p> |
| <p>Programme 2: Land-water linkages</p> | <p>Scope: This programme will enhance our knowledge on the interaction of water and land at various scales. This programme will focus on the driving forces (new developments, emergency spills, erosion, leaks, soil enhancements, etc.) that can impact water resources from land-based activities. The aim is also to research, evaluate and develop common regulatory tools to overcome the challenge of different technical and procedural approaches for water resource and land use management, in order to enhance our water resource protection capabilities. Techniques to delineate, protect and remediate areas, and/or the activities occurring within these areas, will be researched. Research will also be bi-directional where potential impacts on water resources from land-based activities or processes are investigated as well as the impact of water resources on land-based activities (e.g. floods and droughts).</p> |

THRUST 4: WATER RESOURCES AND CLIMATE

Scope: Global environmental change, including climate change, has potential deleterious effects on systems, resources and society, and will be superimposed on currently existing stressors such as unsustainable use of water, deteriorating water quality, and land use and demographic changes in time and space. Potential secondary impacts due to resultant lack of access to adequate water of acceptable quality are likely to also have undesirable impacts on economic growth, food security, health, ecosystem goods and services, as well as community livelihoods. Consequently, adaptation aimed at reducing the country's vulnerability to the currently highly variable climate, under natural conditions and due to human-induced impacts, as well as to projected climate change impacts on water availability, is crucial. This thrust accordingly focuses on developing the understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales. The focus is also 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, but is not limited to, development of tools and systems (e.g. weather forecasts, model scenario projections or early preparedness) for among others, managing floods and droughts and the effects thereof on the resources and the people who rely on those resources, with special emphasis on water quality (e.g. trophic waters) and quantity (due to increased evaporation rates and other) impacts.

Programme 1: Predictive tools

Scope: The need to prepare the country to cope with global climate change and regional climate variability 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. This programme will therefore focus on the following key issues: select and use GCM-generated scenarios of global climate change of appropriate confidence level as a basis for development of model projections; improve techniques for downscaling of scenarios from global (GCMs) to regional and catchment scales to enable or support management at a higher resolution scale and to ensure a high level of reliability and robustness; improve on detection and attribution of anthropogenic impacts of climate change in the Southern African context in order to distinguish those from natural climate variability and change-related impacts.

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| | <p>The programme will also deal with: the choice of relevant and appropriate climate indicators and variables as well as monitoring systems that need to be in place in this regard; determination of the frequency and magnitude of resultant extreme rainfall and flow events; use of existing conceptual and numerical models to utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely inter-related land-use, ecosystem, hydrological (including geohydrological), water yield and water quality changes at regional/catchment level; modification of existing management strategies and tools for adaptation purposes; determining the likely socio-economic impacts for a given structure of society in Southern Africa; and appropriate technological, social and political coping strategies. Other areas that will be attended to include: improving understanding of and forecasting of the variability of rainfall, flow and groundwater recharge, as the ability to forecast at very short time-scales would greatly benefit flood management and disaster mitigation and adaptation activities; and improving the understanding of global climate change impacts and vulnerability for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and adaptation actions. Through this programme, support will be provided for weather and climate disaster mitigation programmes at various levels which will include regional, national and provincial as well as other, more localised, scales.</p> |
| <p>Programme 2: <i>Climate change risk, vulnerability and adaptation</i></p> | <p>Scope: Climate change risk management seeks to promote sustainable development by reducing vulnerability associated with climate risks. The approach involves a range of actions including reduction of vulnerabilities or enhancement of resilience amongst people and societies, protection of ecosystem goods and services, early response systems, strategic diversification, and improved institutional capacities. Climate adaptation refers to the ability of the system to adjust to climate change, variability or extreme to moderate potential damage or to cope with the consequences. This programme is aimed at reducing vulnerabilities among communities and people through development or implementation of systems, tools, approaches and strategies (some of which would have been developed under Programme 1, such as modification of structures or implementation of early preparedness programme for extreme events). Protection or restoration of ecosystem goods and services that are vulnerable to climate variability and change as well as strengthening capacity of people and institutions are some of the techniques that will be investigated under this programme. Climate risk management strategies to be developed under this programme also aim to maximise opportunities in climate-sensitive economic sectors, even under uncertain climatic conditions of high variability. The programme could also deal with implementation of capacity-building and awareness programmes including sharing of climate information as part of a broader adaptation programme.</p> |

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| <p>Programme 3: <i>Integrated flood and drought management</i></p> | <p>Scope: Flooding and drought are major natural hazards to human society and have important influences on social and economic development. The most vulnerable communities are often those who are poorly resourced since they barely have means to cope, and also often live in informal settlements notorious for being drought- or flood-prone with poor infrastructure. 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.</p> |
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THRUST 5: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders, based on catchment and water management area boundaries. The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of IWRM. The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust will support the suitable implementation of IWRM in South Africa. The further articulation of the NWA for the benefit of all South Africans and the fulfilment of the developmental role of the state within the water resource limitations will be investigated. Lessons learnt and evaluations of the IWRM applications in South Africa to date will be part of this portfolio, focusing on home-grown approaches and experiences in water resource management.

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| <p>Programme 1: <i>Institutional governance and reforms</i></p> | <p>Scope: The principle of subsidiarity, or as is sometimes referred to as democratisation of water resource management, has brought about challenges, both conceptually and in terms of application. Although current reforms in South Africa are based on sound IWRM principles, to date the implementation thereof continues to break new ground, proving that institutional engineering cannot provide a one-size-fits-all solution to the new management paradigm. Further understanding and research are hence needed to learn and to decide on best practice as defined in the South African or similar socio-economic settings.</p> |
| <p>Programme 2: <i>Compliance and enforcement</i></p> | <p>Scope: For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Benchmarking and best practice are crucial here to accelerate learning.</p> |

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| <p>Programme 3: Pricing and financing WRM</p> | <p>Scope: The issues of financial sustainability, affordability of charges by users, transparency and corporate governance are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good groundbreaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource charge exclude the poor and will it further cripple local Government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.</p> |
| <p>Programme 4: Transboundary water resources</p> | <p>Scope: This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.</p> |
| <p>Programme 5: Future scenarios</p> | <p>Scope: This activity has been assigned a separate programme to ensure that local South African expertise is qualified to explore future scenarios and answer the 'what if' questions in support of reflection and evaluation of national policy applications. Projecting the water resource management and development institutional arrangements landscape 10 or 15 years from now would be of interest to decision-makers to define policy reviews and enhance decision making. Further complexity can be added through the introduction of the water services institutions. Mapping of the processes for tariff setting between both water resources and water services could allow further investigation into service delivery affordability and efficacy. This programme is likely to employ a phased approach to adding more and more layers to the scenarios, and to enable scenarios to be customised for localised aspects that need not be of national interest.</p> |

RESEARCH PROJECTS FOR 2011/12

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

Groundwater Africa

No. 1763

The project aimed to identify favourable groundwater potential areas for bulk municipal water supplies, to provide a method to quantify them, and to provide the information in a manner that is accessible for planning purposes. In identifying favourable groundwater areas, the focus turned to developing a detailed transmissivity map of the Main Karoo Basin. In order to present groundwater yields in an accessible manner to water supply planners, two methods were developed, namely, the Aquifer Assured Yield Model and the Aquifer Firm Yield Model. The Aquifer Firm Yield Model provides the historic firm yield and uses historic monthly rainfall data together with recharge, evapotranspiration and baseflow to determine aquifer storage in any given month. The firm yield can be considered to define the upper limit of the groundwater resource. In order to establish possible wellfield yields, the Cooper-Jacob Wellfield Model (based on the Cooper-Jacob approximation of the Theis groundwater flow equation) was developed, whereby borehole spacing can be optimised after inputting estimated transmissivity values from the transmissivity map. To aid the planning process, groundwater quality maps were produced, together with the Wellfield Cost Model, which provides an easy way to obtain first-order cost estimates of the wellfield options.

Cost: R3 499 200

Term: 2008 - 2011

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

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

No. 1846

The main objective of this project was the development of an integrated framework for optimised monitoring of water resources that will account for the different components of catchment systems and their interactions. An integrated catchment management tool was developed that linked the various components of the water cycle to assist water managers in finding the appropriate guideline, database, methodology or information for the management of their local water resources. The importance of monitoring the whole water cycle was particularly highlighted, as well as the consequential cause-and-effect relationship between geology, climate, soil and land use. The main target users of the ICM mind map are water management boards (e.g. catchment management agencies) and similar institutions.

Cost: R1 487 200

Term: 2008 - 2011

The preparation of a hydrologically improved digital elevation model for South Africa based on the SRTM data set

ARC

No. 1908

Digital elevation models (DEMs) represent the topography in a landscape and are an important data source used in numerous hydrological and geo-hydrological studies/projects. There are several DEMs available for South Africa, but usually they require significant editing before they can be used for hydrological

modelling. Therefore this project was an attempt to provide a readily usable set of data products for hydrological modelling. The aim of the project was to prepare a hydrologically-improved digital elevation model for South Africa from the Shuttle Radar Topography Mission (SRTM) DEM. The SRTM DEM provides a readily-accessible resource that can be effectively exploited to guide regional planning, especially in data-scarce areas where prohibitive costs preclude the use of high resolution equivalents. Although the utility of the SRTM-derived DEM is incontrovertible, effective use of this dataset is constrained, firstly, by areas of missing data which are mostly associated with water bodies, mountainous areas and desert regions, and, secondly, by occasionally elevated elevation values in flow paths caused by bridges, high trees with large crowns, steep cliffs, etc., obscuring the flow path below. These 'blockages' in the data cause wrong flow path extraction and the formation of 'inland lakes' in the data. In very flat areas elevated elevation values can cause serious misrepresentation of large meandering rivers.

Cost: R350 000
Term: 2009 - 2011

Reducing uncertainties of evapotranspiration and preferential flow in the estimation of groundwater recharge

CSIR

No. 1909

It is widely acknowledged that groundwater recharge estimates can be improved through improved estimation of evapotranspiration (ET) and preferential flow. Uncertainties exist in the estimation of ET that would account for below-potential water use by vegetation as well as preferential flow paths of water and contaminants. Soil water fluxes determining groundwater recharge are also the main drivers of solute and contaminant transport by convection. In that sense, it is inevitable that processes like ET and preferential flow are also relevant to groundwater quality and the protection of groundwater resources. The general objective of this project was to develop

improved process-based estimates of groundwater recharge. The approach consisted of establishing field trials at the two study sites. Evapotranspiration measurements were invaluable in gaining understanding of the water use and water balance of two types of fynbos. It was the first time that measurements of ET were done on Atlantis Sand Plain Fynbos and Kogelberg Sandstone Fynbos. Soil hydraulic properties, in particular saturated hydraulic conductivity and preferential flow patterns, play a large role in groundwater recharge. Less variability in the hydraulic properties of Riverlands soils was evident compared to Kogelberg. The uncertainty of the estimates of groundwater recharge depends on the accuracy of measured input data in the model (e.g. scintillometer measurements, weather instrumentation, etc.) and variability in environmental factors (rainfall, groundwater levels, vegetation, hydraulic properties, etc.). The technique used in the uncertainty analysis showed that the error propagation method can be useful for analysing the influence of input data on the simulated groundwater recharge.

Cost: R2 000 000
Term: 2009 - 2012

Programme 2: Surface water/groundwater hydrology

Protocol for assessing the sustainability of springs

Maluti Water

No. 1488

The primary aim of the project was to develop a method for predicting the sustainability of spring flow from measured parameters. From the sample of investigated springs no reliable relation could be determined between the age of spring water and the sustainability of springflow. It was also not possible to establish a correlation between various water quality determinants or isotopes and the sustainability of springflow. The most suitable method is to measure the flow at various times of the year, taking into account long-term averages, in order to average out short-term peak flows as a result of anomalous rainfall periods.

Cost: R734 100
Term: 2004 - 2011

Influence of catchment development on peak urban runoff

University of Pretoria

No. 1752

This research reviewed catchment response to urban development, using comparative assessment. This required the identification of similar rainfall events during different developmental stages in the catchment for which gauged flow rates were recorded. The hypothesis which is reviewed here is that urban development, which creates more impervious areas, on the one hand, also generates longer concentration times, due to changes in the length of the flow path, as well as greater temporal storage capacity, which could result in increased groundwater recharge. Three catchments in the Tshwane Metropolitan Council Area were evaluated to test the hypothesis by comparing the cumulative rainfall and cumulative runoff produced by similar rainfall events for different development levels in the catchment. This analysis compared years that had similar volumetric rainfall, antecedent conditions and temporal distributions. There was a general trend indicating an increase in the percentage runoff produced as urban development increased; however, certain anomalies were observed.

Cost: R665 000
Term: 2007 - 2011

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

University of the Free State

No. 1760

Geological formations are complex features resulting from geological, mechanical, and physico-chemical processes occurring over a very wide range of distance and time scales. Characterisation of fractured rock environments and especially

secondary aquifers is extremely challenging. One of the major challenges is the ability to measure the bulk flow and transport characteristics of fractured rocks over a range of practical scales. These issues have considerable practical importance in groundwater management. The estimation of regional transmissivity values carries the burden that if the regional transmissivity values for an area are overestimated, inadequate provision of water would be made for water supply to the local community. The focal point of this study was to evaluate methodologies for converting bulk flow properties from a local perspective into parameters that could be applied at a regional level. Thus the critical issue of this study was to determine methods that yielded representative transmissivity values in a heterogeneous aquifer setting.

Cost: R3 353 940
Term: 2007 - 2012

Programme 3: Water resource planning

Integrating water resource and water services management tools

WRP Consulting Engineers; DMM Software Services

No. 1840

The South African water sector has developed a range of tools for managing water and for resolving water-related problems, and most of these have been continuously improved over time. However, in light of IWRM, the usefulness of these tools depends on the logical structure of valuation procedures, and on the common system required for defining complex water problems. Thus this project was solicited to develop an approach for integrating water resources and water services management tools, and to develop a generic integrated framework, which can incorporate relevant and appropriate water management tools that are used both in water resources and water services, linked by a common flexible and extensible database for use at strategic planning and management levels.

Cost: R2 000 000
Term: 2008 - 2011

Programme 4: Water resource infrastructure

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

University of Stellenbosch

No. 1759

This research project produced two reports:

- Volume I. Literature review and case studies, in which the state-of-the-art knowledge on the quantification of the secondary components to be taken into account in the determination of dam freeboard was investigated. Research carried out in the coastal engineering field of aspects which are relevant and applicable to dams was incorporated.
- Volume II. Guidelines for the determination of freeboard for dams, which has also been reviewed by SANCOLD and is now the new South African guidelines document (2011), replacing the 1990 freeboard guidelines of SANCOLD.

Estimated cost: R320 000
Expected term: 2008 - 2010

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

Rhodes University; University of KwaZulu-Natal; Water for Africa

No.1838

The main objective of the project was to contribute to the incorporation of uncertainty assessments in water resource decision making in South Africa, and the main output was the development of a framework for uncertainty assessments in water resources availability analyses within South Africa. This framework has been based on international experience, the water resource analysis methods that are commonly applied within

South Africa, the data constraints that exist within the country as well as the requirements for water resource management decision making. The framework has been supported by the development of some new approaches to applying existing hydrological models and illustrated by examples of their application. The project has identified the main sources of uncertainty and offers some recommendations on approaches to reduce the level of uncertainty. Some of these are achievable in the short-term through changes in technical practices (such as hydrological model parameter estimation), while others require closer engagement in the future between scientists, water resources engineers and policy makers at Governmental level (such as improvements in the national rainfall monitoring network).

Cost: R950 000
Term: 2008 - 2011

THRUST 2: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Water resources in rural communities in the Limpopo Province: Social, chemical and microbiological quality evaluations and interactions

University of Venda

No.1910

This study examined the degree to which parasitic organisms (helminths, *Cryptosporidium*, *Giardia*, *Cyclospora* and *Isospora*) occur in water resources and sewage treatment plants in the Limpopo Province. Treatment plants were not found to be consistently removing these organisms. Limited water resource sampling also revealed the presence of *Cryptosporidium*, *Giardia*, and *Isospora*. Helminths were not analysed for. Fluoride, chloride, nitrate, cadmium and lead levels in natural water resources and some drinking waters were all found to have some values above South African standards for drinking water. The participative

'photovoice' method, which allows local community members to communicate their concerns relating to their water sources via photographs and associated statements, was investigated and found to be well-received. A socio-economic study revealed the use of unsafe water sources, a degree of diarrhoea (though not established as water-related) and a degree of lack of education in respect of water-related health issues.

Cost: R346 260

Term: 2009 - 2011

Programme 2: Water quality modelling

Persistent organic pollutants (POPs) in the environment

North-West University

No. 1561

This study assessed the scale and significance of pollution of South African waters by certain organic pollutants (OPs) and persistent organic pollutants (POPs). Of the 96 chosen sites, 23 had quantifiable levels of dioxin-like compounds. These sites were mainly industrial, semi-industrial or low-income residential. The concentrations were generally intermediate when compared to concentrations measured in some European, Asian and Scandinavian countries. A screening human health risk assessment identified a few chemicals at some locations to be of potential concern, with carcinogenic effects being anticipated. Further investigation is recommended into the sources and levels of certain OPs and POPs at various sites. Regular monitoring is also recommended to detect other possible areas of concern around the country.

Cost: R1 500 000

Term: 2005 - 2011

Development of a model to assess the cost associated with eutrophication

The Institute of Natural Resources

No. 1568

The objective of this work was to develop a generic first-order model of the direct and indirect costs of eutrophication in South Africa and to apply this to the Vaal Dam. This was a desktop study. The modelling was applied to estimate costs to agriculture, water treatment, property, and recreation. A combination of fixed effects, 'seemingly unrelated regression' (SUR), willingness-to-pay methods and integrated models was used. Importantly, these analyses were based on annual average levels, even though eutrophication levels can change significantly over much shorter time-scales. This data-averaging inevitably resulted in underestimates of the cost impacts of eutrophication. The integrated SUR model indicated the following: annual agricultural costs caused by phosphorus varied from R145/ha to R455/ha; property costs in relation to chlorophyll a varied from R850/m² to R3 340/m²; water treatment costs due to ammonia alone varied from 0.1 c/kL to 18 c/kL. The costs of exceeding Resource Water Quality Objectives for chlorophyll a and phosphate (30 µg/L) varied considerably but were as much as R2 900/ha for agriculture, R18 800 m² for property prices, and 144 c/kL for water treatment. In order to better estimate the economic impacts of eutrophication, it will be necessary to adopt a modelling approach that takes account of the impacts of extreme eutrophic circumstances.

Cost: R2 000 000

Term: 2005 - 2011

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

University of Pretoria (Virology)

No. 1686

The aim of the study was to investigate the possible impact of growth stimulants used at cattle feedlots on EDC activity in surface- and groundwater. Water sources close to selected feedlots in South Africa were screened for oestrogenic and androgenic activity, using a battery of bio-assays. A reproductive toxicology study, using the rat model, was performed on a mixture of compounds identified to be in use in South Africa, at environmentally relevant concentrations. A toxicological study on the sharptooth catfish was performed, and the impacts of selected cattle feedlots on aquatic ecosystems at different sites were assessed. As most of the identified growth stimulants were present at levels below the detection limit in the collected samples, there is a clear need for refinement of the analytical techniques used. Zilpaterol tested positive in most of the water samples, and the combination of different bioassays for oestrogenic activity was successful in detecting such activity in most of the samples. Macro-invertebrate community structures differed between sites upstream and downstream of feedlots. Observations from this study suggest a proper investigation of cattle feedlots regarding the use of EDCs and other veterinary compounds as there is reason to suspect an impact on surface- and groundwater. Currently no environmental impact studies are done for registration of EDCs, and it is suggested that monitoring should become part of the licensing process for these potentially harmful compounds.

Cost: R1 900 000

Term: 2005 - 2009

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

University of the Western Cape

No. 1756

This work focused on waters associated with two water treatment plants operated by Rand Water, and the water treatment plant in Stellenbosch, as well as drinking water from Cape Town, Stellenbosch, Bloemfontein and Johannesburg. The plant raw intake waters, their treated drinking water, and the other drinking waters were analysed for chemical elements, bacteria, estrone (an oestrogen), testosterone, and various biomarkers indicating inflammatory effects (biomarker IL-6), humoral immune responses (biomarker IL-10), and cell-mediated immune responses (biomarker IFN γ). There was evidence that substances were present in the raw water intakes of water treatment plants, as well as in some drinking water samples, which in vitro tests indicate can affect immune responses. Estrone and testosterone, two substances which could elicit such responses, were also detected, albeit at relatively low levels.

Cost: R1 500 000

Term: 2007 - 2011

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

CSIR; University of Cape Town

No. 1845

This work attempted to compare the costs of pollution prevention with the costs of treating pollution-related problems ('prevention versus cure') in the context of increasing salinity, eutrophication, microbial pollution and sediment loads. The complicated nature of the interactions between pollution, pollution prevention and pollution impacts made it difficult to make simple comparisons in

each context. However, the most convincing cases for preventing pollution were made for microbial pollution and increasing salinity.

Cost: R2 000 000

Term: 2008 - 2011

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Sampling and monitoring protocol for radioactive elements

University of the Western Cape

No. 1694

Water demand in Beaufort West has been expanding. In addition to the 4 municipal wellfields, more wellfields are being developed to augment the current groundwater supply. This report summarises all of the activities leading from a survey of the hydrology of the Beaufort West area to the radioactive protocols needed for proper evaluation of the threats posed to the water resources of the town by uraniferous deposits underlying the area. The occurrence of radioactive elements in the Karoo Supergroup was first detected in the Karoo Group in 1964 during kimberlite exploration. Most of the uraniferous occurrences are located in the fluvial-channel sandstones of the Adelaide Subgroup of the Beaufort Group. No evidence of uranium contamination was found in Beaufort West during the project. As the duration of the project was relatively limited, an insufficient database is available to categorically state that groundwater in Beaufort West will not be contaminated by the uranium in future. The proposed monitoring should be implemented, with data captured in the relevant DWA database for the evaluation and protection of groundwater security. The project also indicated a proposed approach to setting up a groundwater protection zone strategy for the water supply points.

Cost: R1 500 000

Term: 2006 - 2012

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

University of the Free State

No. 1766

In typical fractured rock aquifer environments the prediction of the transport and behaviour of LNAPL contamination is highly complex due to the heterogenous nature of these aquifer systems. International best practices are often not suitable for the typical fractured rock aquifer systems encountered in South Africa. A systematic review of site investigation and characterisation methods for the fate and transport of LNAPLs is reported, as well as a methodology to construct a site conceptual model. Two main study areas were used, to highlight the differences in applicable methods to characterise a coastal and inland contamination site. Subsequently a conceptual model of each site was constructed incorporating the most significant features that affect remediation options. An estimation of remediation costs was done, although values presented are based on a generalised site with no significant difficulties or complexities.

Cost: R3 500 357

Term: 2007 - 2012

Nitrate removal for groundwater supply to rural communities

CSIR; University of Stellenbosch; Biostream

No. 1848

High levels of nitrate often render drinking water supplies unsafe for human and animal consumption. Nitrate occurs extensively in groundwater in southern Africa and elevated nitrate concentrations occur both locally at isolated points as well as regionally over vast areas extending over hundreds of kilometres. Nitrate removal technologies are both expensive and sophisticated, thus limiting their suitability for rural applications.

In-situ nitrate removal has been demonstrated to reduce nitrate levels using low-level technology that involved a large plastic tank and wood chips/saw dust.

Cost: R600 000

Term: 2008 - 2011

Assessment of the toxicity of cyanobacteria in the Kruger National Park

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

No. 1850

The aims of this work were to survey 13 Kruger National Park (KNP) dams for cyanobacteria and their cyanotoxins and to examine any carcasses for evidence of exposure to these toxins. Six sampling trips took place between June 2009 and February 2011. Samples were analysed for dominant algal species, various physico-chemical parameters including nutrients, toxicity (using the ABRAXIS strip test and enzyme-linked immunosorbent assay - ELISA) and 7 microcystin variants using high pressure liquid chromatography (HPLC). Zebra liver samples were also analysed for evidence of microcystin poisoning. There was considerable evidence of cyanotoxins and their toxicity in the water samples. Symptoms of microcystin poisoning were also evident in the zebra liver samples. The strip test was shown to have reasonable agreement with the ELISA results and was recommended for routine microcystin monitoring.

Cost: R395 000

Term: 2009 - 2011

Quality control and assurance guideline for South African toxicity testing laboratories

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

No. 1853

The primary output of this work was a comprehensive quality assurance manual for aquatic toxicity testing laboratories in South Africa comprising a series of about 200 individual quality management documents that can be customised to individual manager's requirements. This is complemented by two reports: (1) a report on the status quo of toxicity testing in South Africa; (2) guidelines for accreditation of routine aquatic toxicity testing laboratories (focusing specifically on quality assurance and quality control). Nationwide legislative incentives for implementing the Direct Estimation of Ecological Effect Potential (DEEEP) approach, the National Toxicity Monitoring Programme (NTMP) and/or incorporation of toxicity testing into water use licences on a larger scale than at present are likely to be necessary to create sufficient numbers of samples to ensure sustainable financial viability of routine aquatic toxicity testing laboratories.

Cost: R600 000

Term: 2008 - 2010

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

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

No. 1854

This study developed a method for calculating an indicator that gives the relative risk to the aquatic environment of a series of specified pesticides that are being, or might be, applied to crops in a specified location adjacent to surface water resources. Validating the indicator against measured pesticide

concentrations in river water and sediments showed a reasonable level of success. If applied, this method has the potential to support decision making and hence contribute to minimising off-site impacts of pesticides on the aquatic environment.

Cost: R900 000
Term: 2008 - 2011

Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach

Golder Associates Africa (Pty) Ltd

No.1912

This work streamlined, tested and assessed a new and practical approach to integrated water quality management (IWQM) which reduces management to relatively small and well-defined management units and establishes a vertical and horizontal reporting framework. Simple measures of compliance (yes or no) to targets are communicated between neighbouring management units. Accountability was therefore localised and explicit. The general receptiveness of many stakeholders and the effectiveness of the core model were evident.

Cost: R857 120
Term: 2009 - 2011

Scoping study on the management of microbial contamination (taking also chemical quality in consideration) in water resources in CMAs

University of Pretoria

No.1934

A literature survey was undertaken to assess in situ measures that have been used to mitigate microbial pollution in surface waters. These include vegetated buffer strips, wetlands, stabilisation ponds, soil infiltration, settling basins and land management engineering. Secondly, new molecular analytical

techniques, namely, pyrosequencing and phylochip analysis, were investigated. Although successful in providing a detailed picture of bacterial species diversity and abundance, water-borne pathogens were seldom detected. Therefore, health risk assessments cannot be performed using these methods. However, the methods show potential for other more general investigations.

Cost: R250 000
Term: 2009 - 2011

THRUST 4: WATER RESOURCES AND CLIMATE

Programme 2: Climate change risk, vulnerability and adaptation

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

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

No. 1843

This project was initiated as a result of, among others, disparities in water availability and access to water experienced by many of the country's people, which could well be amplified by climate change. Other factors that were taken into account were that South Africa is characterised by a highly variable climate added to an already stressed water situation and an imperfect governance system. It became clear that projected amplification of the effects of climate variability and climate change on hydrological responses requires enhancement of the ability to respond to change. The authors maintain that adaptation and hence adaptive capacity call for the ability of responsiveness as well as a continual uptake of new information into decision-making processes in order to evaluate the negative effects and potential

benefits from climate change. Predictive scenarios, indicating risk levels, for the biophysical changes associated with projected climatic change for climatically divergent catchments in South Africa were then developed. The sensitivity and adaptive capacity of current socio-economic activities to the biophysical changes associated with the projected climatic change were evaluated and quantified, while the likely socio-economic impacts were assessed by accounting for socio-economic resilience and adaptive capacity to climate change. Appropriate policy responses and mitigation strategies to assist communities in adapting to climatic change are proposed.

Cost: R2 500 000
Term: 2008 - 2011

THRUST 5: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

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

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

This study focussed on the achievement of redress of race and gender inequities as water allocation reform is implemented. It aimed to derive lessons from international experience and also from initial implementation of various processes and to make this information available for improving immediate interventions. Existing or current studies on water allocation reform and trading of water rights in relation to economic development were also considered. Existing processes and instruments, some of which have been implemented in some catchments, and their contribution to redress of race and gender inequities, were interrogated, with bottlenecks and hindrances identified, and solutions suggested to improve the achievement of redress while balancing the beneficial use of water contributing to economic development.

Cost: R1 050 000
Term: 2008 - 2010

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

Water and Development Management

No. 1972

The immediate objective of this study was to determine why water users and other stakeholders have not taken advantage of the opportunity to lead the establishment of CMAs in the absence of action by Government. To do this, it sought to identify the concerns of a diverse group of water resource stakeholders about the benefits and disadvantages of establishing a CMA. The wider purpose was to better understand stakeholders' attitudes to institutions such as CMAs as interventions to improve water resource management in South Africa. Focusing on the Upper Vaal and Olifants river catchments, two 'water management areas' that extend from the Free State to Gauteng, Mpumalanga and Limpopo provinces, the knowledge and views of more than 50 water users and other stakeholders were surveyed.

Cost: R600 000
Term: 2010 - 2011

Programme 2: Compliance and enforcement

Towards regulation of water resource management in South Africa

Pegasys Strategy and Development (Pty) Ltd

No. 1842

The effective regulation of the water sector is an increasingly critical focus of the work of the Department of Water Affairs. While the water services regulatory strategy has been fully developed, a comprehensive regulatory strategy for water resources management is still required – one that focuses on the overall regulation of water resources as a critical part of

water resources management. This project aimed to assess international best practice on technical/policy regulation of water resource management and linkages to water services regulatory approaches; clarify definitions, objectives and scope for effective and transparent water resources regulation in South Africa; assess the institutional principles and considerations to guide the roles, responsibilities and institutional arrangements; examine appropriate tools for achieving effective regulation, understand the benefits and risks to using regulatory impact assessments and to disseminate the findings of the project to relevant decision-makers.

Cost: R1 270 000

Term: 2008 - 2010

Development of a system dynamics model for the implementation of IWRM in South Africa: Phase II: Pilot implementation and design of the PMS

Jeffares & Green (Pty) Ltd

No. 1973

The Performance Management Tool for the Implementation of IWRM in South Africa (or PMT) provides CMAs and other organisations that are involved with the management of water resources and catchment areas with a tool for implementing IWRM. The PMT aims to draw attention to areas where management targets for a selected WMA or catchment area are not being met, and to provide possible reasons for this as well as recommendations for the way forward. This will enable the CMA to track and measure its functions, as well as make management decisions and to allocate necessary resources to appropriate areas/activities.

Cost: R442 750

Term: 2010 - 2011

Programme 3: Pricing and financing WRM

Determining the socio-economic value of groundwater in the TMG Aquifer

University of the Western Cape

No. 1974

In the past decision-making systems have focused on the value of groundwater as a resource in its own right. This has led to a significant spectrum of water values being excluded from the decision-making process. There is thus very little knowledge amongst policy and decision-makers regarding the true value of groundwater. This study sought to address this issue through the development and application of a holistic valuation model that incorporates all the significant use and non-use values of groundwater. The case study area was Franschhoek, a small peri-urban community located in the Western Cape. The main objectives of the study were to: (1) develop and apply a valuation model in order to determine the total socio-economic value of groundwater within specific sampling areas and (2) identify the underlying socio-economic factors that influence that the value of groundwater. The scope of the contingent survey was to include only the residential sector and not the commercial or agricultural sector. The method that was selected was the contingent valuation method (CVM). The market value of groundwater is indeterminate because the consumption is non-responsive to changes in price. This is because the price of water is too low and as a result consumers don't factor it into their consumptive considerations. The willingness-to-pay estimates of R119 and R457 for the less affluent and more affluent segments of the Franschhoek community are strong evidence of society's willingness to protect the environment. There are several factors that influence the willingness-to-pay for the non-market values of groundwater, though most of them relate back to household income levels and perceptions of the municipality/state.

Cost: R300 000

Term: 2010 - 2012

Programme 5: Future scenarios

The water sector institutional landscape by 2025

CSIR; Barbara Heinzen (independent consultant); HSRC

No. 1841

The Water Research Commission initiated this research project to build knowledge about key drivers and uncertainties related to the future of the South African water sector institutional landscape. The focus was on water resource management in the country, with relevance also to the water services sector. The institutional landscape referred to the context in which water institutions would operate in the future, rather than different operational models or configurations for water institutions. This knowledge has been translated into different scenarios (or stories) that hold potential implications for social and economic development, as well as for water resources and services. This research provides stakeholders and policy-makers in South Africa's water sector with valuable insights to strengthen decision-making and to counter undesirable trajectories of change. The knowledge produced through this project will not only benefit resource managers and decision-makers, but will empower all role players in the water sector to engage in participative governance. Role players include politicians and policy-makers, Government officials, the private sector, civil society, the urban middle class and poor rural communities.

Cost: R2 000 000

Term: 2008 - 2011

CURRENT PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Delineating Quinary catchments for South Africa and modelling their associated hydrolog

CSIR

No. 2020

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

Estimated cost: R295 000

Expected term: 2010 - 2011

HYLARSMET: A hydrologically consistent land surface model for soil moisture and evapotranspiration modelling over Southern Africa using remote sensing and meteorological data

Pegram and Associates (Pty) Ltd

No. 2024

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

Estimated cost: R1 423 000

Expected term: 2010 - 2013

A comprehensive short-term heavy rainfall forecasting system for South Africa with first implementation over the Gauteng Province (SHORTRAIN)

University of Pretoria

No.1906

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

Estimated cost: R965 900
Expected term: 2009 - 2011

Programme 2: Surface water/groundwater hydrology

Nutrient and organic carbon fluxes from small-scale agriculture

University of KwaZulu-Natal

No.1904

The understanding of the sources and pathways of water in a catchment is essential for successful prediction of water quality impacts on receiving streams as well as for the evaluation of remedial measures proposed to abate unacceptable water quality loads. This is especially true for sediment and nutrient fluxes in agricultural catchments. The research will quantify impacts on

larger scale catchment sediment, nutrient and organic carbon loading from extended small-scale agricultural land use changes. Nutrient management advice for small-scale farmers, as well as to downstream water resource managers, will be available through this project. Carbon flux evaluation will contribute to quantification of the global carbon budget and implications for climate change.

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

The use of isotope hydrology to characterise and assess water resources in South(ern) Africa

University of the Witwatersrand

No.1907

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

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

Hydrology of South African soils and hillslopes (HOSASH)

University of the Free State

No. 2021

It has been recognised that there is an intrinsic and interactive relationship between soil and hydrology; thus hydrologists acknowledge that spatial variations of soil properties significantly influence hydrological processes. Attempts have been made previously to link different hydrological behaviour of different soils at a pedon (or small) scale. This study focuses on upscaling this

pedon classification system towards hillslope hydrology then to catchment scale and thereby improving our understanding of hillslope hydrology. The main aim of the study will be develop a hydrologically-based classification system of South African soils and hillslopes which will assist in hydrological modelling especially in un-gauged basins.

Estimated cost: R 5 000 000

Expected term: 2010 - 2015

The long term impact of *Acacia mearnsii* trees on evaporation, streamflow, low flows and groundwater resources. Phase II: Understanding the controlling environmental variables and soil water processes over a full crop rotation

CSIR

No. 2022

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

Estimated cost: R800 000

Expected term: 2010 - 2012

A method of 3-D fracture connectivity determination and its hydrogeological application

University of the Western Cape

No. 2023

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

Estimated cost: R300 000

Expected term: 2010 - 2011

Programme 3: Water resource planning

National water resource planning for operational needs: an update of applied approaches (Phase 1): Integrated modelling for water resource planning and operational management

University of KwaZulu-Natal

No. 1951

Computer models of water resource systems are a tool for understanding and managing water resources. There are two main drivers for the need for better water resources modelling tools in South Africa: (i) in many catchments water demand exceeds available supply, and (ii) the requirements of the National Water Act (NWA). Water resource managers require improved water resources modelling tools for planning and operations to assist them in making management decisions leading to better water allocation and efficiency. Typically models are developed for specific domains within the water resource system and integrated water resources management will require integration of the models representing specific domains to provide a systems perspective for water management decisions. Water resources modelling tools are required both for water resources planning and for water resources operations. Water

resources modelling for planning is widely practiced in South Africa, though many of the water resources modelling tools currently in use were developed prior to the 1998 NWA and may need to be updated, extended or replaced in order to meet the NWA requirements. The use of water resources modelling for operations appears to be less widely practiced in South Africa and is an area of water resources modelling that requires further development and implementation. Recent improvements in climate forecasting and remote sensing have increased the data and information available to water resource managers and expanded the scope for water resources modelling to aid operational decisions by water managers. It is important that the concepts and methodologies used in water resources modelling for planning and operations are compatible.

Estimated cost: R2 300 000

Expected term: 2009 - 2012

Enhancements to WR2005 study (completed for the WRC in December 2008)

SSI

No. 2019

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

Estimated cost: R450 000

Expected term: 2010 - 2011

Optimal utilisation of geothermal water resources

UNISA

No. 1959

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

Estimated cost: R2 380 655

Expected term: 2010 - 2013

Programme 4: Water resource infrastructure

Structural health monitoring of arch dams using dynamic and static measurement

University of Cape Town

No. 2025

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

Estimated cost: R1 500 000

Expected term: 2010 - 2013

THRUST 2: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

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

No. 1849

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

Estimated cost: R2 964 000

Expected term: 2008 - 2012

Implementation of the rule based-agent for *Microcystis* in Rietvlei Dam

North-West University

No. 1962

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

for prediction and control of cyanobacterial and other algal blooms.

Estimated cost: R175 000

Expected term: 2010 - 2014

The optimisation of available human, institutional, technical and financial resources to strategically approach deteriorating water quality in SA through innovative and collective effort focussing on sources of pollution in prioritised fashion

Golder Associates Africa (Pty) Ltd

No. 1970

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

Estimated cost: R500 000

Expected term: 2010 - 2012

Programme 2: Water quality modelling

A large scale study of the human-induced impacts on the microbial and physico-chemical quality of ground- and surface water in the North-West Province, South Africa

North-West University

No. 1966

The water resources of the North-West Province are deteriorating in quality through pollution and this has impacts on the microbiological as well as chemico-physical dynamics of such a source. It is thus logical that when human-induced impacts on source waters are investigated that both these sets of parameters be included. In a scoping study on the quality of

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

Estimated cost: R1 204 800

Expected term: 2010 - 2012

Investigations into the existence of unique environmental *Escherichia coli* populations

University of Pretoria

No. 1967

A variety of pathogenic and non-pathogenic *Escherichia coli* are found in association with the gastrointestinal tracts of warm-blooded animals. The presence of *E. coli* in other environments is apparently maintained by the constant input of isolates from the primary habitat. For this reason *E. coli* is used as an indicator of recent faecal contamination. This is the basis for using presence of faecal coliforms as indication of faecal pollution. A number of studies have shown that specific *E. coli* strains are capable of surviving in sand and sediments of freshwater systems for longer periods than previously thought. Further evidence suggests that *E. coli* multiply in both tropical and colder waters in the apparent absence of any faecal contamination. These recent findings question the use of *E. coli* as an effective indicator organism

of faecal pollution. The overall goal of the proposed study is to investigate whether natural populations of *E. coli* are structured according to habitat, and if so whether unique environmental strains of *E. coli* exist in nature. It is hypothesised that any imposed separation in terms of habitat would reflect at the genetic and genomic levels.

Estimated cost: R600 000

Expected term: 2010 - 2013

Programme 3: Impacts on and of water quality

The Manual of Guidelines for Projects on EDCs in Water Resources: Volume 1: Monitoring and Assessment Guide

University of Pretoria

No.1915

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

Estimated cost: R1 500 000

Expected term: 2009 - 2012

Guidelines for EDC Management in Water Resources: Volume 4: Management Options for EDCs in Catchments

Golder Associates Africa (Pty) Ltd

No.1933

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

Estimated cost: R1 500 000

Expected term: 2009 - 2012

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Investigation of the fate and transport of selected microorganisms in two simulated aquifer conditions in the laboratory and in the field

CSIR

No.1905

The detailed behaviour of microorganisms in groundwater is not well-understood. There are many kinds of microorganisms and many processes that affect their fate and transport, and these vary from one aquifer type to another. The National Microbial Monitoring Programme for groundwater has been

developed for DWA. Besides the movement of groundwater, there are processes such as natural die-off, formation of biofilms, adsorption, etc., which are taking place, and there is inadequate local understanding of the nature and extent of the chemical, physical, biological and microbiological processes that control the fate and transport of microorganisms in South African aquifers. This project aims to develop a sound database and monitoring protocol upon which future comprehensive fate-and-transport modelling of microorganisms in dolomitic aquifers can be based, and which would enable more detailed modelling (inevitably scenario-based) and could contribute significantly to the development of appropriate strategies that mitigate associated human health risks.

Estimated cost: R1 500 000

Expected term: 2009 - 2012

Assessment of the prevalence of human viral and bacterial pathogens in some recreational beaches and rivers in Amathole District Municipality of the Eastern Cape Province of South Africa

University of Fort Hare

No. 1968

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

physicochemical qualities of selected recreational waters and rivers in the Eastern Cape Province.

Estimated cost: R680 000
Expected term: 2010 - 2012

THRUST 4: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Developing climate change adaptation measures and decision-support system for selected South African water boards

Rhodes University
No. 2018

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

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

Modelled sea-surface temperature scenario considerations and Southern Africa's seasonal rainfall and temperature predictability

South African Weather Service
No. 1913

The objective of this project is to investigate an optimal model configuration that includes the best available description of the surface boundary conditions, as reflected in the projected global sea surface temperature, in order to force global circulation

models (GCMs) to produce seasonal rainfall and temperature over South Africa at lead times of several months. A comprehensive analysis between one-tiered and two-tiered forecasting systems will be conducted to inform decisions on development of a fully coupled forecasting system for the region. The model will then be implemented and run to generate required data. Seasonal predictability will also enhance adaptive water management capacity.

Estimated cost: R488 625
Expected term: 2009 - 2012

Projected impacts of climate change on water quantity and quality in the uMngeni Catchment

University of KwaZulu-Natal
No. 1961

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

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

Modelling daily rain-gauge network measurement responses under changing climate scenarios

Pegram and Associates (Pty) Ltd
No. 1964

Monthly streamflow modelling should be complemented with stochastic rainfall runoff modelling that is coupled with predicted future climatic variability or change. The purpose of this project is to establish a link between rainfall and climate change. The meso-scale scenarios that are typically generated by GCMs will be disaggregated into small spatial and temporal scales

using probabilistic-stochastic methods. The methodology will entail identifying a subset of available Global Circulation Models (GCMs), whose meteorological time series outputs are plausible in a hydrological context, with particular emphasis on Southern Africa. It will then determine links between climate variability (as modelled by GCMs) and daily rainfall as recorded in meso-scale to regional gauge networks and demonstrate the plausibility of generating stochastic ensembles of future multisite rainfall time series, reflecting plausible future climate changes.

Estimated cost: R1 000 000

Expected term: 2010 - 2013

Programme 2: Climate change risk, vulnerability and adaptation

The role of local community institutions in the adaptation of rural and urban communities to the impacts of climate change on water access and use

UNISA

No. 1963

This project should focus on the identification and development of existing policy frameworks for examining adaptation practices in the context of rural institutions' role towards livelihood needs. This will be based on analytical approaches that take into account increases in environmental risks, reductions in livelihood opportunities and stresses on existing resources and social institutions. Investigations into likely responses such as migration or mobility, diversification and other adaptation options in light of climate impacts should also be undertaken. The project includes piloting in a rural setting and at urban community levels. The piloting should advise policy discourse on recommended parameters that can reduce these impacts.

Estimated cost: R3 000 000

Expected term: 2010 - 2013

Developing water-related climate change adaptation options to support implementation of policy and strategies for Water for Growth and Development

University of KwaZulu-Natal

No. 1965

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

Estimated cost: R3 000 000

Expected term: 2010 - 2013

Development of decision-support guidelines for vulnerability assessments and adaptation requirements among rural economies and communities, including gender issues (Phase 1)

University of the Free State

No. 2027

Climate change is already starting to affect some of the poor and most vulnerable communities around the world. The effect that increased droughts, extreme weather events, tropical storms and sea level rises will have on large parts of Africa will be inflicted in our lifetimes. For some rural communities, the consequences could be apocalyptic. These communities have limited access to essential services, and this is also compounded by uneven distribution and overexploitation of water resources. Understanding sensitivities and vulnerabilities

of systems and communities is necessary to inform adaptation action. This approach is particularly crucial since communities' resilience varies according to their adaptive capacities to climate change. These vulnerabilities are not only found in Africa but are a concern worldwide. Various methods and frameworks are available to assess the vulnerability of communities facing various environmental hazards (in this case impacts associated with climate change). These can be applied to the topic of water (both as a problem or a solution) and human security. In such an analysis, the links between the social, ecological and physical systems needs to be addressed and the vulnerability assessment needs to be encapsulated within a wider framework of sustainable development to be policy relevant. This will allow the decision-makers to manage the vulnerability of communities and make the necessary adaptations within the larger context of planning and development.

Estimated cost: R700 000
Expected term: 2010 - 2012

Investigation of effects of climate change on eutrophication and related water quality and secondary impacts on the aquatic ecosystem

Golder Associates Africa (Pty) Ltd

No. 2028

There are a number of risks associated with human-induced climate change, which vary from low to high. Management of eutrophication is of particular concern, since this presents severe problems for the treatment of water and presents a potential health threat when trihalomethanes (THMs) are formed after chlorination. The potential impacts of global warming will increase the frequency of toxic algal blooms, which present a health threat for domestic use and livestock watering, and the clogging of drippers by algae hinders irrigation farming. Decaying algae and macrophytes can also cause oxygen depletion, to the detriment of fish and other aquatic life forms. Waterfowl are adversely affected by the closure of water surfaces with

floating macrophytes. The presence of algae and water hyacinth is aesthetically unacceptable, impairing the use of watercraft, discolouring the water and causing taste and odour problems. The response of the river to nutrient enrichment is affected by many inter-related factors, including phosphate, nitrate and carbon cycling, decay, turbidity, sedimentation, sediment re-mobilisation, temperature, seasonal and diurnal effects, effluent input, abstractions and the critically important hydraulic characteristics of the system. These complex interactions can only be assessed using computer models.

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

Programme 3: Integrated flood and drought management

Extreme events: Past and future changes in the attributes of extreme rainfall and the dynamics of their driving processes

University of Cape Town

No. 1960

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

Estimated cost: R420 000
Expected term: 2010 - 2012

THRUST 5: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Water governance decentralisation in Africa: a framework for reform process and performance analysis

University of Pretoria

No. 1969

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

Estimated cost: R1 000 000

Expected term: 2010 - 2013

The Development of an Institutional Adequacy Index using the Multi-dimensional Poverty Approach

University of the Western Cape

No. 1971

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

Estimated cost: R1 590 000

Expected term: 2010 - 2013

IWRM - from theory to practice

University of the Western Cape

No. 1975

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

Estimated cost: R1 005 000

Expected term: 2010 - 2013

Programme 2: Compliance and enforcement

Development of the AWARE model for the Inkomati CMA

University of KwaZulu-Natal

No. 1935

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

Estimated cost: R1 800 000
Expected term: 2009 - 2013

NEW PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The hydrogeology of Groundwater Region 17: Central Highveld

Council for Geoscience

No. 2049

The main objective of this study is to produce a report that summarises and synthesises the fragmental present-day knowledge about the occurrence of groundwater in the Karst Region. The report will serve as a guide in the exploration and further development of groundwater supplies.

Estimated cost: R700 000
Expected term: 2011 - 2013

Developing a citizen-based rainfall monitoring system

Pegasys Strategy and Development (Pty) Ltd

No. 2057

This project aims:

- To synthesise experiences, both locally and internationally, with regards to supplementing rainfall data with differing data sources, particularly citizen-based gauging
- To source and collect citizen-based rainfall data, bearing in mind the need to develop a more systematised manner for submission of this information
- To evaluate citizen-based data against other data sources such as SAWS and satellite data as well as broadly assessing the uncertainties related to the various data sources

- To model the impacts of the various rainfall data sources upon the understanding of water resources within the Breede Water Management Area and from this to generate key lessons
- To provide insights into systems issues and requirements together with key role players such as DWA, BOCMA, and SAWS

To develop some practical steps to improve the rainfall monitoring networks supported by citizen-based networks, bearing in mind the various institutional roles and responsibilities.

Estimated cost: R400 000
Expected term: 2011 - 2013

The establishment of rain gauge networks for rainfall estimation calibration of the South African new weather radar network

University of the Witwatersrand

No. 2062

Overall, this project aims:

- To develop a rainfall estimation algorithm using rainfall data from the new S-band dual-polarised Doppler radar at Bethlehem and validated against a dense rain gauge network
- To achieve the re-establishment of the Liebenbergsvlei catchment rain gauge network, near Bethlehem, as a ground-based validation/calibration tool
- To achieve the establishment of a rain gauge network in the Cape Town area, so as to create a validation tool for comparisons between convective rainfall (in the Bethlehem area) and stratiform rainfall (in the Cape Town area)

The aim of re-establishing a network of rain gauges is not only for the validation purposes of this project, but to provide a long-term sustainable network for the validation and calibration of future radar/satellite studies. Such a network is also a good platform to provide a long-term record of rainfall data over central South Africa.

Estimated cost: R1 100 000
Expected term: 2011 - 2015

Programme 2: Surface water/groundwater hydrology

Surface water, groundwater and vadose zone interactions in selected pristine catchments in the Kruger National Park

University of KwaZulu-Natal (Pietermaritzburg)

No. 2051

This project seeks to define the interactions of groundwater, surface water and the vadoze zone within a pristine catchment (within the Kruger National Park). This will form a sound base upon which to facilitate further multi-disciplinary environmental research for extrapolation elsewhere; it will also enable the determination and quantification of scale-dependent hydrological processes in clearly organised landscape sequences in a pristine setting.

Estimated cost: R1 800 000
Expected term: 2011 - 2014

Impact of fault structures on the occurrence of groundwater in fractured rock aquifers

Council for Geoscience

No. 2053

Amongst geological features in fractured rocks, faults are one of the most important geological structures that control the occurrence of groundwater in fractured rock aquifers. Fault-controlled aquifers have been one of the most important wellfield development targets for water supply. Problems often arise from the application of current conceptual models on the evaluation of fault-related aquifers. This is mainly due to many unknown parameters of faults that are often required as input to both qualitative and quantitative models. This study aims to (a) develop multiply approaches to the delineation and characterisation of fault-controlled fractured aquifers; (b) develop sound methods

for the establishment of conceptual models of fault-controlled aquifer types which will produce both 2-D and 3-D models; and (c) estimate aquifer properties and groundwater flow based on established conceptual models, using well-calibrated numerical models.

Estimated cost: R600 000
Expected term: 2011 - 2014

Groundwater-surface water interaction: From theory to practice

University of the Free State

No. 2054

The interaction of groundwater and surface water occurs in a complex hydrological continuum, and several studies have been completed that looked at groundwater (GW) and surface water (SW) interactions from mainly a desktop perspective. Other studies took this further through case studies but there is not much that has been done on the actual measurements of the fluxes between these reservoirs. The main aims of this project will be to: (a) review current state-of-the-art methodologies to measure surface water and groundwater interaction methods at local and catchment scale; (b) set up a data collection network and test various observation methods at a test site; (c) develop appropriate innovative methodologies/approaches to measure surface water and groundwater interactions at a test site and/or either upscale and apply to another test site; (d) assess uncertainties arising from the underlying conceptual-mathematical framework; (e) assess the developed methodologies at test sites; and (f) develop guidelines for other test sites and the best-way-forward methodology.

Estimated cost: R2 000 000
Expected term: 2011 - 2014

Investigation of groundwater potential in fractured crystalline rocks of the North-West Province, South Africa

Council for Geoscience

No. 2055

In this research, geophysical, hydrogeological and remotely-sensed data will be used to assess the groundwater potential of the North-West Province. The Vryburg area was selected as a case study site because there is a growing need for water. This project will mainly aim to develop approaches that will assist local authorities in developing potential groundwater supply target zones.

Estimated cost: R1 000 000

Expected term: 2011 - 2013

Development of the pressure release flowing test method for artesian flow aquifers with case study in TMG

University of the Western Cape

No. 2058

This project will develop and evaluate methods to test artesian boreholes and estimate aquifer parameters. It will cater for the artesian flow systems associated with semi-confined, locally confined and weakly confined aquifers. The research will be based on existing boreholes identified in fractured rock. A test unit will be developed that will be mounted in pressurised boreholes to measure the required parameters necessary to determine aquifer properties to improve borehole and/or aquifer management.

Estimated cost: R400 000

Expected term: 2011 - 2013

Validation of the forcing variables (evaporation and soil moisture) in hydrometeorological models

University of KwaZulu-Natal

No. 2066

This project aims to:

- Provide data for the continued support of soil moisture modelling of South Africa using a hydrologically consistent Land Surface Model (follow-on project proposed from K5/1683)
- Provide accurate field and satellite estimates of the forcing variables (Eta and SM) for the calibration of hydro-meteorological models
- Evaluate the spatial variability of SM at catchment scale

Estimated cost: R700 000

Expected term: 2011 - 2014

Programme 3: Water resource planning

Development of a groundwater resource assessment methodology for South Africa: towards a holistic approach

University of the Free State

No. 2048

Project aims:

- Review the GRA II methodology to address identified gaps and improve confidence levels in the current methodology
- Update data sets to address, e.g. distribution of recharge figures, poor distribution of chloride figures, etc.
- Generate data sets for groundwater use
- Revise the methodology and identify data requirements
- Pilot testing of the methodology

Estimated cost: R980 000

Expected term: 2011 - 2013

Implementing uncertainty analysis in water resource assessment and planning

Rhodes University

No. 2056

Project aims:

- To utilise newly emerging field-based information on the various processes involved in surface-groundwater interactions (recharge, storage, evaporation losses, discharge to rivers, etc.) to test and, where appropriate, improve the algorithms of the Pitman model as well as improving the quantification of the relevant parameters, thereby reducing the overall uncertainty in the use of this part of the model
- To further assess rainfall input uncertainties and the possibilities of reducing the uncertainty through the use of different sources of information
- To ensure that the climate change uncertainty assessments are integrated with other approaches designed to reduce uncertainty
- Facilitation to ensure that water resource engineers understand and appreciate the value of including uncertainty and are comfortable with the use of new modelling approaches that include uncertainty
- To determine suitable uncertainty bounds around the existing regional parameters (part of WR2005) of the Pitman model
- To further develop practical procedures for constraining the uncertain outputs from hydrological models using either regional indices of hydrological behaviour and/or observed streamflow data (that may themselves be uncertain)

Estimated cost: R600 000

Expected term: 2011 - 2014

Programme 5: New water

Optimising fog water harvesting

UNISA

No. 2059

Project aims:

- Understanding the physical and chemical complexities of fog and its formation: a) to determine the physical and chemical characteristics of East and West Coast fogs (drop size, density, moisture content, biological and chemical characteristics; b) to determine the factors affecting the occurrence and moisture content of fog (including the relationship between fog occurrence and rainfall, wind speed, sea surface temperature, upwelling extent (west coast), synoptic conditions (west coast); c) to determine the possible influence of climate change on the fog phenomenon and associated environmental and social impacts
- Optimising the fog water harvesting processes: a) to delineate optimal sites for fog water collection; b) to evaluate different materials so as to identify the most effective fog water collector; c) to assess the impact of the erection of fog water collection systems on the environment; d) to investigate possible alternative uses for fog water
- The development of novel products: a) to design and build a water flow meter for low-flow conditions; b) to design and develop fog water harvesting systems for unique/specific environmental conditions; c) to develop a low-cost optical fog detector with LWC potential; d) to develop new materials for fog water harvesting

Estimated cost: R2 500 000

Expected term: 2011 - 2015

THRUST 2: WATER QUALITY MANAGEMENT

Programme 2: Water quality modelling

Implementation of salinity and water management tools for the Berg and Breede catchments in the Western Cape

University of Stellenbosch

No. 2063

The general aim of the project is to implement salinity management tools at pilot catchment(s) in the Western Cape. The specific aims of the research are: to identify specific salinity-related problems and potential solutions in selected pilot catchment(s) in the Western Cape and to collect baseline data and set up catchment management tools (to populate informational databases, design an ideal monitoring network and set up spatial hydrological models). Activities will also include the following: to assess historic and current impacts of climate and land uses on water resources in multi-functional landscapes with particular focus on specific regional problems (e.g. salinity) and to refine and apply existing catchment management tools to the selected pilot catchment(s); and to run scenarios/forecasts and recommend land uses to minimise impacts on water resources in multi-functional landscapes with particular focus on specific regional problems (e.g. salinity), taking into account institutional arrangements and socio-economic implications.

Estimated cost: R1 000 000

Expected term: 2011 - 2013

Nutritional factors influencing the biosynthesis of the neurotoxin Beta-N-methylamino-L-alanine by cyanobacteria

Nelson Mandela Metropolitan University

No. 2065

The aim of the research is to determine the role of environmental nitrogen, phosphorus and light quantity and quality on BMAA production by cyanobacteria, and to determine whether BMAA is produced differentially as a function of growth rate or growth phase. The purpose is also to evaluate a range of easily measured metabolites to find those that correlate with BMAA so as to facilitate easy BMAA measurement without expensive equipment and to establish the mechanism of BMAA biosynthesis in cyanobacteria.

Estimated cost: R500 000

Expected term: 2011 - 2013

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Vadose zone hydrology: Spatial and temporal influences, assessment techniques and aquifer susceptibility

University of Pretoria

No. 2052

The safe locating of potential sources of contamination and the mitigation and rehabilitation of contamination can be better assessed based on an improved understanding of the spatial (or lateral), vertical (or horizon-based) and temporal (or time-dependent) influences on vadose zone seepage. This project will investigate the behaviour of water and solute within the unsaturated zone and evaluate field, laboratory and empirical assumptions currently being made to assess the fate and transport of contaminants in the vadose zone.

Estimated cost: R1 000 000

Expected term: 2011 - 2014

Towards an integrated framework for the assessment and management of sediment-related impacts on water resources in South Africa: A dam performance case

Muondli Consulting and Projects

No. 2064

This project assesses and reviews existing knowledge and literature on existing sediment-related impact assessment and management frameworks. This will cover impacts of sedimentation on major rivers and navigation pathways, aquatic ecosystems, and water supply systems. The project will, as one of the key outcomes, investigate and identify new concepts, technology and data sources that could improve the processes involved in an integrated sediment related impact assessment and management platform. A case study will also be developed that will demonstrate the use of a framework by developing a generic methodology for the analysis of impacts of sedimentation on the performance of dams in South Africa and also apply the developed methodology on selected dams in South Africa.

Estimated cost: R1 100 000

Expected term: 2011 - 2013

Guidelines for the delineation of protection zones in a complex aquifer setting

University of the Western Cape

No. 2069

In this project guidelines will be developed to delineate groundwater protection zones in complex aquifer settings. This guideline will build on the work done by DWA and will include the latest international best practice, minimum data requirements, the latest data collection methodologies and a risk analysis approach. This guideline will be tested at the Rawsonville research site where the fractured TMG aquifer is intersected by a fault and a river.

Estimated cost: R740 000

Expected term: 2011 - 2013

Preventing production borehole clogging by *in-situ* iron removal in South African aquifer systems

Council for Geoscience

No. 2070

This project will test local applicability of the *in-situ* iron removal technique for prevention of clogging in a primary aquifer and associated boreholes as well as a borehole(s) situated in fractured rock aquifer(s). This project aims to eliminate iron-related clogging problems experienced in SA by eliminating the underlying source. This would be done through preventing high Fe (II) concentrations developing in and mobilising from the aquifer. Studies have been done since the 1970s into prevention of iron dissolution from the aquifer matrix and implemented abroad. To date, a practical rather than a pure theoretical approach into Fe (II) fixation in SA aquifers has not been found and this knowledge gap is what this project aims to address through the proposed research. Based on experiences abroad, the most viable option at the moment to research and apply to fixation of Fe (II) in SA aquifers would be through the *in-situ* iron removal treatment.

Estimated cost: R600 000

Expected term: 2011 - 2014

Programme 2: Land-water linkages

Water Sensitive Urban Design (WSUD) or Low Impact Design (LID) for improving water resource protection/conservation and reuse in urban landscapes

University of Cape Town

No. 2071

The aim of this project is to assist planners in water management through guidelines on water resource protection, conservation and reuse using WSUD or LID. The guidelines will include holistic best management practices and assist in establishing urban spaces that will protect the health of watercourses as well as how to implement these BMPs. Innovative solutions will

be developed for, among others, reducing runoff; minimising effluent discharge; increasing recycling opportunities and reducing water demand. This will be achieved within a catchment management framework. It is expected that this project will build on an ongoing WRC project entitled 'Alternative technology for stormwater management'.

Estimated cost: R2 000 000

Expected term: 2011 - 2014

THRUST 4: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Unifying weather and climate variability predictions - An operational seamless forecasting system for Southern Africa at time scales from days to seasons

CSIR

No. 2050

This research project aims to analyse a set of regional projections of climate change in extreme events, particularly CCAM over Southern Africa, within the context of anthropogenic forcing. This will be done in order to develop an optimal operational forecasting system for extreme events over Southern Africa that has the potential to bridge the gap between weather and seasonal forecasts, i.e., a seamless forecasting system. The project also aims to develop an operational seamless streamflow forecasting system for South Africa, and an operational seamless tropical cyclone prediction system for the south-western Indian Ocean, as well as to improve communication between forecast providers and forecast users.

Estimated cost: R950 000

Expected term: 2011 -2014

South African climate multidisciplinary analysis

University of Cape Town

No. 2060

The aim of this research project is to provide an improved conceptual understanding of ocean-atmosphere linkages to hydroclimatic variability in Southern Africa at relevant spatial and temporal scales, with a focus on drought and wet period, the cause of non-linearity between ENSO and Southern Africa hydroclimate and the causes of decadal fluctuations of the ENSO Southern African hydroclimate relationship. This will be achieved by characterising the South African rainfall regime and the evolution of rainfall characteristics and hydrometeorological parameters with climatic fluctuations, documenting the impact of ENSO on the winter rainfall region, assessing the adequacy of models used for seasonal forecasting or climate change scenarios and reviewing and improving knowledge related to the future state of the oceans and coastal regions of Southern Africa. Other tasks will include documenting and understanding the changes in ocean temperature and the Southern African hydroclimate, and the link between the two, over the past 25, 50 and 100 years, and to train students and researchers in data analysis of large and complex datasets, such as the huge dataset generated by high resolution coupled models or satellite remote sensing.

Estimated cost: R1 200 000

Expected term: 2011 - 2014

Development of defensible regional climate change projections for adaptation and policy

University of Cape Town

No. 2061

This research project aims to explore the changes in regional rainfall in relation to climate processes on multiple scales, and so develop more confident understanding of the regional expression of anthropogenic climate change in relation to natural variability. Methodologies include the following:

- Assess techniques in probability/uncertainty analysis for application to South African climate change projections, drawing on existing literature, perturbed physics simulation techniques, and contextualised by understanding of natural variability
- Integrate emerging data sources, especially from multiple models of CMIP5 and CORDEX, along with local institutional climate modelling activities, to support the development of regional climate change projections with associated measures of the envelope of possibilities and uncertainty
- Develop region-relevant skill assessment of model and downscaled climate change projections, and apply appropriate measures for evaluating the quality and value of the different data sources so as to maximise the development of robust interpretations and probability measures.
- Develop and test a framework for incorporating the advances of the above aims into a robust approach to developing regional climate change projections, with appropriate support information on probability and confidence
- Leverage the value of existing perturbed physics model simulations for South Africa (from the UCT/Hadley centre collaboration) to strengthen the assessment of possible attribution of regional climate change

- Incorporate new knowledge into existing climate service activities for the dissemination and communication of regional climate change and incorporate the regional projections into a hydrological model and/or collaborate with external partners to assess the consequences in relation to the existing literature

Estimated cost: R1 317 750

Expected term: 2011 - 2014

The limits of predictability of the South African seasonal climate

University of Cape Town

No. 2067

The research project seeks to determine the limits of the predictability of the South African seasonal climate state and how these limits depend on the season and on ocean and land surface forcing, to determine the robustness of the estimated predictability properties to choice of atmospheric model structure, estimate the contribution of anthropogenic emissions to forecast predictability, estimate the attribution of the risk of extreme weather events to anthropogenic emissions and to characterise the relevance of the limits of predictability in the operational forecast setting.

Estimated cost: R1 200 000

Expected term: 2011 - 2014

Programme 3: Integrated flood and drought management

Improvement of early preparedness and early warning systems for extreme climatic events flood warning

South African Weather Service

No. 2068

Enhancement of the early warning systems of extreme flood events, particularly the SAFFG system, based on in situ observation and remotely-sensed hydro-meteorological information as well as the prediction tool, to support water resource and disaster managers in flash-flood risk evaluation and analyses, river flow forecasting as well as precipitation estimation, is in the aim of this project. Methodologies will include reviewing of international best practices of early warning and preparedness for flash-flood events, and comparison of available technology such as the SAFFG, TOPKAPI and others. Other activities will entail the following:

- Improve rainfall estimation (from radar and satellite) and nowcasting input into the flash flood guidance modelling system
- Improve the hydrological input and products of t-flood guidance warning system, including soil moisture estimation products
- Enhance the integration of system components to enable seamless application of flash-flood warnings down to end-users such as disaster management and water managers

Estimated cost: R813 000

Expected term: 2011 - 2014

THRUST 5: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

Advancing Strategic Adaptive Management (SAM) as a framework for implementation of IWRM by catchment management agencies

University of the Witwatersrand

No. 2072

The overall aim is to advance the understanding and practice of SAM as a framework for IWRM in complex social-ecological systems. This will be achieved by:

- Actively partnering with the ICMA to implement the Inkomati CMS in a participatory and adaptive manner that is cognisant of the demands of complex system management
- Develop sustainable and independently functioning participatory decision-making systems in the Inkomati catchment
- Develop a sound working relationship with DWA to integrate planning and decision systems to make the most of commonalities and differences in mandate and operating procedures between DWA (the regulator) and ICMA (the implementer)
- Gain broader international experience and understanding of IWRM and adaptive management practices, thereby further advancing SAM and IWRM in South Africa
- Undertake a programme of knowledge and skills transfer within South African water sector

Estimated cost: R1 637 975

Expected term: 2011 - 2014

Change-oriented learning and water management practices: knowledge flows and mediation tools

Rhodes University

No. 2074

The aim of this study is to:

- Identify two water management practices in the Eastern Cape to investigate and pilot change-oriented learning models and approaches
- Research learning in two water management practice activity systems to identify features of the learning process, and materials for mediating water management practices in this context
- Produce a question-driven resource that will help to inform and support learning processes associated with the water management practices; the resource will pilot new approaches to mediating water knowledge in relation to these practices (e.g. using multi-media tools)
- Test and develop a training process for mediators, based on the learning models and using the resource for mediation
- Research and develop a community-directed resource catalogue to support change-oriented learning; the purpose of this will be to make knowledge resources accessible within the mediation and learning process.
- Theoretically explore the role of knowledge and learning in building a democratic society with a focus on water resource management practices

Estimated cost: R900 000

Expected term: 2011 - 2014

Investigating stakeholder engagement cycles and identities within water resource management, using narrative techniques

The Narrative Lab

No. 2076

This study will be undertaken in collaboration with Monash University and other notable researchers and will focus on investigating the stakeholder engagement cycles and stakeholder identities that impact on effective water resource management within three contexts selected according to current engagement levels. The study will utilise a narrative research paradigm to ascertain the history of stakeholder engagement at the focus sites, to understand and interrogate the cyclical nature of engagement. The study will also aim to identify the identity discourses that prevail within varying levels of engagement, with a particular focus on the volunteer identity. The second leg of the study will aim to identify the high-potential opportunities that occur within stakeholder engagement cycles so that locations with water resource challenges may leverage the opportunities that present themselves in the future for stimulating increased and sustainable stakeholder engagement.

Estimated cost: R746 108

Expected term: 2011 - 2014

Programme 2: Compliance and enforcement

Embedding property rights theory in cooperative approaches to the management of aquatic ecosystem services in South Africa

University of KwaZulu-Natal

No. 2073

This study is aimed at examining the salient attributes of property rights regimes, particularly common property regimes that sustain cooperative approaches over relatively long periods of time; identifying property rights knowledge gaps in the

management of water resources in South Africa; analysing national policy and legislation with a view to assess the extent to which property rights theory and understanding have been integrated; developing a collective understanding of how property rights regimes, particularly common property theory, influence the management of aquatic ecosystem services in South Africa. Contextualising property rights within the water sector and defining the impact of property rights will be considered in the contexts of: water and society, water and the economy, water and the environment, and water and health.

Estimated cost: R600 000
Expected term: 2011 - 2013

Considering alternative dispute settlement practices for water resources management In South Africa

University of Stellenbosch

No. 2077

This project is aimed at evaluating the need and possibilities for alternative dispute settlement in water resource management, in view of current mechanisms and laws. It intends to ultimately propose alternative dispute settlement mechanisms to complement develop and implement provisions for dispute resolution in water law for South Africa.

Estimated cost: R1 400 000
Expected term: 2011 - 2014

Programme 3: Pricing and financing WRM

Approaches to engaging basin risk and the political economy of water in the Western Cape system

Pegasys International

No. 2075

This study is aimed at: (1) framing possible Government and corporate responses at a basin level which reflect the shared risk

paradigm, the political economy of water use and the challenges of future development and climate uncertainty. It also intends to (2) improve the understanding of the political economy of water use in a river basin, based on the use and movement of embedded water in goods and services, at subsistence, local market, regional economic and international trade levels, and considering linkages into food, energy and water security. The study will (3) develop and improve tools and approaches for quantitatively and qualitatively evaluating basin water use and its political economic implications, under future climate and development uncertainties, and (4) foster dialogue between Government, corporate and civil society representatives about the use, protection and development of basin water resources to secure political, economic, social and ecological development imperatives, through the lens of shared risk in a basin with increasingly stressed water resources.

Estimated cost: R700 000
Expected term: 2011 - 2014

An analysis of water pricing instruments governed by the DWA water pricing strategy, and its potential for generating revenue for CMAs

Prime Africa Consultants

No. 2078

This project aims to investigate the income potential of various instruments for water resource management. It intends to demonstrate the income potential of these instruments on a case study basis. The results from this study should advise on water pricing and CMA budgeting and financing with the purpose of strengthening CMAs.

Estimated cost: R610 000
Expected term: 2011 - 2014

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KSA 2: WATER-LINKED ECOSYSTEMS



*Dr Stanley Liphadzi:
Director*

SCOPE

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river) and water table-dependent (dependent on a water table, but not on surface water). This KSA focuses on the protection and sustainable utilisation of the aquatic environment and biota (instream, riparian and groundwater). This includes the research needs around the international conventions on environmental management (e.g. biodiversity) as well as human needs from the aquatic environment (e.g. sustainable management for equitable ecosystem resource utilisation, recreation and ecotourism). Research undertaken within this KSA continues to address the conservation of aquatic ecosystems in order to provide the knowledge necessary for their sustainable management and functioning. This is done in terms of the national and international commitments ensuring that there is ongoing provision of goods and services which people rely on ecosystems to deliver. This research portfolio will contribute in the delivery of mainly two Government outcomes.

Specific outputs for each outcome, which are relevant to the scope of this KSA, are addressed within the mandate of the WRC. Although special attention is given to the Government outcomes, no major changes in strategic direction took place in 2011/12. The above is achieved by developing technologies

and methodologies, adaptive management processes and capacity to protect the resource and to sustain the flow of environmental goods and services. Technologies and methodologies are developed within this KSA to support the implementation of the national water policy to ensure protection and sustainable resource use and to enhance opportunities to deliver on Government outcomes.

OBJECTIVES

In the light of international trends in research, the portfolio of research falling within the scope of and addressing this KSA was unchanged. The primary and secondary objectives of this KSA have been found to address future research need scenarios appropriately. The main objective is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water; and to develop an understanding of the ecological processes underlying the delivery of goods and services from the water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

This is achieved through the following (secondary) objectives:

- Develop an understanding of the ecological processes underlying the delivery of goods and services
- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems

- Transfer the knowledge to appropriate end-users through the development of innovative tools and methods for effective knowledge dissemination. These will be developed in conjunction with other KSAs within the WRC.
- Strategically align research with the WRC mandate and Government outcomes and other priorities
- Promote good science and build capacity in both research and management to sustainably manage aquatic ecosystems

THRUSTS AND PROGRAMMES

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 abovementioned objectives and are summarised as follows:

THRUST 1: ECOSYSTEM PROCESSES

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

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

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Scope: This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation for the provision of the ecosystem benefits that people depend

on. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings. The following programmes are addressed:

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

THRUST 3: ECOSYSTEM REHABILITATION

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

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

RESEARCH PORTFOLIO FOR 2011/12

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

within this KSA has contributed to the development of the National Water Act (NWA of 1998) and associated policies, an example being the ecological Reserve. This has meant that work within this field has not only addressed the strategic needs of the country, which have increased in line with the increased global recognition of the importance of the role of sustainable environmental management, but has also addressed some of the immediate research needs related to the NWA and its implementation. What people require of the environment is an area of increasing importance, and the building of capacity amongst the country's citizens (managers and the various user groups) to manage the environment sustainably is of cardinal importance.

BUDGET FOR 2011/12

The approved funding of the research portfolio for 2011/12 leads to a committed funding budget of R13 102 000 (excluding roll-over). The consolidated research project budget is presented below:

| Research portfolio | Approved 2011/12 (R) |
|--------------------|----------------------|
| Current projects | 10 654 138 |
| New projects | 2 447 862 |
| Total | 13 102 673 |

CORE STRATEGY

Healthy people depend on a healthy environment. This is particularly true in the case of the rural poor who rely directly on the environment for their livelihood. For instance, while poor quality water can be improved in treatment works (at increased cost), those directly dependent on the resource will suffer the consequences of drinking water containing pollutants or disease-causing organisms. At the same time, the flow of goods and

services such as fish, fibres, cultivated and medicinal plants from a poor quality ecosystem will be less than it should be. For these and other reasons, sustainable management of the ecosystems making up the environment is central to an improved quality of life. The scale of ecosystem benefits varies from individual, for example, fibre for mat- and basket-weaving or medicinal benefits, to universal, such as good quality water for abstraction and urban use and intact wetlands to aid in improvement of water quality and flood attenuation. In short, society cannot survive without the underpinning support from the environment.

The core strategy was fundamentally aligned to the WRC's mandate and remained unchanged from 2010/11, but focus was given to development of innovations that will help in speeding up implementation of relevant policies. The KSA will furthermore internalise national initiatives and priorities such as Presidential priorities (Government MTEF) and Government outcomes. Research funded from within this KSA continued to address, within the mission and vision of the WRC, the three legs of sustainability (society, economy, and environment) as defined by the *2002 Johannesburg Summit* and the needs of the legislation and international conventions (e.g. biodiversity conservation planning – Convention on Biological Diversity and Wetland Integrity – Ramsar) of South Africa.

Strategic context

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

The aquatic ecosystem comprises the resource and is a legitimate water user in terms of the National Water Act of

1998. Aside from this legal protection, aquatic ecosystems are important for a number of reasons. They provide a barometer of ecosystem health, and hence environmental quality, which is responsive to change and easy to interpret. They also provide a number of goods and services which are used by all sectors of the population. Examples of these are water for domestic, agricultural and industrial use, polishing of effluents, basic food and fibre (fish, plants), traditional medicines, and opportunities for recreation, to name but a few. A stable ecosystem provides the necessary resilience to cope with extreme events such as floods and droughts (natural) and pollution events (anthropogenic). In the past a proportion of the national cost for the treatment of wastes was externalised to the environment and, although the environment was degraded by this, by and large the load did not exceed the capacity of the environment to cope with it. However, it is beneficial for all to maintain the resource in a good condition rather than to carry the costs associated with a poor-quality resource.

To this end, the WRC has funded research on ecosystems since the latter part of the 1980s. The work funded has been a balance between the generation of knowledge needed to understand ecosystem processes and ensuring that the knowledge generated supports sustainable management and utilisation of aquatic resources. Sustainable management of the aquatic resources includes rehabilitation of the degraded resources with the aim of restoring process, form and function of the aquatic ecosystems. Knowledge gained through the KSA's research is utilised to guide the direction of future resource management and planning, which supports Government legislation and other initiatives.

Research funded through this KSA not only provides knowledge for the protection of the resource and the biodiversity of aquatic ecosystems, but also supports sustainable utilisation of aquatic resources while ensuring equity between generations. The KSA strengthens the notion of promoting ecosystems as natural water infrastructures and shared resources that should

be valued by everyone. The KSA research further addresses the commitment to international conventions, the needs and implementation of policy as well as sustaining the capability of the environment to support the flow of benefits on which society depends. Various aspects of climate change (including, adaptation and mitigation) are addressed by the KSA and this entails developing an understanding of the impact of global warming (water temperature) on aquatic biodiversity (ecosystems). This knowledge will enable societies (especially rural, poor people) depending on goods and services from the environment to improve their resilience to climate change.

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

Water and Society

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

Water and the Economy

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

Water and the Environment

Most of the research studies funded by this KSA primarily address this impact area. The knowledge generated by KSA 2 studies is needed to improve protection of ecosystems and suitable utilisation of goods and services coming from aquatic ecosystems.

Water and Health

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

Links to Government outcomes

Research on water-linked ecosystems enables good environmental governance and ensures that water is managed in a sustainable manner that protects ecosystems from the adverse impacts of demographic and climate change. The research creates an understanding of the ecological processes underlying the delivery of goods and services, and provides knowledge and expertise to sustainably manage, protect and utilise aquatic ecosystems. This research portfolio will contribute in the delivery of mainly two Government outcomes, which are, 'Environmental assets and natural resources that are well protected and continually enhanced' (Outcome 10), and 'Vibrant, equitable and sustainable rural communities and food security for all' (Outcome 7). Specific outputs for each outcome, which are relevant to the scope of this KSA, will be addressed within the mandate of the WRC.

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced

- *Output 1:* Enhanced quality and quantity of water resources: In support of this output, the WRC continued to support ongoing studies about evaluating the potential contribution of episodic toxicity data to environmental water quality management in South Africa as well as those on endocrine-disrupting compounds. The project on food-web manipulation provides knowledge on how to restructure the food web in water reservoirs (such as Hartbeespoort Dam) by removing or introducing a specific species (e.g. fish), as a means to improve water quality of the dam. This is based on the understanding that activities of certain species exacerbate the water conditions that enhance eutrophication. The WRC, in collaboration with DWA and other stakeholders, is supporting a study to show the long-term trends of environmental water quality in South Africa.
- *Output 2:* Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality: To contribute to the body of knowledge on climate change and to assist in developing adaptive strategies, the WRC funded a project that has produced a locally-made version of miniature water temperature loggers. These loggers are small and cheap in comparison to the loggers that are imported into the country. The loggers can be left in water, attached to solid river bed or rocks, for a long time. Long-term water temperature data are and will be required to model and manage challenges related to climate change.

- *Output 3: Sustainable environmental management:*
The WRC will continue to enhance and promote our understanding, as a country, of the use of endemic biota for biomonitoring the health and integrity of water resources in South Africa. A project on aquatic microbial diversity assessment of water resources in South Africa will be completed within the next two years. The assessment will enable the water sector to develop methods and tools that will be used to assess the health and functioning of estuarine ecosystems. This will be important to enhance the protection and sustainable management of estuaries. The success of this study will assist in the development of the estuary management programme that is similar to the DWA's River Health Programme.
- *Output 4: Protected biodiversity:*
A project on the assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park and the physical and chemical factors affecting their distribution is in progress and will soon be completed. This deliverable output will also be supported by the research on identification of relationships between soil processes and biodiversity, to improve restoration of riparian ecotones invaded by invasive acacias. In collaboration with DWA, DEA and SANparks, the WRC is supporting a research study on biomonitoring of the fish health of two impoundments on the Olifants River, Limpopo Province. This study supports efforts to determine the cause of crocodile deaths recently reported in the Kruger National Park and other areas. The death of crocodiles is seen as an indication of the greater threat that aquatic biodiversity and ecosystems are exposed to in rivers and other water resources. Various other projects on control and management of alien and invasive species will continue to be supported.

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all

- *Output 2: Improved access to affordable and diverse food:*
Most of the projects in this KSA contribute to ensuring that people access water, food and natural medicines that are not contaminated. Most of the KSA 2 projects promote environmentally-friendly land-use practices, protection of water resources and aquatic life, and assessment of water quality, which bring about access to food (fish and vegetables) as well as natural medicines that are free from contaminants (enhancing water and food security). For example, the WRC has ongoing projects on: the management or prevention of non-point source pollution from different land uses to protect water resources and ecosystems, interactive effects of pesticide mixtures in water on selected species, environmental assessment in an area where ongoing DDT spraying occurs, and setting and establishing buffer zones along and around water resources to enhance quality and quantity of the water resources.
- *Output 4: Improved employment opportunities and promotion of economic livelihoods:*
The WRC will continue to ensure that postgraduate and post-doctoral students are part of the project research teams or are employed to work on WRC projects. Although the employment, like research projects, is for less than four years, this is a good opportunity for most students who intend to pursue academic or consulting careers. Moreover, disadvantaged students are able to earn some form of a living. Employment within WRC projects also improves employment opportunities of the involved students because they gain work experience and skills that the academic and consulting institutions require.

Needs analysis

The KSA continues to put effort into introducing and promoting ecosystem knowledge to local Government institutions, especially SALGA and LAB, portraying ecosystems as natural (water) infrastructure that provides humans with different benefits such as flood control and improvement of water quality and quantity. Moreover, the KSA addresses specific needs that promote and support sustainable management and protection of water resources and associated biodiversity. However, the need also exists, possibly more than ever, for strategic research for innovation, the lead for which may come from global trends not necessarily reflected yet as needs in South Africa. There is also a need for repackaging of both the existing and new knowledge that will help in both water management, training and public awareness. The need to implement legislation tends to distract attention from this long-term need, although this is handled proactively as far as possible within this KSA so that anticipated research products are available when needed. The KSA will continue to support research that addresses the longer-term needs of the country. Funding research to contribute to the capability to sustainably manage ecosystems is an overarching need which this KSA continues to address. In addition, involving both the decision-makers and the community in the above is key to the successful implementation of the research findings.

At the higher level, it is necessary to improve the interface between scientists on the one hand and managers and the public, including rural communities, on the other. Without this, the concept of sustainable management will remain in the realm of theory.

Research is needed to address the processes and functions of various components of aquatic ecosystems. It is becoming increasingly apparent that with the switch to largely addressing the needs of management over the past decade and a half, we are reaching the limits of current knowledge. In recognition of this, the KSA has begun more research initiatives in selected

areas in order to ensure that our knowledge remains ahead of the need to apply it, and the KSA will continue to provide guidance and leadership to the research community.

Water quality deterioration has reached crisis levels in the country's heavily used catchments, with fish kills in the Vaal River and Olifants River (Mpumalanga) and crocodile deaths in the Lower Olifants River. A multidisciplinary approach is necessary to address this problem adequately. To resolve these challenges this KSA has completed a scoping study on factors causing the deterioration of water quality in the Olifants River; the results are used to inform management and research plans for that river and for Kruger National Park. In collaboration with other stakeholders, the WRC is funding an ecotoxicology study investigating the cause of crocodile deaths in Kruger National Park. Moreover, a family of projects on endocrine-disrupting compounds (EDCs) is ongoing under the guidance of the WRC. The KSA also started a three-year research project in 2010 focusing on linking land use to water quality.

At the operational level, in addition to the issues around the implementation of legislation, there is a need to provide knowledge on the mitigation of the effect of development on ecosystems and the goods and services that they provide to people. The contributions and roles that aquatic ecosystems play in rural communities will be enhanced by this KSA through rehabilitation and restoration programmes such as RHP, Working for Water and Working for Wetlands. These national programmes also make an immense contribution to supporting job creation and water security. The KSA, in collaboration with DWA and DEA, will continue to pay special attention to the effectiveness and efficiency of RDM methods and tools, particularly those used in the Reserve determination, with the intention to meet the needs of users and beneficiaries.

Overview of technological trends

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

- **Climate change:** Current knowledge further emphasises the importance of the phenomenon of climate change. There is an increasing body of knowledge on the effects of climate change from the temperate latitudes, but this deals largely with increasing temperature vulnerability and adaptation. More relevant to Southern Africa is the predicted change in rainfall, with the dry west becoming drier. The ramifications of this for management of the resource could be substantial. Research in this field has developed methods for continual monitoring of river water temperature, and this is being piloted in a new WRC project. Moreover, the KSA completed some preliminary studies in 2010 on the effects of climate change on aquatic ecosystems. One of those studies, as an example, has identified hydrological parameters or drivers with potential to determine the response of aquatic biota to the impact of climate change. Methods of assessment and interpretation of climate change data have been developed by this study. However, it was recognised that, for the methods and data to be more useful at a local scale, ecologists' views and their interpretation of data is important. Further research work will emanate from these studies, such as the fate of threatened species and ecosystems, the fate of alien and invasive species in view of increasing temperature regimes and methods or technology required to manage and control alien and invasive species.
- **Payment for ecosystem services (PES):** This is a new trend. The development of a PES scheme and related economic tools are important and require attention in a developing country like South Africa. An appropriate PES scheme has potential to leverage business opportunities that can benefit poor people (especially rural people) in areas with ecosystems that supply goods and services. Another important aspect attached to a PES scheme is benefit-sharing mechanisms, which has been investigated and developed by this KSA in the context of the South African environment. The ongoing research project K5/1978 will lay the technical and theoretical foundation needed in developing a PES scheme appropriate to South Africa and Africa.
- **Ecohydrology:** The science of ecohydrology is gaining momentum in many countries. Research conducted in this KSA and in the Water Resource Management KSA addresses aspects of ecohydrology, and these linkages will be further explored in all WRC projects relating to environmental flows.
- **Ecological limits on hydrological alterations (ELOHA):** This is a new trend. The KSA interacts with international researchers and institutions that are advancing this field or concept with intention to make a meaningful contribution in this emerging field. However, the KSA has found that the concepts upon which this field is based stem from past WRC research studies on environmental flows or environmental water requirements. The KSA will take advantage of the working relationships fostered during the February 2009 international conference organised and hosted by this KSA in Port Elizabeth.
- **Application of natural wetland knowledge to constructed wetlands (biomimicry)** was explored as a research project in collaboration with the KSA on Water Use and Waste Management in 2011/12. The WRC has assembled experts in artificial wetland construction and those researchers with better understanding of wetland form, function, and process.

- **Capacity for sustainable utilisation** in the context of sustainable development is a key intervention in this regard and is being built through initiatives (projects) in this KSA.
- **Shared rivers:** The KSA has initiated a long-term initiative that focuses on management aspects of rivers that South Africa shares with her neighbours. A focus of this initiative is the implementation of the NWA as well as seeking to achieve congruence between the implementation of the NWA and related policies and legislation. The second phase of the study, which aims to look into compliance with the NWA, started in 2010/11 and the output will assist Government in strengthening its monitoring programmes and prosecution of defaulters (K5/1920S).
- **National freshwater priority areas (NFPA):** The WRC is working closely with its stakeholders (K5/1801) to carry out a study on national freshwater priority areas (NFPA) of South Africa, in recognition that these areas are water production factories of the country and the region in some cases.

In response to stakeholders' views expressed in the 2009 consultation workshop, the KSA continued to undertake the following assignments:

Enhance water governance: The Ecosystem Governance research programme was improved by encouraging innovative and relevant research studies that will support and fast-track enforcement of water regulations, including the NWA of 1998. It is important to find new ways of involving communities and local Government in our research projects. One way is to interact with local people (stakeholders) and the local municipality (LAB-Government) to identify and carry out water-based (ecosystem-orientated) research, the output of which feeds directly into municipality or local Government development plans. This kind of action research study builds capacity of officials in local Government. Involving all stakeholders and local schools can advance public understanding of water issues and the possible looming water crisis, at both local and national levels.

Improve monitoring and evaluation as well as enhancing raw water quality: The KSA and DWA are working together to bring in more role-players in intensifying the 'Adopt a River' initiative under the River Health Programme (RHP). This voluntary monitoring programme will utilise simpler versions of data collection suitable for non-technical public participants. The WRC has always provided knowledge and tools to the RHP activities. These tools will be developed to cover voluntary monitoring of wetlands and estuaries in the future. This community empowerment initiative has the potential to assist the Blue Scorpions to enforce water regulations relating to quality and quantity. These KSA efforts will address the issue of bridging the gap between knowledge, societal upliftment and participation in IWRM.

Water security and conflict over water: This is dealt with by the KSA through research that addresses the dynamics of implementing the ecological Reserve in the midst of both population increase and global warming, both of which have a serious impact on local water demand. There is a need to revisit the principles and practicality of the implementation of this part of the NWA, in consideration of the international obligations that South Africa is a signatory to. There is a view suggesting that South Africa may have to re-negotiate changes of river flows (Reserve), and the kind of agreements it has with its neighbours such as Mozambique, to avoid possible conflicts over water.

Key stakeholders

The key stakeholders remained largely unchanged. In addition to the Departments of Water and Environmental Affairs (DWA and DEA), other Government departments such as Agriculture, Fisheries and Forestry (DAFF), Science and Technology (DST), and Rural Development and Land Reform (DRDLR), are of importance. This KSA closely supports DWA, specifically at this time when they are implementing new strategies such as *Water for Growth and Development* and Government outcomes. Provincial and local government form another group of stakeholders, and the needs of

the catchment management agencies (CMAs) which are currently being established influence research direction. Other end-users of the research are water boards, and rural communities and others living off the land.

Donor funding is available in this field, usually for specific tasks which satisfy the donor's mandate. The largest funder is the Global Environment Facility (GEF), funded by the World Bank, which has been instrumental in establishing large biosphere reserves as well as the Cape Action Plan for the Environment (CAPE) in South Africa. The IUCN, WWF, Ramsar 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/water sector for specific projects.

Other 'players'

There are two main groups in this category nationally, funders and end-users of research not mentioned above. DWA gives some funds for research, although this is largely for the purpose of consultancies aimed at addressing specific short-term needs. Some organisations, such as the science councils, fund research internally to increase their competitiveness in areas of opportunity. All of these offer the opportunity for leverage and synergy with WRC funds where the integration can be managed. Important international players are IWMI (currently mainly through their Challenge Programme), WWF, UNEP and the World Bank. There are a number of other end-users of research such as South African National Parks and various consultants who have specific requirements and who also play, directly or indirectly, an important role in managing the aquatic environment. The needs of these groups are important as well.

Research providers

Researchers are located at the universities (Limpopo, Venda, North-West, Witwatersrand, Johannesburg, Free State, Zululand, KwaZulu-Natal (both Pietermaritzburg and Durban), Fort Hare, Rhodes, Nelson Mandela Metropolitan, Stellenbosch, Walter Sisulu, Western Cape and Cape Town), science councils (in this field predominantly the CSIR and the ARC) and within various consultancy firms. Efforts will continuously be made to build research capacity of historically-disadvantaged individuals, especially at the academic institutions.

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

IMPLEMENTATION PLAN

Research portfolio for 2011/12

In essence, the implementation plan followed that of previous years in that the primary objective of this research portfolio was the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country during a time of demographic and climate change. The research portfolio for 2011/12 (broken down into thrusts and programmes) is presented in Table 1.

TABLE 1**Overview and description of thrusts and programmes****THRUST 1: ECOSYSTEM PROCESSES**

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

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

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

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

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| <p>Programme 1: Ecological Reserve</p> | <p>Scope: Within this programme research will be conducted to develop and refine methods for determining and operationalising the ecological Reserve as required by the NWA. The programme will address the more strategic issues such as the development of new and improved methods as well as the shorter-term issues such as implementation of the Reserve. This programme is managed in close association with DWA.</p> |
| <p>Programme 2: Estuary management</p> | <p>Scope: Within this programme research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage estuaries sustainably. This programme is managed in close association with Marine and Coastal Management, DEA.</p> |
| <p>Programme 3: Ecosystem health</p> | <p>Scope: The River Health Programme (RHP: custodians are DWA, WRC and DEA) aims to implement nationally (at the level of provincial Government and industry) a coherent bio-monitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and so are kept in the same programme. Research on the environmental health of wetlands, estuaries and impoundments is also included in this programme. As such the programme covers all water resource types, hence the inclusive name of: National Aquatic Ecosystem Health Monitoring Programme is used, with RHP focusing only on rivers. This programme links to the WRC impact area of Water and Health and includes resource management actions which may affect human health.</p> |
| <p>Programme 4: Environmental water quality</p> | <p>Scope: Within this programme research will be conducted to develop bio-assays (both in the laboratory and the field) which will be employed to protect people and the environment from the effects of poor water quality. It will develop methods and competence to enable the use of toxicology in effluent discharge licences as well as its use in environmental water quality as required in the ecological Reserve. This programme addresses the longer-term development and refinement of methods and the competence to use them, as well as the shorter-term competence required to implement policy in terms of the NWA. This programme links to the endocrine disrupter programme within the WRC impact area Water and Health.</p> |
| <p>Programme 5: Endocrine-disrupting compounds</p> | <p>Scope: The overall objective is to characterise, and acquire information for assessing, the EDC effects of various chemicals and compounds in water (singly or in combination), both those occurring naturally and those resulting from pollution, which have the potential to cause detrimental health effects in humans, animals and the aquatic environment, as a guide to develop and implement cost-effective treatment and control strategies. Further emphasis is on the development of simple, rapid and cost-effective detection techniques. This programme will be implemented in three phases, of which the first phase is already completed.</p> |

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| Programme 6: Socio-economic considerations | Scope: The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with the ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment. |
| Programme 7: Ecosystem governance | Scope: The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this. |

THRUST 3: ECOSYSTEM REHABILITATION

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

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| Programme 1: Wetland rehabilitation | Scope: Within this programme research will be conducted to develop methods to rehabilitate wetlands which will address both abiotic and biotic components, and seek to rehabilitate ecological processes and restore biodiversity as far as possible in degraded wetlands. This will be done in terms of both the international conventions to which South Africa is signatory as well as recent legislation from both DEA and DWA. The programme will also develop the competence to implement rehabilitation. Projects in this programme link closely with each other, and are managed as a unit. |
| Programme 2: River and impoundment rehabilitation | Scope: The research conducted within this programme aims to provide protocols for the rehabilitation of rivers and impoundments, with the emphasis on urban rivers and the impoundments that they feed, that have been degraded as a result of anthropogenic activities or invasive biota. |
| Programme 3: Influence of instream-constructed barriers | Scope: This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems. |

RESEARCH PROJECTS FOR 2011/12

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

Riparian landscapes: Interfluvial patch mosaics

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

No.1790

The character and behaviour of rivers depends on the nature of their catchment. Nevertheless, hillslopes and channels are generally studied separately. A holistic approach is needed. Landscape patterns of water, soil, vegetation and topography are not easy to disentangle, but in semi-arid environments the distribution of vegetation and soils often occurs in patterns that are both cause and consequence of topographically-controlled water fluxes. A hierarchical framework, based on an integration of aquatic and terrestrial perspectives, was developed to facilitate the synthesis of knowledge across many disciplines, focusing on spatial and temporal scales relevant to conservation management (10^1 - 10^3 km² and seasons to decades). Topography is an important control on the distribution of water and hence on the distribution of landscape patches and it is highly organised in space. The classification demonstrates how the framework addresses landscape complexity that involves multiple feedbacks within and across scales. Spatially explicit landscape classification is central to both systematic conservation planning and strategic adaptive management.

Cost: R570 000

Term: 2008 - 2011

Deriving conservation targets for freshwater systems

GroundTruth

No. 1796

This research proposes a new method, based on established measures of species diversity and river ecology theory, to improve approaches for setting river conservation targets. Alpha, beta and gamma diversities of aquatic macroinvertebrates and fish were assessed in nine rivers in South Africa (Western, Eastern Cape and KwaZulu-Natal Provinces), using longitudinally located sites from surveyed and historical data. While fish species patterns showed no clear spatial patterns, aquatic macroinvertebrates showed predictable patterns of distribution and turnover rates down river axes. Alpha diversities peaked in the upper third (mid-orders) of river lengths; beta diversities showed exponential decay rates, being highest in the upper third of river axes. Turnover rates could be decomposed into contributions by common and rare species, and driven by multi-scale processes, including geomorphology, flow and water temperatures, and coinciding most sharply with river profile inflection points. Conservation planning, as a tool to prioritise rivers for conservation action, relies strongly on methods for setting biodiversity feature targets. An objective approach to setting river targets is yet to be developed, with planners currently using a value of 20% in the absence of any other measured and agreed targets. A single 20% target for river types is not adequate, and it is proposed that at least upper versus lowland targets of 40 to 20% be applied. Further research is recommended on effects of seasonality on species turnover, and contributions of alpha and beta diversity to gamma diversity in setting regional river targets, as well as aligning the derivation of targets with conservation planning processes and policy.

Cost: R404 015

Term: 2008 - 2011

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

Deployment, maintenance, and further development of SPATSIM hydrological decision-support framework (SPATSIM-HDSF)

University of KwaZulu-Natal (Durban)

No. 1870

The Spatial and Time Series Information Modelling (SPATSIM) software is a hydrological modelling framework, initially developed by the Institute for Water Research (IWR) at Rhodes University in South Africa, and described as an integrated hydrology and water resource information management and modelling system. The SPATSIM modelling framework was further developed as part of WRC Project K5/1490 and is now referred to as SPATSIM-HDSF. At the end of WRC project K5/1490 it was recognised that there was a need to further test and debug the restructured SPATSIM-HDSF modelling framework, further develop the framework, further develop the modelling tools associated with the framework, and provide user training and support for the framework and associated models. There are two aspects of integrated modelling that have received increasing attention in recent years: (i) the coupling of models representing different water resource domains, and (ii) the development of integrated modelling frameworks or decision-support systems. These integrated modelling frameworks typically include a common data repository, common data editing tools, common spatial and temporal data visualisation and analysis tools, and a collection of framework compatible models that make use of these common tools. The further development of SPATSIM-HDSF included changes to the database structure, changes and enhancements to the main user interface, enhancements to the internal GIS functionality, development of additional time series analysis tools, and the development of an ArcGIS

extension to provide further Geographic Information System (GIS) functionality. As part of the same project, the ACRU agrohydrological model was modified and a new model input structure and supporting tools were developed to include the ACRU model as one of the framework-compliant models available to users.

Cost: R2 265 000

Term: 2008 - 2011

Water temperatures and the ecological Reserve

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

No. 1799

Freshwater systems, both globally and within South Africa, are under pressure, and are amongst the most deteriorated systems, due in part to water abstraction, flow regulation and pollution. Successful implementation of environmental flow management requires taking cognisance of the full spectrum of flows together with thermal regimes, including their temporal and spatial variability. Water temperature is recognised as an important abiotic driver of aquatic ecosystems, and understanding the role that temperature plays in driving ecosystem change is important if effective management of thermal stress on aquatic ecosystems is to be achieved. This study provided an opportunity for fundamental research linking water temperatures and biotic responses to water temperature and incorporation into the requirements for the ecological Reserve.

Cost: R2 323 558

Term: 2008 - 2011

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

Water for Africa; Rhodes University (Institute for Water Research)
No. 1856

The previous version of the Reserve Desktop model was based on hydrology and regional parameters which were largely based on seasonal distributions of stream flow. One recent development in EWR methodology is the flow stressor response method which links the hydraulic habitat requirements of biota to the hydraulic characteristics of a channel cross-section to specify the ecological stress conditions that will occur under different flow regimes. Components of the model deal with hydrology, hydraulics and ecological requirements. The hydraulic sub-model uses a desktop approach to define the characteristics of a representative channel cross-section in the absence of detailed field surveys. The ecological requirements of fish are based on the Velocity Depth Guild (VDG), an approach developed to interpret ecological consequences from generic information on the stream width. The RDRM has been compared to the Intermediate and Comprehensive Reserve Determinations and has reached a Beta version where it can be used with caution. A draft user manual is included which will be revised once the method has been more widely tested. One situation not catered for is when the present day flows in one or both seasons are greater than natural flows.

Cost: R850 100
Term: 2008 - 2011

Situation assessment of the basic human needs and ecological Reserve

Water Matters
No. 1939

Funding was made available for the project by the Department of Water Affairs, the Water Research Commission and WWF, via a project managed by the WRC. The project resulted in a book entitled: Sustainable use of South Africa's inland waters. The book has eight chapters: (Part 1: Background) (1) Water supply and demand; (2) Water Law in South Africa: from 1652 to 1998 and beyond; (Part 2: Implementation) (3) Institutional arrangements for protection of aquatic ecosystems; (4) Tools and procedures for Resource Directed Measures; (5) RDM and basic human needs; (6) Knowledge and skills development; (7) Giving effect to Resource Directed Measures; (8) The way forward.

Cost: R1 090 090
Term: 2009 - 2011

Programme 2: Estuary management

Estuaries and economic empowerment

University of KwaZulu-Natal (Centre for Environment, Agriculture & Development)

No. 1705

During the Eastern Cape Estuaries Management Programme, it became apparent that the disadvantaged people living at or near estuaries were continually marginalised, in spite of the national imperative of economic growth. This project aimed to address this issue. Research assessed the state of, and opportunities for, economic empowerment in the estuaries of the Wild Coast, where the main drivers of economic empowerment at the estuary level were resort hotels and the opportunities which they provide. A methodology for assessing economic empowerment opportunities, was developed and tested in three situations, and these case studies are discussed. Key findings for the

case studies are that: there are significant opportunities for establishing estuary- and wetland-based enterprises; stakeholder response to the methodology was positive; participants were able to engage the process effectively; the methodology could be applied in numerous pro-active and responsive planning and management contexts and is transferable to other common property resource systems.

Cost: R1 500 000
Term: 2007 - 2011

Programme 3: Ecosystem health

Pilot design implementation and testing of a simple cost-effective method for monitoring temperature in SA rivers and streams. Refinement of business plan, Phase 2

DH Environmental Consulting cc

No. 1872

This project has successfully refined the prototype design of a miniaturised water temperature logger developed during a previous Water Research Commission Project. The project has met all of its aims and the outcome has been a small, robust data logger, with associated peripherals – including software – that has proved its worth under testing. Instrument configuration and data download is accomplished wirelessly using a simple hand-held device. Problems encountered during the second phase of testing were easily and rapidly resolved. Further options for improvements during eventual production were identified. The design of the loggers has incorporated retro-add capabilities that will enable other measurements to be incorporated into the same physical dimensions. Design of this type of technology continually offers options for improvement of future units – both in terms of components and physical size and shape. Although per unit costing is dependent on future build volumes and demand, it is evident that the loggers as designed in this project will be significantly cheaper than any other product currently on the market.

Cost: R647 500
Term: 2008 - 2009

Programme 4: Environmental water quality

Chronic toxicity test method for selected indigenous riverine macroinvertebrates

Rhodes University

No. 1313A

The project aims were: to develop chronic toxicity test methods for indigenous riverine invertebrates using non-lethal experimental end-point assessment criteria such as stress proteins, measures of growth and fecundity and morphometric analyses for both nymph and adult stages, to use the newly developed chronic toxicity test methods for indigenous invertebrates to evaluate the current method of determining water quality criteria for the ecological Reserve, which uses single-substances and mortality as an end-point, to assess effluent standards by testing the newly developed chronic toxicity test method using whole effluent, to undertake a scoping study of the use of stress proteins and morphometric analyses, to assess how these approaches could be used in combination with biomonitoring and water chemistry information in the evaluation of non-point source pollution and pesticide contamination, and to compare results of chronic toxicity tests using indigenous invertebrates to those of *D. pulex* in an ongoing benchmark assessment of the use of *D. pulex* to determine water quality criteria for South African rivers. An indigenous test organism, *Caridina nilotica*, was used in this study. The results suggest that the embryonic development of *C. nilotica* can be a valuable indicator of contamination in freshwaters by aging the dead eggs and comparing their morphometry to the experimental values. Morphometric measurements of the developmental features could be an indication of an effect caused by chemicals. However, it would be necessary to extend this study to other pollutants to achieve more generalised conclusions useful for water quality monitoring.

Cost: 770 000
Term: 2002 - 2011

Development of a diatom-based bio-monitoring protocol for South African rivers and streams. Phase III: Regional testing, method refinement and calibration; index formulation and River Health Programme

DH Environmental Consulting

No. 1707

The core aim of this project was to provide a water quality index, informed by diatom species and abundance, which would encompass South African river and stream conditions and, at the same time, incorporate ecologically relevant characteristics of endemic species – i.e., supporting the derivation of ecological inferences from diatom assemblages. The use of previously-available indices was constrained by their lack of autecological information on southern African diatoms. Creation of the first version of the South African Index has been achieved through the collection, processing, examination and analysis of 768 individual samples – together with their associated water quality information. All of the samples have been curated in the South African Diatom Collection. In addition the extensive notes on the ecology of SA diatoms, compiled by BJ Cholnoky, have been included in this index. The index has been provided in the form of an upgrade addition to the existing OMNIDIA software, with the intention being that the index will form part of future releases thereof. In this format, the South African Diatom Index (SADI) constitutes the second largest index supported by autecological data currently provided by OMNIDIA. The SADI is based on the same platform as the majority of European diatom indices but, in particular, on the Specific Pollution sensitivity Index (SPI). The SPI index has the broadest species base of any index currently in use. This species base has been augmented by the addition of endemic SA diatom species, with scores modified for other cosmopolitan and commonly-occurring species found in South Africa, thus increasing the accuracy of diatom-based water quality assessments in South Africa. A secondary aim of the project

was to enable skills transfer and training in the use of diatoms as a means to assess lotic environments and to draw ecological inferences therefrom. In this regard the project has been particularly successful, as is evident from the Capacity Building Report. The tools and methods developed during Phase 2 of the Diatom Assessment Protocol have been widely accepted (locally and internationally) and South Africa now has two commercial laboratories offering the procedure. In addition, the DWA is in the process of establishing the protocol across the RHP sites. This phase of the work also saw the second version of the taxonomic key being produced. This version is being hosted on the Internet for both local and international use.

Cost: R 2 185 733
Term: 2007 - 2010

Programme 5: Endocrine-disrupting compounds

Environmental assessment in an area where ongoing DDT spraying occurs

Rhodes University (Institute for Water Research)

No. 1706

Vertebrate and invertebrate indicators of possible effects of DDT were compared from areas where DDT-spraying occurred and from an area upstream (reference) of a DDT-sprayed area in the Limpopo Province. DDT is used in indoor residual spraying (IRS) for malaria control in this area. Macro-invertebrate investigations and SASS5 scores did not differentiate between sprayed and non-sprayed areas, except for the 'GSM' biotope. All other indicators had, however, some indications of stress that may be associated with DDT. DDT was found in shrimp, and effects were seen on acetylcholinesterase in the field. Laboratory studies confirmed the toxicity of DDT and DDE in water. Snails showed indications of ED effect, but cause-effect relationship needs to be established. No effects were seen in frogs (*Xenopus* spp.). Bird eggs, especially from the Grey Heron, had very high levels of DDT. These levels exceed known effect levels elsewhere and

suggest a possible reason for the relatively low numbers of water birds seen downstream of Albasini Dam, and the absence of breeding colonies.

Cost: R999 415

Term: 2007 - 2011

Programme 6: Socio-economic considerations

Extracting scientific evidence for the development of ecosystem services production functions for the Resource Directed Measures

Prime Africa

No. 1978

WRC project K5/1644 developed a set of guidelines and a manual for the evaluation of trade-offs in aquatic ecosystem services that may result from different water management scenarios. These guidelines combine water management practices; the Millennium Ecosystem Assessment (MEA) framework of ecosystem services, and best practices in environmental and resource economics (ERE) valuation into a four-phased approach. This four-phased approach contains a series of analysis methods by which to analyse and evaluate chains of causality and the trade-offs that result from different water resource management scenarios. It thus connects the social and ecological sub-systems such that we can consider, in a structured and repeatable way, how they might respond to interventions we may choose to make or to naturally-occurring changes. However, a key gap identified relates to both the methodology by which to analyse chains of causality and the burden of evidence required to specify and quantify chains of causality. The knowledge of and data for analysing chains of causality are often dispersed and poorly archived. Furthermore, limited guidance is available on how to make use of different types of available evidence. The purpose of this study was thus to explore the field of 'evidence-based analysis of socio-ecological systems' (E-BASES), with the purpose of identifying potentially feasible methodologies for finding evidence, both

ecological and social, in support of analysing chains of causality in complex, water resource dependent, socio-ecological systems. The study investigated the applicability of ecological production functions to analyse chains of causality and the applicability of the evidence-extraction methods of evidence-based medicine (EBM), and evidence-based conservation (EBC) to Southern African conditions; proposes alternative evidence-extraction methods; and demonstrates the application of a set of five evidence-extraction methods in selected case studies.

Cost: R550 000

Term: 2010 - 2011

Programme 7: Ecosystem governance

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

No. 1711

Based on the findings of the study, achieving ERs – and indeed the Reserve – does not reside within the environmental domain alone; it is a collective action involving participation by multiple stakeholders in specific learning and training forums. Indeed, achieving the Reserve is predicated on water reform and IWRM and the collective contribution and synergies of a number of strategies, plans and practices. Of utmost importance is the recognition of the fact that achieving the Reserve cannot be done in isolation. The Reserve is but one of the key components of the IWRM which is required for proper integral management of water resources at the basin level. Progress towards this complex goal varies widely between catchments and at different scales. Cases where systems show a more balanced approach need strengthening – especially where this is achieved through collective action, good governance, strong leadership, feedback, learning and regulation. These can offer lessons and frameworks for weaker situations. If a people-centred approach that is guided by sustainability is to be sought, then there is a need to find

new ways of understanding, collectively, the benefits associated with water resource protection measures (such as through the Reserve). Such thinking needs to extend across boundaries, be they upstream-downstream, sectoral or international. This is critical in ensuring mechanisms of sharing our scarce freshwater resources collectively.

Cost: R810 760

Term: 2007 - 2010

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

SANBI; CSIR (Natural Resources and the Environment)

No. 1801

The National Freshwater Ecosystem Priority Areas (NFEPA) project was a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute for Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). The NFEPA project aimed to: 1) identify freshwater ecosystem priority areas (hereafter referred to as FEPAs) to meet national biodiversity goals for freshwater ecosystems; and 2) develop a basis for enabling effective implementation of measures to protect FEPAs, including freeflowing rivers. The NFEPA study responded to the high levels of threat prevalent in river, wetland and estuary ecosystems of South Africa. It provides strategic spatial priorities for conserving the country's freshwater ecosystems and supporting sustainable use of water resources. Intended key users of NFEPA products include: the national departments of Water Affairs and Environmental Affairs, catchment management agencies and their associated stakeholders, the national and provincial departments of agriculture, the Department of Mineral Resources, South African National Biodiversity Institute, South African National Parks, bioregional programmes, provincial

conservation agencies, provincial environmental affairs departments, municipalities, non-Governmental organisations, conservancies and environmental consultants. The purpose of this report was to document the scientific methods and results used in generating the NFEPA map products, and describe the approach and concepts used to guide the project in developing an institutional basis for effective uptake of these maps. The project atlas and implementation manual are more appropriate tools for communicating the project results and outputs in a less technical manner. The Atlas of Freshwater Ecosystem Priority Areas packages the map products and provides a DVD of all NFEPA products and shapefiles. The Implementation Manual for Freshwater Ecosystem Priority Areas explains how to use NFEPA map products within the existing policy and legislation, and provides freshwater ecosystem management guidelines.

Cost: R1 620 200

Term: 2008 - 2011

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

Primary producers as sinks for nitrogen and phosphorus in the Great Brak estuary

Nelson Mandela Metropolitan University (Botany Department)

No. 1982

The study will provide knowledge of the processes that regulate nitrogen and phosphorus cycling in a temporarily open/closed estuary. The previous Great Brak Ecological Water Requirements Study recommended that further studies are needed to determine the loads of nitrogen and phosphorus flowing through the estuary and to determine how effective the estuarine flora, macroalgae and macrophytes, are at trapping and removing these nutrients from the system. Understanding this aspect has

become critical in view of the increased water requirements from PetroSA and Mossel Bay and the related decreased inflow to the estuary. Less river inflow to the estuary translates into more closed mouth conditions, which in turn will cause more nuisance algal blooms in the system impacting on both the sense of place and biota of the estuary. The main aims of the study are: to identify the sources and determine the loads of nitrogen and phosphorus entering the estuary, through point-source discharge (e.g. river, sea and storm drains), diffuse discharge (e.g. groundwater seepage from septic tank overflow and golf course irrigation water), atmospheric deposition (rain water) and remineralisation from organic material trapped in the sediment; measure the flux of nutrients between the water column and the benthos; measure the nitrogen and phosphorus content in living plant material; describe the environmental conditions in the estuary that favour macroalgal blooms; provide recommendations to be included in the Great Brak Estuary Management Plan; and to compare results from the Great Brak Estuary, an estuary dominated by macrophytes and macroalgae, to estuaries dominated by phytoplankton (e.g. the permanently open Sundays Estuary).

Estimated cost: R955 000
Expected term: 2010 - 2013

Programme 2: Riverine processes

Periphyton flow dynamics

University of Cape Town (Zoology Department)

No. 1676

Periphyton (benthic algae) in rivers is highly sensitive to changes in both water quality and flow. Periphyton forms the base of the riverine food chain and any change at this level will be reflected throughout the ecosystem. In addition, the growth of undesirable periphyton can have negative economic consequences in several ways. Filamentous algae can clog irrigation and water purification equipment as well as render the habitat unfit for

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

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

An assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park (KNP) and the physical and chemical factors affecting their distribution

Bioassets cc

No. 1928

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

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

Biomonitoring the fish health of two impoundments in Olifants River, Limpopo Province

University of Limpopo

No. 1929

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

Estimated cost: R674 500

Expected term: 2009 - 2012

Linking hydrology and lateral riparian vegetation zones

Southern Waters Ecological Research & Consulting

No. 1981

The research will focus on standardising the number of lateral riparian vegetation zones, their names and their links to aspects of the flow regime. This has been proposed by Mackenzie et al. (1999) and underlies the recommended data collection approach for riparian vegetation in the Building Block Methodology (Kemper and Boucher, 2008). Possibilities for standardising zone definitions have been explored to some extent in other work done on rivers in the Kruger National Park and also arose out of the previous WRC project (K5/1407), which proposed a biological description of four lateral zones but did not formalise the links with any hydrological data. This initial description requires testing on rivers elsewhere in the country. Therefore, a concise account of lateral zones with consensus on their names and predicted locations; descriptions of their floristic and other attributes, and an assessment of their correlation with flows of different return periods will be invaluable to specialists involved in Reserve

determinations, practitioners involved in using VEGRAI under the NAEHP and, importantly, to new entrants to the field of riparian botany. The main objectives of the study are: to identify the number and composition of lateral zones in riparian vegetation communities in a selection of rivers around South Africa; suggest standardised names for the identified lateral vegetation zones; explore the relationships between these lateral vegetation zones and aspects of the daily flow hydrology and, if possible, link the identified zones to flows of particular return periods; and to seek simple methods for the identification of the lateral vegetation zones.

Estimated cost: R1 765 310

Expected term: 2010 - 2013

Programme 3: Wetland processes

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

Rhodes University

No. 1857

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

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

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

Establishing ranges of water quality variables in wetlands and their relationship to land use and ecosystem response: towards refining the ecological Reserve

University of Cape Town (Freshwater Research Unit)

No. 1921

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

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

Regional wetland processes of the Maputaland coastal aquifer on the Zululand coastal plain

ARC (Institute for Soil, Climate and Water)

No. 1923

Previous studies about the wetlands on the Zululand coastal plain could not use environmental attributes to explain the wetland type and distribution on a regional scale. There is no clear classification and characterisation of wetlands which addresses the interaction of environmental factors and processes on a broad scale. An understanding of environmental factors and processes is required before human-induced changes can be evaluated.

The research will provide a workable framework that will link environmental factors and processes for different wetland types and distributions on the Zululand coastal plain and enable the prediction of the response to land-use and water-linked ecosystem change on a regional scale.

Estimated cost: R893 364
Expected term: 2009 - 2011

Evapotranspiration from the Nkazana Swamp Forest and the Mfabeni Mire

CSIR (Natural Resources and the Environment, Pietermaritzburg)

No. 1926

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

Estimated cost: R908 000
Expected term: 2009 - 2011

Identifying relationships between soil processes and biodiversity to improve restoration of riparian ecotones invaded by invasive acacias

University of Stellenbosch

No. 1927

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

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

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

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

Fluvius Environmental Consultants

No. 1788

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

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

Application and testing of a strategic adaptive management system for freshwater protection, associated with implementation of South Africa's national water policy

SANParks Scientific Services; University of the Witwatersrand; Fluvius Environmental Consultants; Alexander & Llewellyn (Environmental Division); SAEON (Ndlovu Node)

No. 1797

River-based goods and services, with the explicit benefits to society, rely on healthy sustainable ecosystems. South Africa's water policy requires CMAs to manage the resource to achieve equity and social justice within ecological limits.

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

Estimated cost: R1 335 725
Expected term: 2008 - 2012

Environmental water requirements for non-perennial systems: Phase III

University of the Free State

No. 1798

Non-perennial rivers are distinguishable from perennial rivers, in that their hydrology is spatially and temporally much more variable, creating high levels of disturbance for stream communities. Previous WRC research has shown differences in Reserve determination between perennial and non-perennial systems using existing methodology, e.g. the relevance of groundwater in relation to surface water. Furthermore, standard hydrological models cannot predict along the whole hydrological spectrum, from perennial to episodic systems; therefore, water licensing will have to be based on a new understanding or model of the non-perennial hydrology. This study is aimed at testing the prototype methodologies on different river systems.

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

Shared Rivers Initiative: Phase II: Analysis of the ecological Reserve implementation scenarios with the intention to design an effective implementation approach/plan

AWARD

No. 1920

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

Estimated cost: R800 000
Expected term: 2010 - 2013

Review and update of resource directed measures (RDM) for estuaries

Anchor Environmental Consultants

No. 1930

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

Estimated cost: R604 400
Expected term: 2009 - 2010

Decision-support system for determination of environmental water requirements

Southern Waters

No. 1873

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

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

Linking of daily and monthly hydrological time series for use in monthly water resources models in support of the determination of ecological water requirements

Water for Africa (Pty) Ltd

No. 1979

The purpose of this study is to develop an effective methodology which utilises the daily hydrology available from the ACRU model to generate statistical parameters which describe the incremental daily flow for any quaternary catchment in South Africa and utilise this within existing monthly models to address the shortcomings of existing in monthly EWR determination methodologies. The outcome of such a method would be a stochastic simulated stream-flow time-series of daily natural discharges for all quaternary catchments which is consistent with Pitman monthly hydrology.

The daily time-series will not necessarily be a true representation of the flow on any particular day but will be statistically the same and will be of tremendous value to the EWR ecologists. The main aim of this research is to incorporate daily natural stream flow time-series into existing monthly water resource system modelling tools in order to enhance the ability of ecologists to determine the ecological flow requirements of rivers, specifically to: establish regression relationships between ACRU daily flows and the existing nationwide monthly naturalised flows (Pitman); incorporate these relationships into an existing monthly water resource model so as to provide a modelling tool which can estimate the change in daily flow (statistically) at any point in a catchment under various development scenarios; and to incorporate daily output tools for use by the ecologists.

Estimated cost: R378 000
Expected term: 2010 - 2012

Programme 2: Estuary management

The application of choice modelling techniques to guide the management of estuaries in South Africa – case studies at the Kromme, Bushmans, Sundays and Keurbooms estuaries

Nelson Mandela Metropolitan University

No. 1924

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

Estimated cost: R770 000
Expected term: 2009 - 2011

Programme 3: Ecosystem health

Osmoregulation in freshwater invertebrates in response to salt pollution

Rhodes University (Institute for Water Research)

No. 1585

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

Estimated cost: R201 160
Expected term: 2005 - 2009

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment

University of Stellenbosch

No. 1712

Scientific research has shown that all major aquatic wildlife groups are experiencing endocrine disruption (ED). ED, at many sites, is caused by a complex mixture of substances, very often in low concentrations but acting in synergy with other compounds in the mixture. Imperfect knowledge about the effects of endocrine disrupting compounds (EDCs) on ecosystem structure has implications for environmental risk assessment for EDCs. An important emerging approach is to develop models for ED

exposure in food chains, including pathways for human exposure. This study will research and design a conceptual risk assessment model related to the unique features of EDC dynamics in the aquatic environment in South Africa. This project aims to assess the advances made in the development of ecological-based risk assessment models and the use of the precautionary principle (vs. weight of evidence) in ecological risk assessments, as well as associated data requirements, with particular reference to EDCs. An appropriate ecological risk assessment model or framework for application in South Africa will then be recommended. The results will add value to the existing EDC programme and will provide guidance regarding future research.

Estimated cost: R370 000
Expected term: 2007 - 2013

Genetic diversity studies on selected taxa in the Klip River System: Towards the assessment of the usefulness of genetic diversity as an indication of ecological health

Sinelwati Scientific Research & Management

No. 1976

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

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

Expanding on a National Wetland Vegetation Database for the purpose of conservation planning, monitoring and wetland rehabilitation

University of the Free State (Plant Sciences, QwaQwa campus)

No. 1980

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

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

Programme 4: Environmental water quality

Survey of potential ecological and human health risks posed by persistent organic pollutants in aquatic environments in densely industrialised and urbanised areas

University of KwaZulu-Natal (Chemistry)

No. 1977

A group of contaminants that is receiving ever-increasing attention in water and sediment quality surveys and monitoring programmes in many regions of the world is persistent organic pollutants (POPs). This attention is related to the fact that these compounds and/or their breakdown products are widely acknowledged as a significant health risk (e.g. direct toxicity, endocrine disruptors, carcinogens). Urbanisation is recognised as a far more significant source of contaminants to surface waters compared to agriculture, and surface waters in these areas are

often the sole source of drinking and washing water to informal communities. Estuaries are the ultimate sinks for contaminants introduced into upstream waters and hence should provide an integrated understanding of potential problems at the catchment scale. The research has another aim in the context of costs of laboratory analyses and implementing monitoring programmes, namely, to assess whether the monitoring of estuaries (especially those in cities and towns) would be simpler and cheaper than for rivers. The overarching aim of the research is to perform a survey for an extensive suite of persistent organic pollutants in aquatic ecosystems from a highly industrialised and urbanised area and to assess the potential ecological and human health risks of measured concentrations.

Estimated cost: R1 543 176

Expected term: 2010 - 2013

Linking land use and water quality for effective water resource and ecosystem management

CSIR; GroundTruth cc; University of KwaZulu-Natal

No. 1984

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

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

Estimated cost: R1 500 000

Expected term: 2010 - 2013

Programme 5: Endocrine-disrupting compounds in water resources

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

University of Stellenbosch (Department of Zoology)

No. 1680

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

Estimated cost: R400 000

Expected term: 2006 - 2009

A study of the interactive effects of pesticide mixtures in water on selected species

University of Stellenbosch

No. 1932

Scientific research revealed that all major aquatic wildlife groups are experiencing endocrine disruption (ED) in contaminated sites, and that at many sites this is caused by a complex mixture of substances. Our ability to predict higher-order effects is still weak, and the imperfect state of our knowledge about the effects of EDCs on ecosystem structure has implications for environmental risk assessment of EDCs; therefore ecosystem-based research is much needed. Only in a few cases could a

causal link between EDCs in freshwater systems and altered endocrine activity/function in exposed fish or amphibians be established. This study will be a laboratory study to investigate the explicit ED effects of mixtures of at least two pesticides, used in agricultural areas of intensive and concentrated crop-cultivation practices, which could contribute to the ED effects seen in the environment (thus not taking the effects of industrial or other pollution into account).

Estimated cost: R1 600 000

Expected term: 2009 - 2012

**Guidelines for the Management of EDCs in Water resources:
Volume 2: EDC Sampling Guide**

Golder Associates Africa (Pty) Ltd

No. 1983

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

Estimated cost: R1 000 000

Expected term: 2010 - 2013

Programme 6: Socio-economic considerations

Establishing the fishery potential of the Nandoni Dam in the Luvuvhu River, Limpopo Province

University of Venda

No. 1925

Nandoni Dam was completed in 2004, and is ideally suited for both an extensive commercial fishery and an aquaculture industry. However, in order to manage the resource sustainably it is necessary to know what the productivity of the impoundment is. Impoundments typically go through a period of high productivity just after filling, as a result of the release of nutrients from the recently flooded land. This then settles down to the long-term level once the initial nutrient release is over. Nandoni Dam is reaching this stage and the level of fishery that the impoundment can sustain needs to be determined in order that the management target can be effectively set. The research conducted during this project is aimed at providing this information.

Estimated cost: R823 200

Expected term: 2009 - 2012

Programme 7: Ecosystem governance

The Shared Rivers Initiative Phase 2: Implementation of the Reserve (NWA)

AWARD

No. 1920

Research conducted will develop a dynamic synthesis of the reasons for the lags in the implementation of the National Water Act (NWA) of 1998, focusing on the ecological Reserve. It will not be a blueprint for solving the problem, but it will provide the principles and framework to guide water practitioners and managers in solving context-specific problems. Key to the whole programme is the building of

capacity amongst the people involved in all levels of water resource and service management (relevant spheres of Government, agriculture, mining, etc.) through action research. A means of working in this study is through collective action, networking, self-organisation and practice-based feedback loops, the aim being to develop these features where they do not already exist. It is anticipated that this will be a collaborative process and some of the outcomes will need to be negotiated. The overall aim of the Shared Rivers Initiative is to understand and effect change in the implementation of policies and legislation, specifically the ecological Reserve, relevant to the wise use of the Lowveld river systems. In addition, the study will design and implement a series of actions that will build capacity and confidence in the legal competence to enforce obligations associated with environmental water requirements in the region and specifically the ecological Reserve in South Africa. This must be done in such a manner as to allow a generic way of introducing ongoing change which is consistent with adaptive learning.

Estimated cost: R2 500 000

Expected term: 2010 - 2013

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Wetlands and livelihoods: Restoration of wetland ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods

University of KwaZulu-Natal (CEAD)

No. 1986

Wetlands are highly productive and are important for the conservation of biodiversity as well as water resource protection. They are also used by people in both formal and informal (subsistence) agriculture as well as for various

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

Estimated cost: R800 000

Expected term: 2010 - 2012

Programme 2: River and impound rehabilitation

Conservation of tigerfish, *Hydrocynus vittatus*, in the Kruger National Park with the emphasis on the establishment of management plans for the protection of its riverine habitat

University of Johannesburg

No. 1922

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

Reserve has been determined for these rivers, and research conducted during this project will ascertain the state of the tigerfish population in the KNP and will investigate whether the ecological Reserve, as determined, is sufficient to maintain a viable population of tigerfish in the rivers flowing through the KNP.

Estimated cost: R1 844 120

Expected term: 2009 - 2012

Food-web manipulation Phase II: Food-web interactions in South African reservoirs traced using stable isotopes

DH Environmental Consulting

No. 1918

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

Estimated cost: R1 500 000

Expected term: 2009 - 2011

NEW PROJECTS

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 3: Ecosystem health

Assessment of locally manufactured radio telemetry equipment for manual and remote behavioural monitoring of fish in lentic and lotic freshwater ecosystems in South Africa

Rivers of Life Aquatic Health Services cc

No. 2111

In this study, a cost-effective, locally-manufactured prototype biotelemetry system, followed by a commercially available model, will be obtained from YRless and tested. These systems will be used to monitor the behaviour of fish in different surface aquatic ecosystems including flowing (lotic) and standing (lentic) water ecosystems in South Africa. Thereafter comparisons between locally manufactured YRless equipment and existing high-cost American Advanced Telemetry Systems equipment will be made and a methodology for the use of cheaper digital radio telemetry systems for the monitoring of fish in South Africa will be developed. There are many advantages of using this technology in monitoring, such as provision of real-time data on temperature, animal activity (e.g. fish), and depth. According to the researchers, more variables can be added to the equipment, such as electrical conductivity, as required. All these water quality variables are key to water resource management, and use organisms in their environment, with minimal disturbance.

Estimated cost: R841 000

Expected term: 2011 - 2013

Programme 4: Environmental water quality

Aquatic microbial diversity: A sensitive and robust tool for assessing ecosystem health and functioning

Rhodes University (Biochemistry)

No. 2038

The aim of this study is to employ high throughput pyrosequencing of the 16S rRNA genes to characterise estuarine microbial diversity with a view to assessing ecosystem health and functioning in selected estuaries along the Eastern Cape coastline. The intention is to use the data from this pilot study to establish criteria for an early warning system to monitor aquatic ecosystem health based on changes in microbial diversity. The overall objective is to apply this technology in assessing the function and health of both freshwater and marine ecosystems in the future. The project will offer a unique opportunity to characterise the microbial biodiversity in aquatic/estuarine systems.

Estimated cost: R800 000

Expected term: 2011 - 2014

The effects of sediment as a physical water quality variable on macroinvertebrates as input into sediment water quality guidelines development

Rhodes University (Centre for Environmental Water Quality)

No. 2040

The overall aim of this study is to investigate the impact of suspended sediment particles (particulate) as a physical water quality variable on the macroinvertebrates. The project will focus on investigating the impact of suspended sediment particle size and not the bed-load, though the latter is likely to cause more abrasive effects on invertebrates. Utilising the existing data and literature on sediment effects, a generic framework of sediment water quality guidelines will be

developed. The microcosm nature of the investigation may need field or experimental mesocosm verification in order to establish a credible and scientific basis for development of sediment water quality guidelines. This project must be conducted hand-in-hand with a sediment bio-toxicity study commissioned by the WRC.

Estimated cost: R1 000 000

Expected term: 2011 - 2013

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

Long-term response of specific wetlands to Working for wetland rehabilitation

GroundTruth cc

No. 2035

The primary objective of this project is to investigate the long-term response of the specified wetland systems to the rehabilitation that was undertaken by Working for Wetlands. Despite the fact that South Africa spends in excess of R80 m. annually on the rehabilitation of wetlands, formal evaluation of the long-term ecological outcomes of this investment has been very limited. Therefore the need for such evaluation is considerable. The monitoring and performance evaluation component of the wetland rehabilitation research programme undertaken from 2002 to 2007 included the establishment of long-term sites for the monitoring and evaluation of wetland rehabilitation undertaken by the national Working for Wetlands (WfWet) programme.

Estimated cost: R199 580

Expected term: 2011 - 2012

Programme 2: River and impoundment rehabilitation

Setting objectives for urban river rehabilitation

Aurecon Group

No. 2036

The ultimate objective of the project is to develop usable tools for both land owners and regulators to assess a wetland and its rehabilitation requirements, and set clear, feasible and practical objectives for rehabilitation. All of this will be combined into a user-friendly guideline document for setting urban river rehabilitation objectives. The research will draw on international best practice examples and contextualise this in the South African situation, using existing and current South African case studies.

Estimated cost: R850 000

Expected term: 2011 - 2013

Hyperspectral remote sensing of water hyacinth: From plant physiology to landscape level changes

University of the Witwatersrand

No. 2037

To have better water hyacinth management, infested sites must be monitored so that the growth trajectory of the weed population is understood, and also to be able to predict what intervention will be required, and by when. This project therefore intends to develop remote sensing as a tool to make predictions; firstly to measure growth and the effects of biological control agents on the weed at a landscape level, and secondly to investigate the impacts of heavy metal water pollutants on biocontrol agents of water hyacinth. Because hyperspectral remote sensing (RS) can detect heavy metals and the effects of insect herbivory on the plants, measurements will be

instantaneous and eventually cheaper than laboratory analysis of the plants. Depending on the deployment of the RS sensor, either hand-held or airborne, the weed population can be assessed as a whole, not just as a small sub-sample.

Estimated cost: R610 561

Expected term: 2011 - 2013

Biology, ecology and management of indigenous and invasive alien fish species in the Groot Marico River and Sundays River catchments

Consortium: SA Institute for Aquatic Biodiversity (SAIAB); Golder Associates Africa (Pty) Ltd

No. 2039

The management of invasive fish and conservation of biodiversity is a high priority in the National Environmental Management Act (1998) and the Environmental Management: National Biodiversity Act (2004). In order to effectively conserve the indigenous ichthyofauna and manage the impact of alien invasive fish species an understanding of the distribution, biology, ecology and impact of both the alien and the indigenous fish species in the system is needed. The research will also investigate and assess the role that the water-utilisation infrastructure of the SRIS plays in the ongoing invasion of the Sundays River catchment.

Estimated cost: R1 600 000

Expected term: 2011 - 2013

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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 the negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, is 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 a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, reuse and treatment of wastewater from domestic to industrial and mining activities has been and is of even greater importance to our country, especially in the light of problems related to the deteriorating quality of our water resources and the rising costs and reliability of energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond to the issues of poor O&M, competency and capacity constraints, reuse, energy-efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

OBJECTIVES

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

The secondary objectives are to:

- Improve the management of water services in both rural and urban areas
- Develop appropriate technologies for improving the quality and quantity of our water supplies for both domestic use and industrial applications
- Develop new approaches to manage and enhance hygiene and sanitation practices
- Provide appropriate, innovative and integrated solutions to water and waste management in the industrial and mining sectors
- Develop applications for improved treatment of wastewater and effluent and improve processes for enabling increased reuse thereof
- Improve health, economic and environmental conditions, while supporting the development of appropriate technologies and socially-focused management practices related to water and effluent management

THRUSTS AND PROGRAMMES

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

- Thrust 1:** Water Services – Institutional and Management Issues
- Thrust 2:** Water Supply and Treatment Technology
- Thrust 3:** Sustainable Municipal Wastewater and Sanitation

Thrust 4: Sustainable and Integrated Industrial Water Management

Thrust 5: Mine-water Treatment and Management.

Thrust 6: WaterSmart Fund

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

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

Current programmes are:

- Financing of water services
- Institutional and management issues – Water services
- Innovative management arrangements – Rural water supply
- Regulation of water services
- Community education and awareness

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

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

Current programmes are:

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

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

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

Current programmes are:

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

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Scope: Water is a strategic issue to the industrial sector. While the water usage by the industrial sectors is not as great as, e.g. agriculture or domestic consumption, the impacts of the pollutants in industrial wastes and effluents on health and the

environment can be significant, costly and long-lasting. The aim of this thrust is to quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycle, recovery and beneficiation. This thrust also aims to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries. In addition, Thrust 4 establishes the governance, policy and regulatory environment that currently exists and the enabling environment that will be required to change behaviours to conserve water, grow the economy, and protect society and the environment.

Current programmes are:

- Emerging challenges and solutions for the 21st century
- Integrated management
- Quantification, prediction and minimisation of water use and waste production
- Governance, policy, regulatory and economic instruments to improve industrial water management
- Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

THRUST 5: MINE-WATER TREATMENT AND MANAGEMENT

Scope: The usage of water in mining and mineral processing/refining produces high volumes of solid wastes and liquid effluents. Some mining activities generate acid mine drainage (AMD) or other mining-impacted waters. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector. Future operations will almost exclusively take place in water-scarce regions (e.g. Waterberg, Eastern Limb) and their development will require reallocation of already stretched resources through, e.g. improved water demand and water conservation management. Additional priorities will include brine handling, biological sulphur compound transformation

and aversion of future impacts. Linkages (including memoranda of understanding) with organisations such as Coaltech, ESKOM and SASOL provide scope for the scale-up and demonstration of newly-developed technologies.

Current programmes are:

- Water use and waste production
- Regulatory, management and institutional arrangements
- Minimising waste production
- Mining in the 21st century
- Low-volume mined products

THRUST 6: WATERSMART FUND

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

RESEARCH PORTFOLIO FOR 2011/12

The KSA's continuous activities, supported by needs analysis and needs expressed by the Minister of Water and Environmental Affairs, as well as through the variety of strategic workshops and seminars with DWA and other stakeholders, ensure that the KSA's objectives and thrusts are aligned to the priorities and are well supported. The *External Review 2006* highlighted that the relative weight of this KSA's thrusts seems to be well-balanced regarding the needs of urban-industrial-mining and rural research needs, but, given the urgency to redress past inequities, there is a need to increase the number/weight and relevance of research

projects related to sustainable rural water supply and sanitation projects. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. Thus, the primary and secondary objectives of the KSA remain unchanged.

During 2011/12 the portfolio continued to build on the strategic changes from previous years, as well as strengthen the portfolio towards making greater impacts on the social, health, environment and economy of the country. This KSA will continue to build on and strengthen the strategic direction implemented over the recent years, which has resulted in foresight orientating the portfolio to emerging and new issues. Thus the portfolio of thrusts and programmes responds to these needs and we have redirected the scopes of thrusts and programmes to give us the flexibility to be more inclusive of emerging issues. Specifically, we have created two dedicated thrusts to deal with mine-water and industrial water issues. This emphasis responds to needs expressed by these sectors to allow for more integrated solutions. We have also merged the basic sanitation issues with wastewater management, so that attention is afforded to municipal sanitation as a whole.

The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs' strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the framework strategy *Water for Growth and Development* (Version 6), and towards supporting Government's outcomes.

BUDGET FOR 2011/12

The consolidated budget for 2011/12 is presented below:

| Research portfolio | Approved 2011/12 (R) |
|--------------------|----------------------|
| Current projects | 24 782 045 |
| New projects | 10 816 850 |
| Total | 35 598 895 |

CORE STRATEGY

Strategic context

Water is an essential ingredient for economic development, the maintenance of natural life support systems and basic human existence. Urbanisation and industrialisation rates in developing countries have escalated significantly and continue to grow. Economic growth and development result 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 poses great challenges for many developing countries. South Africa is no exception to this situation and this has led the Government to embark on major water-related infrastructure development projects and to introduce water conservation measures, the focus being on optimal utilisation of existing water resources, the upgrading of existing sources and the conservation and protection of catchment areas.

Although the water requirements for the domestic (rural 4% and urban 23%), industrial (3.5%), power generation (2%) and mining (2.5%) sectors are a fraction compared to total water availability and water consumed, it is the assurance (98%) and continuation of the supply that dictates the high capital and infrastructure costs. Industrial and mining processes, though a small user of

water, together contribute to the bulk of the pollution affecting our water environment. The commercial use of water in the domestic urban areas accounts for 20% of the total urban water use. With the increase in population and the economy, it is projected that by 2025 water demand in the domestic sector will increase to between 30 and 35%. Any future peaks in water demand will affect the assurance levels, resulting in demand being exceeded and vulnerability increasing.

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

A situation of growing dichotomy created by past practices, the current challenges for the water services sector are split into bridging the gap between the poor and unserved in terms of access to water and sanitation services, and supporting the growth of the economy through improving infrastructure and services to industry. The rate of urbanisation is fundamentally affecting the provision of water services and is beginning to result in regular failure of existing infrastructure. The increased migration

from rural areas and influx to urban areas is continually putting demands on existing systems. In the rural areas, traditional settlements present significant challenges to service delivery. While many achievements have been made by the water sector over the years in addressing these issues, the greatest and most elusive challenge is the sustainability of these achievements. The lack of investment in infrastructure operation and maintenance over the years, coupled with a skills shortage and lack of investment in replacement of infrastructure, is resulting in many systems failing to meet the requirements of good service delivery. This situation is escalating and is evidenced by the increase in reports highlighting problems.

The situation is further compounded by climate change, shortages of high-quality water sources, growing mega-cities, growing informal settlements, capacity and financial constraints, energy shortages and higher expectations for water, which are challenging the sustainability of the water industry in the long term. Efficient use of water for domestic, industrial and mining purposes, as well as improved sanitation, would be critical for improving public health, eradicating poverty and contributing to global competitiveness.

Taking into account all of the achievements and developments to date, it is clear that South Africa has amassed a substantial knowledge base and the competencies required to face the future challenges. However, there is a need to develop more environmentally sound technologies and processes that command greater integration in the solutions they provide. A more holistic and integrated approach is required towards providing sustainable solutions focusing on aspects related to the participation of society, the impact on the environment and resource base, institutional and management issues, minimisation of wastes and other emerging issues.

As water consumption continues to rise, Government will face the huge challenge of meeting increasing water supply and wastewater treatment demands. Only by developing long-term

strategies to address these issues, including the introduction of water conservation measures and continued investment in water-related infrastructure, will access to clean water and treatment facilities be available to a greater proportion of the population in the future. It is clear that the cost of providing clean water to an expanding and growing population and growing economy will continue to increase.

To achieve the above, more innovative policies and improved implementation strategies for water use and waste management will be required, supported by a strong basis for appropriate technologies, changes in infrastructure approaches and broader water management policies. It is inherent that institutional processes and capacity must be in place, supported by sound technologies and methodologies. The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas:

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

The costs and the price of water and water services have a significant impact on the economic growth of the country, since water is considered to be both a social and economic

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

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

Eradicating all forms and types of water and sanitation-related disease, resulting in the improvement in the quality of life of people and an increase in productivity, is ideally what is to be impacted through the area of **Water and Health**. Good, clean, safe drinking water and safe sanitation technologies are key

ingredients, together with strong institutional support to realise this objective. The KSA achieves this through the development of innovative technologies, improved testing protocols for measuring water quality, identifying emerging pollutants and their consequences on human health, developing sound educational materials and communication techniques and undertaking risk assessments. Some examples of projects which contribute are: the development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply; the development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters; assessment of WatSan and hygiene in relation to home-/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas; development of more user-friendly structures for home-based treatment in rural areas; development of more robust and lighter VIP structures.

Linkages to Government outcomes

The current portfolio is aligned and responsive to Government's outcomes as highlighted below:

The portfolio of programmes and projects in Thrust 1 contribute towards Government outcomes of improving the effectiveness and functioning of local Government to provide water services (Outcome 9), as well as, importantly, to strengthen regulation and reduce the existing water services backlog while stimulating livelihoods at a local level. With the biggest challenges being in rural municipalities, we have investigated institutional options for effective local level management and delivery of water services. The research outputs on franchising have been realised in an experimental pilot, which is proving to be a successful model and offers one option for municipal arrangements. Supporting this option we have completed a study on people-centred approaches to management of water services. At an urban level, studies have looked at how local people can participate in supporting municipalities, by unlocking procurement and operational hurdles. New initiatives address the concepts of adapted CLTS with

the intention of stimulating local ownership, investment and livelihoods in the delivery and maintenance of sanitation facilities, resulting in accelerating sanitation delivery and moving towards Government's outputs on improving access to sanitation for the poor. Ongoing and new projects are investigating further opportunities or modalities to enhance local levels of service provision and are looking at institutional models for both centralisation and decentralisation. Effective municipal institutions are supported by a healthy and robust financial situation, which is one of the key outputs of Government. Three new projects have been initiated which aim to support the strengthening of municipal finances. These look at understanding proper tariff setting, establishing capital investment requirements for regional water management and establishing the funding requirements to completely meet Green Drop requirements. Future research will put greater emphasis on municipal finances and funding of new infrastructure. These initiatives further contribute to and support Government's output towards establishing a robust water economic regulator. In support thereof we have completed studies on the standardising of municipal accounts, since these form an importance base for water services revenue and consumer awareness. New initiatives are looking at how customers value their water services and the resources; this forms an integral part of regulation since user behaviour will influence water use, tariffs and affordability and form the basis for regulation. In meeting Government's goal of strengthening municipalities, the third phase of the benchmarking of water services has been launched, in partnership with SALGA. This initiative has many outputs which will support regulation and process improvements in the functioning of municipalities and support effective acceleration and delivery of services.

Thrust 2 contributes directly to Outcome 6: 'An efficient, competitive and responsive economic infrastructure network', for example, through the development of an internet-based electronic Water Quality Management System, which provides a tool which will enable the water service authorities and Department of Water Affairs to work together to attain Output

6: 'Develop a set of operational indicators for each segment'. Programme 2 (Water Treatment for Rural Communities) in particular speaks to Outcome 7: 'Vibrant, equitable and sustainable rural communities and food security for all', Output 3: 'Rural services and sustainable livelihoods' and Output 4: 'Rural job creation linked to skills training and promoting economic livelihoods'. The WRC has supported projects to develop appropriate water treatment units based on membrane technology, gravity and wave power, which will not only enable rural households to access clean, safe drinking water but which will foster local economic activity for the servicing and repair of the treatment units themselves. One example is the immersed membrane microfiltration system for the treatment of rural and industrial waters. In early work on this topic a novel idea for an immersed membrane microfilter was investigated, based on a locally-produced woven fibre microfiltration fabric. The woven fibre microfilter was designed to be operated as an inside-out tubular filter. However, with modifications, the microfilter could be operated in an outside-in configuration, i.e., as an immersed filter. The results indicated that the local development had great potential in immersed membrane microfilter applications. Very good water qualities were obtained, on both raw river water and biological sludges. The local system can be backwashed, which is not a common practice with other flat-sheet systems internationally. However, the overriding advantage of the local development is that it is extremely robust and inexpensive to produce, making it highly applicable for use in developing economies. Trials of this system have commenced in the Eastern Cape, to assess the ease of use in rural households and reveal operational issues that might arise when the units are used by the public.

The programmes and projects in Thrust 3 largely contribute directly towards Government Outcome 10, in the protection of environmental assets and natural resources from domestic and industrial waste that is currently treated within treatment plants. This thrust has projects that deal with the development of technologies such as the anaerobic baffle reactor system which

is being piloted in eThekweni municipality as a decentralised wastewater treatment option for communities. Linked to this, is the concept of sustainability which sees the addition of previously developed WRC-funded flat-sheet membranes and constructed wetlands as polishing technologies for the final effluent, to a quality which can be used for small-scale agricultural crops by the community. The WRC has embarked on several constructed-wetlands projects which will feed knowledge, capacity building and know-how into these pilot innovations by municipalities, which can then be replicated elsewhere in the country. The WRC has sought to stimulate new ideas for future wastewater treatment technologies by funding a project on innovative designs (i.e. biomimicry) for constructed wetlands of the future. It has provided solutions for the incremental improvement of nitrogen standards by demonstrating the ability of using South African clinoptilolite as a polishing step at wastewater treatment works. Additionally, projects on sewerage in SA, especially for dense informal settlements, will lead to guidelines on technology options and implementation for municipalities. A project looks at management of stormwater using water sensitive urban drainage principles to lessen pollution loads to rivers and prepare for more frequent rainfall events which may be due to climate change. Indirectly, this thrust touches on providing solutions to Government for supporting rural services, such as 'sewer planning made simple', a set of tools for small rural municipalities, as well as knowledge generation which leads to more effective local Government decision making by repackaging existing knowledge on technology choices and decision-support tools in user-friendly poster formats. In partnership with SALGA, WIN-SA, DBSA, DWA and municipalities this thrust has also seen the need to capture operational case studies on the infrastructure refurbishment costs, and operation and maintenance and infrastructure asset management efforts, in municipalities.

The programmes and projects in Thrust 4 were revised in 2010 and largely contribute directly towards Government outcomes of the protection of environmental assets and natural resources from industrial waste. A series of projects relating to membrane

bioreactors and membrane technologies has been investigated for the pulp and paper, textile, olive oil and chemical industries which will assist in industries meeting discharge standards to either the natural environment or municipal sewers. One of the key gaps with the use, and thus the sustainability and cost-effectiveness, of membranes is fouling, and a project under Thrust 3 at the University of the Western Cape is investigating the possibility of designing membranes that foul less. The knowledge derived can be used for both industrial and domestic wastewater treatment. Over 10 years of WRC research on co-digestion of various industrial effluents has led to eThekweni municipality piloting a full-scale implementation at one of its works, for the eventual capture of biogas and the reuse of the final effluent. This builds on a more holistic and sustainable approach to waste management as set out in Programme 2 of this thrust. The completion of projects such as sustainability factors in industrial complexes has highlighted an emerging concern around brine (salts) disposal and liability. The initiation of projects such as forward osmosis and industrial brine minimisation deals with the emerging issues faced by Government around energy use by different technologies and brine waste accumulation in South Africa. This thrust also supports local Government effectiveness by developing protocols for the evaluation of industrial wastewaters for discharge permitting and technical guidelines for the determination of municipal effluent charges, as a means to encourage industries to switch to cleaner production approaches rather than end-of-pipe approaches.

The programmes and projects in Thrust 5 were revised in 2010 and contribute directly towards Government outcomes of the protection of environmental assets and natural resources from industrial waste. This thrust also supports local Government effectiveness by developing methods for the evaluation of the long-term impacts of mining activities, to encourage industries to switch to cleaner production rather than waste generation followed by treatment. The WRC has been conducting mine-water related research for over ten years. The research is conducted with specific end-user groups in mind. These range from the

general public to mine engineering staff, practitioners and specialists. The earlier research projects dating back to the year 1989 were based on gold and uranium mines. The focus areas of these studies were the water requirements and pollution potential of these mines. Subsequent research projects focused on issues such as the impact of mining on the surface water environment, treatment options for mine effluents and the rehabilitation of mine soils. A significant amount of research is conducted on modelling techniques and predictive tools. The studies tackled issues such as industry-wide water balance, development of low-cost passive water treatment systems and water modelling systems for the mining industry. From the year 2005 the WRC extended its scope to coal mines and acid mine drainage, where it focused on predictive tools for long-term water quality management in underground collieries, as well as the quantification of the potential and magnitude of acid mine drainage under South African open-cast conditions. Support to Government outcomes is exemplified by the Regional Mine Closure Strategy. In 2005 the Department of Minerals and Energy developed and subsequently implemented a regional mine closure strategy for hydraulically-linked mines following a significant array of research conducted by the WRC on mine-water and dating back to the year 1989. Specifically, the WRC published a report on mine closure strategy entitled 'The development of appropriate procedures towards closure of underground gold mines from a water management perspective', which made an important contribution to the DME closure strategy. The premise of the mine closure strategy was that most mines are hydraulically interconnected with adjacent mines. As such the closure of one mine within the region will often have impacts on the remaining mines. The last mine to cease operations in the region also ran the risk of bearing the cumulative burden imposed by all the other mines that ceased operations before it. The mine closure strategy thus assisted in providing an equitable basis to share responsibility between neighbouring mines in the same region. It also contributed to long-term plans to deal with the legacy of poor quality water from mines,

thus assisting to address Outputs 1, 3 and 4 within Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'.

Thrust 5 is directly linked to support Government's output on 'Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water'. As highlighted above, the objective of Thrust 3 is to stimulate innovation and application of novel water saving and efficiency devices which can, overall, reduce the consumption of water and the generation of wastewater.

Needs analysis

The KSA, in its endeavour towards identifying research needs, as well as developing and improving research strategies at the thrust level, has continuously engaged at a strategic level both nationally and internationally, to identify any gaps and to strengthen the portfolio of priority research topics and areas requiring attention. We believe that the continuous process of analysing and reviewing our strategy ensures that the KSA remains on a strategic path, as well as responding to challenges of the sector. The new DWA framework *Water for Growth and Development* has set priority imperatives for the water sector and the KSA portfolio is aligned to respond to the challenges posed.

In the previous year, the following areas of priority of relevance to the KSA activities were highlighted:

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

- Better understanding and management of the water crisis
- Skills development
- Non-compliance issues
- Water security and availability
- Carbon footprint vs. water footprint debate
- Cost of water to industry
- Improved dissemination and knowledge transfer
- Water quality
- Asset management
- Dealing with acid mine drainage
- Performance of wastewater systems
- Financing of water services infrastructure
- Energy-efficiency

Impending changes to the institutional environment will also have an impact on the KSA strategy and focus. DWA is going through a water services review process, as well as an institutional realignment process. Similarly, CoGTA is going through an institutional review process and is considering the effectiveness of the three tiers of Government process, and National Government has established the Planning Commission.

In reviewing the wealth of information generated through the various processes, including consultation with DWA and other stakeholders, it was clear that the key challenges facing the water sector in South Africa, as identified in previous years, have remained unchanged and warrant greater emphasis and support. We believe that our strategy and focus are in line with supporting Government's long- and short-term objectives, and especially those of ASGISA (Accelerated Shared Growth Initiative for South Africa) and the recent DWA framework strategy *Water for Growth and Development*. These objectives are:

- In a changing and dynamic legislative and strategic environment many solutions are required for sustainable and affordable water services provision. A key focus over the next few years will be on strengthening the capacity of local Government to function in this challenging environment, the introduction of successful models of service delivery which

enjoy the support of all stakeholders, addressing the issue of poverty and service provision (including affordability and cost-recovery), development of appropriate strategies, tools and policies to regulate water services and give effect to the water services and related legislation. The aspects of community participation and local economic development are central to these objectives.

- The realisation of the challenges of meeting the MDG targets, and in the case of South Africa, eliminating the water and sanitation backlogs.
- The water services environment is in a continuous process of dynamic change. The newly-published related legislation, besides setting a new set of challenges and goals for the sector, has reached a point of review. It will be imperative that the success of these frameworks and legislation will realise the ultimate goal of national water policy and local Government legislation.
- The provision of sanitation is more complex and provides greater challenges as the responsibility is spread across many Government departments. The short-, medium- and long-term goals are to find effective and efficient mechanisms to accelerate sanitation delivery and hygiene education coverage. These two components are essential ingredients for sustainability and for achieving public health objectives. Focus areas over the short term are to develop appropriate technical solutions, finding cost-effective ways to provide high-impact hygiene education, finding acceptable and affordable service arrangements, models for sanitation delivery and O&M, and improving the legislation and policies that contribute to an enabling environment. The sustainability of low-cost and onsite sanitation systems is already beginning to surface. Short design life, pit emptying, relocation and access to pits are some of the key technical challenges which may jeopardise achievements made to date and the provision of sustainable sanitation.
- It is evident that new issues in water supply (water treatment, distribution, etc.) will continue to emerge as new contaminants are introduced into the water sources. Great

challenges also exist in providing sustainable and affordable technical solutions for the poor and indigent sections of the population.

- The energy crisis in the previous years has raised the need for more efficient use of electricity and the need for alternative energy sources. As part of the KSA's objective of efficient and affordable water services, three key variables have been the focus for many years; these being energy, chemicals and materials, which together make up an estimated 70% of the operational cost of providing water services. More emphasis is now being placed on energy issues and proactively we have initiated and promoted many approaches to support this important cause. The research on efficient water use has also been stepped up, and this has a direct bearing on the energy requirements of supplying water services. These areas will continue to grow in an endeavour to meet the needs.
- Gearing the sector towards the impetus created towards water for growth and development
- In water supply and treatment technology, the needs over the next few years revolve around the supply of more affordable water of improved quality, especially to those people who do not yet have a reliable drinking water supply. Specific issues and research needs include the reduction in cost of water treatment and supply; the removal of organic contaminants; the removal of *Cryptosporidium*, *Giardia* and other pathogens; the identification and removal of emerging contaminants posing negative health effects; safe and efficient water fluoridation; improvement in the cost efficiency and sustainability of small- to medium-sized water treatment plants; dependable and efficient distribution systems; cost-effective distribution systems for rural water supply and sustainable and low-cost small water treatment systems. Medium- and long-term goals are to focus on infrastructure and asset management.
- Most of the country's industrial and mining activities are concentrated in areas where there is a lack of water resources. These sectors generate large amounts of wastes (toxic and non-toxic), which have a profound impact

on the ecology of the receiving water environments. As urbanisation and industrialisation increase, increasingly complex wastewater streams are introduced. It is imperative that solutions are generated to manage these negative impacts. Furthermore, there is growing recognition for more innovative approaches such as water footprint, cleaner production and waste minimisation. These areas require greater research support for knowledge generation and application.

- The mining industry presents additional needs that emanate from its legacy of water quality-degrading waste that has been accumulating for more than a century, and which could potentially affect water quality for future generations. In the case of gold mines these needs have to be addressed with urgency, as many mines are about to close down, which may represent lost opportunities to introduce pollution-prevention measures. Key areas to be addressed include the process of acceleration of cleaner production and waste minimisation technology and the development of innovative solutions, to deal with the legacy of waste and acid mine drainage potential that has accumulated as a result of mining activities.
- There is a need for improving institutional capacity in the management of water and wastewater problems, as it has become increasingly clear that these problems cannot (in the South African context) be solved by technical solutions alone. Institutional reform and strategic management issues (such as regulation, capacity, competencies, partnerships, tariffs, community participation, etc.) all play an equivalent role in achieving an integrated solution. Great strides in information gathering and knowledge generation and application are required in this area over a short period.
- Over the past few years great strides have been made in covering water and sanitation backlogs resulting in significant achievements. This has also resulted in the expansion and growth in infrastructure in urban and rural areas. More small schemes have come into existence and, from international and local experience, pose greater challenges in their sustainable management.

- Furthermore, the infrastructure and associated resources are the assets of our country and contribute to improving the quality of life and these assets need to be managed effectively. Lack of attention over the past few years to O&M, together with the lack of training and capacity, is beginning to show its weaknesses in the state of our water infrastructure. This valuable investment, if not given due attention, could prove costly for the country.
- Industry and mining is facing increasing pressure on the rising cost of water, but also increased scrutiny on the sustainable use of the resource. The concept of a 'water footprint' is an emerging and effective tool being developed to assist industry to scrutinise their activities and continuously strive to reduce their footprint on the environment.

In this regard, we have continued to build on these imperatives and greater emphasis has and will be placed in the years 2011 to 2014 in the following areas:

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

Overview of technological trends

At an international level key pressures which drive research and solutions are:

- Economic development and population growth
- Increasing demand for food, energy and water
- Global and regional changes to the climate
- Degradation of water quality
- Risks associated with infrastructure deterioration

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

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

Internationally, there is a new drive to accelerate sanitation and hygiene education delivery and radical new policies and strategies are being investigated to achieve the millennium goals. It is essential that these concepts and ideas be translated at a local level, thus requiring the need for developing improved strategies, policies and mechanisms that create a sustainable and enabling environment.

In water supply, the emphasis is on efficient use of water and managing demand, as well as looking at the contributory elements such as energy, pipe components and materials, water supply components and behavioural aspects. In terms of treatment technology, the current international trends are toward the increased removal of more specific contaminants in the water. In addition, it is aimed at adding fewer chemicals to the treated water product (improved source quality). The removal of pesticides, heavy metals, endocrine disruptors, disinfection by-products and other harmful organics is receiving attention. The removal of *Cryptosporidium* and *Giardia* and the use of membrane filtration in this regard are receiving much attention – especially in the USA. There is a strong trend towards improving determination techniques of these new emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues to be on breaking the transmission cycle of water and faecal-oral related diseases through understanding the practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

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

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

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

The mining industry has yet to embrace these new realities, and wastewater and waste treatment in this sector presently continues to be material- (e.g. chemicals) and energy-intensive, although more environmentally-friendly solutions are increasingly favoured, for example, biotechnological treatment of acid mine drainage associated with potential recovery and reuse of the renovated water for a variety of purposes. The cost-effectiveness of cleaner production technology is increasingly recognised and will in itself be a strong driving force for the accelerated introduction of the technology. Another driving force is the international trade sanctions that are increasingly being applied against manufacturers that do not apply responsible environmental practices. Increased activity in the field of mine-water has resulted in the creation of a dedicated thrust with two entirely new programmes to cater for it. In South Africa, it is foreseen that the introduction of waste discharge charges will be a further powerful driver towards internalising pollution costs and implementation of cleaner technology.

The contribution of mining-related non-point sources to water quality degradation is increasingly appreciated and has given rise to a need for improved techniques with which to quantify their contribution and improved technologies to minimise their effect.

Key stakeholders

The Minister of Water and Environmental Affairs is the shareholder of the WRC, and DWA and DST are its key stakeholders. In addition, the following stakeholders also continue to be of key importance to the WRC in general and to this KSA in particular. They comprise both internal and external stakeholders. Over the years, our international partners and business partners have also proven valuable to us.

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

The external stakeholders include:

- Government ministries and departments
- Beneficiaries (i.e. the users or potential users of research, development and knowledge products produced through WRC funding)
- SALGA, local Government, provincial Government units; including one-to-one interactions at the local and district municipality level
- Development Bank of Southern Africa
- Water boards, water services providers, catchment management agencies, water user associations
- Industrial sectors and industry-representative bodies (mining, forestry, water services, etc.)
- NGOs, CBOs and international aid agencies
- Private consultants
- Tertiary institutions, primary and secondary education institutions, science councils, professional bodies (Water Institute of Southern Africa (WISA), South African Institute of Civil Engineering (SAICE), Institute of Municipal Engineering of Southern Africa (IMESA), etc.), media agencies
- The public
- International coalitions such as Global Water Research Coalition (GWRC), Water Supply and Sanitation Collaborative Council (WSSCC), Water Utility Partnership (WUP), Emerging Technologies (ET), United Nations Environment Programme (UNEP), International Resource Centre (IRC), Water Research Fund of Southern Africa (WARFSA)
- The business sector

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.

IMPLEMENTATION PLAN

Research portfolio for 2011/12

The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the DWA framework strategy *Water for Growth and Development* (Version 6). We believe that the programmes and projects are strongly orientated to the challenges. This is receiving, and will therefore continue to receive, greater attention.

The new portfolio of projects continues to provide solutions that support these directions in the following ways:

- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education

- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including grey-water and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes
- Opportunities of energy from water and sanitation
- Supporting water for growth and development
- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology
- Investing in emerging contaminants affecting water quality

The scope and expected outcomes of the thrusts and programmes are provided in Table 1.

TABLE 1**Overview and description of thrusts and programmes****THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES**

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

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| Programme 1: Cost-recovery in water services | Scope: The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this programme intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches. |
| Programme 2: Institutional and management issues – Water services | Scope: Relationships and partnerships between service providers, both external and internal, are important prerequisites to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation. |
| Programme 3: Innovative management arrangements – Rural water supply | Scope: The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development. |
| Programme 4: Regulation of water services | Scope: Regulation of water services is important for the sector to achieve improved functioning and performance in the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment. |
| Programme 5: Water services education and awareness | Scope: A fully informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services. |

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

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

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| <p><i>Programme 1: Drinking water treatment technology</i></p> | <p>Scope: The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.</p> |
| <p><i>Programme 2: Water treatment for rural communities</i></p> | <p>Scope: This programme aims to produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.</p> |
| <p><i>Programme 3: Drinking water quality</i></p> | <p>Scope: The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.</p> |
| <p><i>Programme 4: Water distribution and distribution systems</i></p> | <p>Scope: The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to end-users. The programme has the following expected outcomes: to develop reliable processes in predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs; to ensure that the quality and quantity of water is maintained in the distribution system – from the water treatment plant to the furthest end-user; and to develop innovative methods, tools and processes that will improve system integrity and reliability.</p> |

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

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

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| <p><i>Programme 1: Emerging treatment technologies – Preparing for the future</i></p> | <p>Scope: It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as to support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment, etc. It also supports research aimed at informing future policy through data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.</p> |
| <p><i>Programme 2: Application of appropriate technologies and tools</i></p> | <p>Scope: This programme addresses the improvement and innovative application of existing ‘fit for purpose’ technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate application to consistently achieve strict standards, with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy-efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.</p> |
| <p><i>Programme 3: Stormwater and sewerage systems</i></p> | <p>Scope: The programme supports the strategic and technical aspects of managing stormwater and sewerage and their impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology including water-sensitive urban design (WSUD) and stormwater reuse. It will cover technical design, operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.</p> |
| <p><i>Programme 4: Wastewater sludge and faecal sludge management</i></p> | <p>Scope: All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, de-watering, disinfection and beneficiation is encouraged.</p> |
| <p><i>Programme 5: Sanitation technology and innovations</i></p> | <p>Scope: To develop innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.</p> |

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Scope: Water is a strategic issue to the industrial sector. While water usage by the industrial sectors is not as great as, e.g. agriculture or domestic consumption, the impacts of the pollutants in industrial wastes and effluents on health and the environment can be significant, costly and long-lasting. The aim of this thrust is to quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycle, recovery and beneficiation. This thrust also aims to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries. In addition, Thrust 4 establishes the governance, policy and regulatory environment that currently exists and the enabling environment that will be required to change behaviours to conserve water, grow the economy, protect society and the environment.

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| <p>Programme 1: <i>Emerging challenges and solutions for the 21st century</i></p> | <p>Scope: This programme seeks to look at major challenges that may face South Africa in future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable future industrial complexes and their water management will allow for better planning and regulation of new industries, enabling improved adoption of integrated resource management systems, processes and tools.</p> |
| <p>Programme 2: <i>Integrated management</i></p> | <p>Scope: This programme focuses on integrated and innovative management arrangements, e.g. public-private partnerships (PPP), to support industry and Government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.</p> |
| <p>Programme 3: <i>Quantification, prediction and minimisation of water use and waste production</i></p> | <p>Scope: In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.</p> |

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| <p>Programme 4: <i>Governance, policy, regulatory and economic instruments to improve industrial water management</i></p> | <p>Scope: The regulatory authorities are responsible for authorising and regulating the impact of industrial 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 governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective in order to improve, review and enable implementation.</p> |
| <p>Programme 5: <i>Water efficiency, cleaner production, beneficiation and treatment of industrial effluents</i></p> | <p>Scope: This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial activities, and thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycle, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. 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. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse, and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary economy opportunities within South Africa.</p> |

THRUST 5: MINE-WATERTREATMENT AND MANAGEMENT

Scope: The usage of water in mining and mineral processing/refining produces high volumes of solid wastes and liquid effluents. Some mining activities generate acid mine drainage (AMD) or other mining-impacted waters. This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector. Future operations will almost exclusively take place in water-scarce regions (e.g. Waterberg, Eastern Limb) and their development will require reallocation of already stretched resources through, e.g. improved water demand and water conservation management. Additional priorities will include brine handling, biological sulphur compound transformation and aversion of future impacts.

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| <p>Programme 1: <i>Water use and waste production</i></p> | <p>Scope: This programme focuses on investigations into quantification of water used and waste produced by the sector, currently, and predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.</p> |
| <p>Programme 2: <i>Regulatory, management and institutional arrangements</i></p> | <p>Scope: The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point-source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: Policy development falls under KSA1).</p> |
| <p>Programme 3: <i>Minimising waste production</i></p> | <p>Scope: This programme focuses on investigations into developing technologies and methods to decrease/ minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.</p> |
| <p>Programme 4: <i>Mining in the 21st century</i></p> | <p>Scope: The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, etc. (especially innovative ideas and piloting/scale-up).</p> |
| <p>Programme 5: <i>Low-volume mined products</i></p> | <p>Scope: Much research attention has been paid to coal and gold mining; however, other quarried or mined products such as radio-nuclides and platinum group metals also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.</p> |

THRUST 6: WATERSMART FUND

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

RESEARCH PROJECTS FOR 2011/12

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Critical assessment of raising basic level of water services

Nemai Consulting

No. 1892

A comprehensive financial and technical model was developed to determine the implications of raising the basic level of service for a municipality. The model allows users to input required water services scenarios and the output is given as a cost for each required level of service. In addition to the cost implications for the level of service, the model also raises a number of flags to highlight issues that cannot be captured as a cost. The outputs of the models can be extrapolated to a national level to highlight some potential national level implications and conclusions. The model shows that progress up the steps of the water ladder is not one of smooth transitions. Indications are that the following per-household costs would be applicable:

| Water ladder step | | Per-household cost (R) |
|---------------------------|--|------------------------|
| Starting level of service | Ending level of service | |
| No service | Standpipe & communal taps, VIP latrines | 7 730.68 |
| Standpipe & communal taps | Yard taps, VIP latrines | 3 520.44 |
| Yard taps | House connections, waterborne sanitation | 15 972.99 |

South Africa had made the initial decision to take the first step on the ladder in 1994 and the decision to take subsequent steps has not been made. The model concludes that bringing all households to a Yard Tap level of service with a minimum sanitation level of VIP Latrines, would have half the cost implications of the 1994 decision.

Cost: R600 000

Term: 2009 - 2011

Programme 2: Institutional and management issues – Water services

A toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa

Tshwane University of Technology

No. 1700

The original question that spurred this work was whether small community water supply interventions in South Africa were beneficial to their recipients and to what extent? The purpose of the research was two-fold: to develop and apply a methodology to measure impacts of small-community water supply service interventions. This report presents the method and the research undertaken to develop and apply it. The results showed that there were significant and seemingly beneficial function changes brought about by the water supply interventions – incrementally (from no service to rudimentary service to basic service) as well as direct intervention (no service to basic service). These did not appear to translate into any beneficial effects for the households in terms of the effect indicators used in this study. This is in all probability because of the use of containers to collect water from the improved source points and to store water at home while using it, as well as poor maintenance and operation of the water supply systems. This does not, however, mean that the service improvements failed.

Cost: R406 000
Term: 2008 - 2010

Development of strategies and guidelines for integrated water meter management

University of Johannesburg; Rand Water

No. 1814

There is currently a lack of proper water meter management in South Africa, with many bulk water suppliers and municipalities without optimal and integrated meter calibration, replacement, reading, and information management systems. Often the divided responsibility between billing and meter management results in poor billing, incorrect information capture, and poor maintenance. This is further compounded by the fact that, where initiatives of water demand management and conservation are required, the data is not easily accessible to the departments responsible for this task; there is frequently also a lack of integration between domestic and bulk water metering. It was envisaged that this project will provide clear and practical guidance on the operating principles of water meters, and the way that they should be managed in a water services institution. The focus of the project was on applying current knowledge on water metering to South African conditions, and on making this information accessible to South African engineers and managers. A guide book was developed to help address the need for better water meter management by providing a practical introduction to the technical and managerial aspects of water meters. Since water metering affects different departments within a municipality, as well as various external parties, it is important to look at this topic from a holistic perspective; hence the title refers to integrated water meter management.

Cost: R540 000
Term: 2008 - 2011

Guidelines on determining the vulnerability and risks of water services infrastructure

Emanti Management

No. 1893

Despite the availability of numerous asset management texts, a general current lack of effective asset management (and associated water service delivery) still exists at many WSI. A need therefore exists to further support WSIs through provision of simple, easy-to-use guidelines and associated tools which can enable WSIs to initiate asset management good practice at their institutions. In addition, there is also a clear need to capture and transform broad sector information into sector intelligence which is able to contribute towards regional and national water services infrastructure management strategies. To address these needs, a guideline document (and associated software tools) was developed to assist WSIs to conduct vulnerability and risk assessments with the purpose to identify, prioritise and manage vulnerabilities and risks associated with their water services infrastructure.

Cost: R996 800
Term: 2009 - 2011

The provision of FBW to backyard dwellers and/or more than one household per stand

Nemai Consulting

No. 1987

Backyard shacks occur in all provinces in South Africa and according to the Stats SA General Housing survey, 2008 (2009), numbers of backyard dwellings range between 11 000 in the Northern Cape and 555 000 in Gauteng. These dwellings make up 81% of informal dwellings in the Western Cape, 75% in the North West, 67% in Mpumalanga and 66% in Gauteng. By contrast, the numbers of backyard dwellers in 1996–1998 were much lower (approximately 150 000 households in Johannesburg were living in informal dwellings). In addition, backyard dwellers in the past

have been overlooked by housing policies that focus on upgrading and/or eradicating informal settlements. However, due to the lack of mass visibility, access to water and sanitation services by backyard dwellers is not well known. Backyard dwellings are not temporary in nature and legislation and policy to address access to water and sanitation is urgently needed. In addition, free basic services including free basic water are meant to be provided to each household. They are currently provided to each stand and the difficulty in providing water infrastructure to each backyard dwelling is colossal. Backyard dwellers can apply for free basic water as part of the indigent policy and a greater allotment of water would be provided to each stand. However, there are no mechanisms to ensure that each household has access to the free basic water allotment. Indigent policy does provide some mechanism for backyard dwellers to access free basic services, but the lack of legislation makes control of this access difficult and backyard dwellers are dependent on the good will of landlords for access to water and sanitation services. Legislation to formalise the backyard dweller/landlord relationship may provide the mechanisms to provide access to free basic water.

Cost: R571 800

Term: 2010 - 2012

Programme 3: Innovative management arrangements – Rural water supply

Health Impact Assessment (HIA) of water, sanitation and hygiene services in relation to home/community-based care services for HIV/AIDS especially with regard to home/community-based care

University of Venda

No. 1738

A substantial burden of the care of people with HIV and AIDS has been placed on the elderly, school-going children, family members, friends and different care organisations within the community. Among many Governments and communities,

home-based care is based on volunteers who are unrecognised, under-valued and frequently unpaid. They are largely women and girls. Home-based care is seen as work that does not require remuneration and therefore it is not currently considered within the scope of policies and legislation. The aims off the WRC project was to investigate home-based care practices with regards to the experiences of carers and to perform a health risk assessment of the water used for domestic purposes in households caring for people living with HIV and AIDS. The investigation highlighted that the plight of home-based care that essentially comprises unpaid work. Community Health Workers were sometimes paid for their work but the Government chose to not make them employees of the state. Many carers provided their services for free. They were exposed to a series of health risks and, similarly to those suffering from HIV and AIDS, experience stigmatisation, isolation and poverty. The burden of home-based care has disproportionately become the responsibility of women. Elderly woman and young girls spend many of their personal and study hours looking after the sick. They worked many more hours than men. Home-based care often included physical and psychological stress. The lack of safe water in many areas of the country, the availability of water and the quantity of water have been highlighted as some of the most important aspects that prevent adequate home-based care. The lack of these services adversely impacts on both the sick and the carers.

Cost: R500 000

Term: 2007 - 2009

How does the HIV and AIDS epidemic in South Africa impact on the water, sanitation and hygiene sectors?

University of the Western Cape

No. 1813

There is sufficient evidence that access to and quality of water, sanitation and hygiene is critical for people living with HIV and AIDS (PLWHA). Access to basic sanitation and effective solid

waste management is essential in reducing HIV and AIDS-related morbidity and mortality. Access to clean water is essential in promoting effective health and hygiene practices. All of these require an enabling environment that includes not just safe water supply, but effective wastewater disposal and solid waste management. The raising of health and hygiene awareness amongst affected households will be of limited value unless safe water supplies are available to these households so that they can practice good hygiene. Hygienic behaviour reduces opportunistic infections and lengthens the time period between HIV infection and full-blown AIDS. This extends the period in which HIV sufferers can be both socially, domestically and economically active. The specific objectives of this study were to investigate presently available water, sanitation and hygiene resources available to HIV and AIDS infected individuals in three different communities in South Africa: Ukhahlamba (Eastern Cape Province), Khayelitsha, City of Cape Town Metropolitan Municipality (Western Cape Province) and Groblersdal, Greater Sekhukhune District Municipality (Limpopo Province). The study revealed a wide range of issues in their various dimensions: understanding the currently available WSH requirements for people living with HIV/AIDS in rural, peri-urban and/or informal settlements; assessing the impact of HIV/AIDS at municipal workplaces within water and sanitation sectors; and drawing insights and recommendations on the needs of water services providers (WSPs) and the challenges undermining the ability and capacity of municipalities as key WSPs.

Cost: R765 000
Term: 2008 - 2011

Development of people-centred programmes

Mvula Trust

No. 1815

This research applied the concept of people-centredness to the question of operations and maintenance (O&M) of rural water supply. Operation and maintenance issues go to the heart of

sustainability in rural water supply: with good operations and maintenance, a community has an uninterrupted water supply of enough quality and volume to support their health and wellbeing. Without it, a community is exposed to health and hygiene problems and food insecurity, as well as social tensions that arise around these issues. The study sought to understand the implications of people-centred approaches to operations and maintenance challenges in South Africa's rural areas by investigating the history, current reality and future potential of operations and maintenance approaches to (remote) rural water supply. The results of the study indicate that the option of developing village water committees (VWCs) as SMMEs should be considered very carefully. If VWCs are to be developed into SMMEs, it should be part of an integrated approach to local economic development (LED) where the VWC plays a role to provide a basis of development skills as well as productive water for planned and supported LED. This also implies that issues of productive water access and use should be included within this planning.

Cost: R480 000
Term: 2008 - 2011

Investigating the social vulnerability of people and their livelihoods and their response to water infrastructure

Umvoto Africa

No. 1888

In this study, vulnerability at the community level was examined in the context of hazards that have a negative impact on the quality of, or access to, water services. Water-related hazards could be natural (e.g. floods, droughts, storms) or induced by human processes (e.g. pollution, climate change, dewatering of aquifers, mismanagement of water resources and water-related infrastructure, leading to long-term degradation of supply in terms of both quality and quantity, amongst other consequences). The measurement of vulnerability and risk at a local scale is an important tool for identifying the capacities of communities to

overcome disasters. Vulnerability analysis recognises the negative ends of the scale (vulnerabilities) as well as the positive coping capabilities of an individual/group to survive and recover from a hazard impact of a given severity. During the case study research and the development of the methodology for risk assessment at community level, problems were identified regarding the lack of proactive risk reduction approaches in relation to water infrastructure. Some of the issues identified included: lack of vision for long-term sustainability and relationship to disaster risk reduction; public participation is seen as a case of ticking boxes; the funding system and cycle supports new infrastructure rather than the maintenance and operation of existing infrastructure; and general institutional failure and a lack of responsibility as long as key performance area (KPA) indicators can be seen to be met.

Cost: R500 000

Term: 2009 - 2011

Social scarcity of water and water use

African Centre for Water Research

No. 1940

Given that the modification of existing water services planning practices inevitably has wide-ranging implications for key stakeholders, the WRC conceived this project as a scoping study to identify key issues for further research and to improve preparedness and understanding. The primary objective for this project was therefore to develop a methodological framework for linking future scenario-based water services planning at meso- and macro-levels, on the one hand, to water scarcity and water use at micro-community and household levels, on the other. Two key outputs of this study are a working definition of the concept of 'social water scarcity' and a Methodological Framework towards Integrated Future Scenario-Based Water Services Planning. In addressing the project aims and objectives, this report foregrounds the concept of 'social' water security rather than social protests. The rationale is that the latter are one component of a diverse basket of strategies that people adopt

to secure their livelihoods against perceived risks and hazards. In themselves, therefore, social protests do not provide a sufficient basis for deepening understandings of social aspects of water scarcity and water use. The report also considers, *inter alia*, that 'socio-political stability' should be understood in the context of the South African Constitution. Such clear understandings are prerequisite to the forging of long-lived co-governance relationships between micro-level water users and meso-/macro-level water services planning institutions. To begin with, the study sought therefore to develop a working definition of the concept of 'social water scarcity' – social scarcity of water refers to a social construct of 'resource management', which is determined by political, economic and social power dynamics underpinning the institutions that provide structure to social relations, security of access to bases of social power and productive wealth, and stability to the social organisation of human societies. Since secure access to water is an integral part of people's multi-faceted livelihoods, manifestations of social water scarcity become most evident at the micro-levels of social organisation, namely, communities and households at the local level.

Cost: R500 000

Term: 2009 - 2011

Investigating operational and indigenous knowledge of water use and waste management, and establishing ways to integrate them into water service management

Nemai Consulting

No. 1941

This research was aimed at introducing communities, municipalities, practitioners, etc., across South Africa to alternative ways of managing water and to allow indigenous knowledge to inform future policies. The approach to the study included a literature review to establish local and international trends, consultation with key stakeholders, identifying and documenting local and international case studies, compiling a research report and preparing content material for a coffee table

book. The history of indigenous water and waste management (IWWM) in South Africa is dominated by water as a collective good and a finite resource; therefore it was carefully protected and conserved. Very little written information is available on the history of pre-colonial South Africans in relation to water and sanitation practices. Not one of the 35 identified indigenous water management practices is predicted to have a negative impact on the environment; 71% have a high environmental significance rating, leaving 29% with a medium environmental significance rating. This finding is in line with general consensus that indigenous practices are environmentally sustainable. However, it must be cautioned that if these IWWM practices are not managed it could result in environmental degradation. Adapting IWWM practices to suit current conditions requires that planners understand the full local environmental implication of the technology before it can be implemented. It was concluded that IWWM could assist in addressing various challenges currently facing the water sector. Only 5 of the identified 35 IWWM practices originated in South Africa; therefore the team concluded that there was insufficient material for a coffee table book.

Cost: R530 000
Term: 2009 - 2011

Using ethnographic research to better understand water and sanitation practices in rural South Africa

Sarah Slabbert Associates

No. 1990

This study aimed to test the viability of an ethnographic participative technique, i.e., the use of digital media in the form of a video camera, to do research about water-related issues in rural communities. In addition its intention was to inform communication and education campaigns aimed at effective water management. Due to the nature of exploratory research, it was predicted that other unexpected outcomes could present themselves. The study responded to the call in developmental

discourse that indigenous household water practices and innovations should be taken into consideration in development interventions and solutions for rural water problems. This study has clearly shown that the ethno-visual tool can be used in a participatory non-interventionist manner in rural communities. The study was innovative in that it was non-interventionist, allowing rural people the opportunity to examine their problems through their own eyes and using their own perspective. The use of different perspectives, both from insiders and outsiders to the community, broadened the scope of the study. Apart from the film footage, other material collected was graphically and visually provided to the elders in the community, allowing for debate on a level previously unknown to them.

Cost: R412 000
Term: 2010 - 2012

Programme 5: Water services education and awareness

Survey of handwashing and hygiene behaviour

Sustento Development Services

No. 1886

Limited information was available on the impacts of the different approaches to hygiene education or health and hygiene awareness interventions in South Africa. Scientific information on the impacts of hand hygiene interventions on changing hand hygiene behaviours was even more limited. As a result, little was known regarding the most appropriate hygiene promotion interventions for different contexts in South Africa and the effectiveness of the health and hygiene (h&h) promotion initiatives were not well-understood. This study showed that present hand hygiene interventions, which focus on providing basic sanitation services and the use of disease theory to promote the need for hand hygiene, were focussing on some, but not all, of the key aspects required to improve hand 'cleanliness' and hand hygiene technique. However, this report also showed that measuring the effectiveness of hand hygiene interventions

in South Africa may be more difficult than initially anticipated and may rely on a number of variables, which are not yet clear. What was clear from this study was that hand hygiene in South Africa showed significant differences with what has been reported in international literature. There are presently many gaps in the local and international understanding of hand hygiene and more research is needed to address these gaps.

Cost: R520 670
Term: 2009 - 2011

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

The establishment and piloting of the Technical Assistance Centre for small water and wastewater treatment plants

Chris Swartz Water Utilisation Engineers

No. 1896

The Technical Assistance Centre (TAC) for small water and wastewater treatment plants was established to provide technical (but also non-technical) support to water services providers (WSPs) experiencing challenges with their water and wastewater treatment plants. During the initial establishment stages of the TAC, it was decided that the establishment, piloting and roll-out of the Centre be phased over two years, during which time specific implementation tasks would be performed to ensure progress against milestone and planning budget. This Final Report provides an overview of the establishment and piloting of the TAC, consisting of a description of the structure, mission, aims and activities of the TAC. It also provides feedback on piloting of the TAC that was performed in the Eastern Cape and Western Cape Provinces. Included is an overview of generic challenges common to many of the treatment plants in the provinces. The initial decision by the WRC to pilot the TAC in two provinces proved to be correct as the roll-out of the TAC proved difficult.

However, there are many lessons that can be taken from the pilot exercise. These include: legitimacy of a TAC needs to be clear to all stakeholders; there must be buy-in from all stakeholders from all levels of Government; there must be a budget for priority interventions; accountability from stakeholders is required in following through with the strategic and planning direction provided by the TAC in the longer term.

Cost: R275 000
Term: 2009 - 2010

Programme 2: Water treatment for rural communities

Improving health-related microbial quality of drinking water at the point of use by selected home treatment interventions: Effects on rural people living with HIV/AIDS

University of Venda (Department of Microbiology)

No. 1653

The consumption of contaminated water can result in increased incidence of waterborne diarrhoea, a leading cause of morbidity as well as mortality worldwide. Immuno-compromised people exposed to microbially contaminated water are more likely to experience adverse health effects. It has been reported that up to 60% of persons affected with HIV and AIDS in developed countries report diarrhoea frequently, of which 5 to 16% of these cases are related to *Cryptosporidium*, a waterborne protozoan pathogen that can cause chronic and life-threatening diarrhoeal illness in people living with HIV and AIDS. This study investigated whether improved household drinking water at the point-of-use will improve the wellbeing of people living with HIV and AIDS. The effectiveness of the clay filter in improving household water quality has been demonstrated in this study. However, it is necessary that the standard of production and quality control remain at a constant level for the ceramic filters in order to work efficiently. In addition, it is important for people to change their attitudes with regard to point-of-use intervention devices. The filters were highly effective in reducing microbial

indicator microorganisms, but in some households the filters were subject to recontamination due to unhygienic household practices. Therefore, people need to be educated on sanitation and hygiene practices to improve their wellbeing. Although the pathogens which were detected were prevalent in the water and the faecal matter, exact deductions could not be made regarding the link between presence and infection, using the Bio-wipe kit in the investigation of diarrhoeal samples. It was difficult to determine the impact of improved microbial water quality on the health of people living with HIV and AIDS, in rural households, as measured by the incidence of diarrhoea and improved immune status, because of the use of ARVs and other factors which could impact wellbeing.

Cost: R800 360
Term: 2006 - 2009

Programme 3: Drinking water quality

Management of microbial waterborne diseases: Volume 5 – What our children need to know

University of Venda
No. 1672

This guideline document presents the fifth in a five-volume series aimed at addressing the question of how best South Africans can protect themselves from water-related microbial diseases. It provides practical guidelines and awareness of hygiene and sanitation practices at the household level from the point of view of the family and the range of actions which family members need to undertake in order to protect themselves from infectious and emerging diseases. Several sources worldwide have been used in the preparation of this guideline document. Other aspects (and actions) related to action to promote hygiene are also included.

Cost: R400 000
Term: 2006 - 2009

Situation and gap analysis of water quality testing in South Africa

Jeffares & Green (Pty) Ltd
No. 1720

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

Cost: R800 000
Term: 2007 - 2009

Rapid enzymatic detection of organophosphorus and carbamate pesticides in water

Rhodes University

No. 1902

Pesticides can contaminate drinking water resources. Organophosphate and carbamate pesticides function by inhibiting the enzyme, acetylcholinesterase (AChE), which occurs in all living organisms and thus pesticides also have an effect on unintended targets such as humans and animals. As a result, contamination of water by these pesticides must be monitored. Due to the cost and complexity of traditional analysis methods, rapid screening methods need to be developed. As AChE is the intended target for organophosphate and carbamate pesticides, it is a suitable method for detection of these pesticides, with the concentration of the pesticide having a linear correlation to the inhibition of the enzyme. Using AChE as a detection mechanism is cheaper than most methods and allows for high initial throughput screening. Its sensitivity allows for testing at toxicity levels below stipulated legal limits. In addition to toxicity, pesticides have been identified as having possible endocrine-disrupting effects. Therefore this study also used the yeast oestrogen screen (YES) bioassay to assess the oestrogenic effects of selected pesticides. The main aims achieved during the study were the optimisation of pesticide detection to achieve lower detection limits than the minima set by legislation; the use of this assay to determine pesticide contamination in Eastern Cape water sources; and the assessment of the oestrogenic effects of these pesticides. Previous scoping studies indicated that AChE can be used to detect the presence of carbamate pesticides (CPs) and organophosphorus pesticides (OPs) in water. The AChE assay was optimised and used to establish the detection of individual OPs and CPs and then used to test the effect of pesticide mixtures. The degree of enzyme inhibition correlated with the concentration of pesticide. The

assay was then used to detect the pesticides in water sources. Chemometrics was applied to the data to ascertain if individual pesticides could be identified. The YES assay was used to determine the oestrogenic effects of the pesticides and the MDA-kb2 and T47D-KBluc assays were used to test androgenic activity. The AChE assay detected individual pesticides at nanogram levels as well as pesticide mixtures, which were found to have an additive inhibitory effect on AChE. The results obtained from the samples that were tested using this assay did not appear to have any receptor-mediated oestrogenic or androgenic activity in the YES, T47D-KBluc or MDA-kb2 assays, respectively. Some Eastern Cape water sources may be contaminated with pesticides, as indicated by the AChE results. The optimised AChE assay may also be effective in identifying individual pesticides within mixtures in conjunction with chemometric analysis. The YES assay proved to be an effective method of determining oestrogenicity, but the fact that not all pesticides are receptor mediated needs to be considered.

Cost: R600 000
Term: 2009 - 2011

Programme 4: Water distribution and distribution systems

Inverse transients to determine deficiencies in pipelines

University of Pretoria

No. 1721

A major shortcoming in the optimal utilisation of water distribution systems is the uncertainty about the physical status and the difficulty in identifying operational deficiencies. The two major problems reducing the hydraulic efficiency is the presence of air and leaks in pipelines. A previous study by the WRC (Report No. 1177/1/04) reflected the influence of air on the hydraulic capacity of pipelines. Another major problem with aging infrastructure is the occurrence of leaks. Both the location and presence of air and leaks are difficult to establish

in a cost-effective way. Numerous methods to locate air and leaks are available, none of which is non-intrusive and non-interruptive. This study reviewed the use of inverse transients as a non-intrusive, non-interruptive and cost-effective way to locate leaks and localised air pockets in pipelines. The procedure is based on the recording and assessment of the propagation of an induce pressure variance (waves) generated from a rapid change in flow rate through the pipeline, and the identification of reflecting waves which are rebounding/reflecting from a leak or an air bubble. Based on the findings from the field work, the validity of this technique has been established. With further field tests and the development of a guide on the use of inverse transients this technique could be commercially applied as part of the quest for the optimal management of the water asset infrastructure of South Africa.

Cost: R530 000
Term: 2007 - 2011

Dual grey- and drinking-water reticulation systems for high-density urban residential dwellings in South Africa: A pilot study

University of the Witwatersrand; University of Johannesburg;
University of Cape Town

No. 1821

The experiences garnered from this study show that implementing grey-water reuse for toilet flushing in South African high-density urban buildings already supplied with municipal potable water, must be approached carefully. Implementation of grey-water reuse systems for toilet flushing should only proceed after a rigorous evaluation and conclusion on several critical issues including: the availability of regulations or guidelines to which the reuse system would be accountable; consideration (on the part of both the implementing agency and beneficiaries) of the trade-offs between implementing low-technology, low-cost, high maintenance but requiring minimal skill, and low grey-water quality reuse systems versus other grey-water reuse system permutations; employing accredited grey-water reuse systems; targeting the most

appropriate end users, i.e. young people and non-residential buildings; achieving economic viability based on a maximum payback period of 8 years; and the need for regular beneficiary awareness and engagement operations. A cursory evaluation of the above issues would likely result in the failure of such systems.

Cost: R1 055 500
Term: 2008 - 2011

Web enablement of a Water Safety Plan and incorporation of existing similar supply system assessment tool

eManti Management

No. 1993

Water Safety Planning is a systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241, by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery. In so doing the process allows for better understanding of water supply systems. Once the risk has been identified, control measures can be put into place to mitigate these risks. The process also needs to identify systems by which these measures are implemented and monitored. Management plans describing actions taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes, should be included. This project aimed to establish a methodology to identify and manage the risks of water services infrastructure and the means by which water services institutions (WSIs) are better able to identify and manage these through use of Water Safety Planning. The guidelines introduce Water Safety Planning to the reader, highlight key steps to be considered when developing a Water Safety Plan and provide step-by-step guidance as to how to use the Water Safety Plan Tools currently hosted on the electronic Water Quality Management System (eWQMS)/Emanti.

Cost: R420 744
Term: 2010 - 2012

Assessment of non-revenue water in South Africa

WRP Consulting Engineers

No. 1996

This study builds on two previous assessments undertaken through the WRC. This study is the most comprehensive and detailed study of its type to date and expands on the knowledge acquired previously, through collaborative efforts with the DWA Regional Offices in the data gathering process. Data were gathered from 132 of a possible 237 municipalities throughout South Africa, representing over 75% of the total municipal water supply. From the analysis of the results, it was estimated that the current level of non-revenue water for the country as a whole is 36.8%. This figure is similar to the estimated world average of 36.6% but is on the high side when compared to other developed countries and is low when compared to other developing countries. The use of percentages is not recommended by the International Water Association when referring to water losses or leakage levels as this can often be misleading – the Infrastructure Leakage Index (ILI) is often used as an alternative to percentages when quantifying the real or physical leakage. The ILI indicator is a simple index which typically ranges from 1 in very well managed systems to over 100 in very badly managed systems. The average ILI value for all of the South African municipalities was estimated to be 6.8, which again is in line with the world average and would be above average (i.e. bad) when compared to most developed countries and well below average (i.e. good) when compared to most developing countries. Effectively, the ILI value of 6.8 tends to support the perception created from the percentage non-revenue water figures for South Africa (36.8%). There is clearly a high level of wastage or water losses in the country and considerable scope for improvement.

Cost: R994 500
Term: 2010 - 2011

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Materials mass balances modelling of wastewater treatment systems

University of Cape Town (Department of Civil Engineering)

No. 1620

This project made significant advances towards developing steady-state mass balance based integrated wastewater treatment plant (WWTP) models which link primary sedimentation, nitrification denitrification (ND) activated sludge (AS) and aerobic or anaerobic digestion (AD) of primary (PS) and waste-activated sludges (WAS). The most significant of these developments is the finding that particulate organics that are non-biodegradable in the AS reactor are also non-biodegradable under AD conditions. AS and AD simulation models can therefore be linked through common compounds to form plant-wide WWTP models. Development of a mass balance based steady-state model for the entire WWTP, comprising primary settling, NDAS and aerobic or anaerobic digestion of PS and WAS was completed. Mass balance C, N, O, H and total oxygen demand (TOD) stoichiometry was also developed to complement the steady-state models so that the different products exiting the WWTP via the solid, liquid and gas streams can be calculated, such as N loads in recycle streams, methane production for energy recovery and greenhouse gas (CO₂, CH₄) generation. It was also found that the WWTP type makes little difference to greenhouse gas generation if the disposed sludge contains the same percentage residual biodegradable organics. From the experimental results of aerobic digestion of concentrated WAS (2% TSS) from biological excess phosphorus removal (BEPR) AS systems only about one third of the P in the polyphosphate-accumulating organisms (PAOs) appeared as ortho-P in the bulk liquid due to struvite precipitation. Aerobic digestion, modified

to include intermittent aeration to promote denitrification and lime addition to enhance P precipitation, is a simple system to stabilise concentrated BEPR WAS yielding a dewatering liquor with low N and P for recycle back to the biological reactor.

Cost: R720 000

Term: 2005 - 2007

FISHing for indigenous anammox bacteria

Stellenbosch University; CSIR (Natural Resources and the Environment)

No. 1823

Anammox (anaerobic ammonium oxidising) bacteria are slow-growing, anaerobic autotrophs that convert ammonium and nitrite to dinitrogen gas. Consequently, these bacteria require 25% less metabolic energy than the bacteria employed in conventional biological nitrogen removal processes. In addition, these bacteria do not need an organic carbon source and have a low sludge production. Sludge and energy are two major challenges in the operation of wastewater works. The primary aim of this project was to identify and verify the presence of anammox bacteria in samples obtained from various anaerobic habitats in South Africa and to enrich for the organisms. Samples were obtained from anaerobic and activated sludge plants from around Cape Town. In addition, sediment mud samples were obtained from the ocean. The results may be summarised as follows:

- Microbiological techniques demonstrated the presence of anammox bacteria in ocean and wastewater samples, albeit at low levels.
- Enrichment proved to be difficult and the research resulted in recommendations for future enrichment studies. Enrichment screening for anammox bacteria in small-volume reactors can be considered ineffective, since oxygen toxicity has a greater impact due to diffusion.
- The microbiological techniques of FISH, 16S gene sequencing and pyrosequencing were effective to varying degrees in identifying anammox bacteria.

While all objectives were not fully realised due to the sensitivity of the organisms, the benefit of this biological nitrogen removal process remains attractive, and the establishment of viable anammox populations from the environment still remain the most important step in this work. Since the presence of anammox bacteria was demonstrated in natural and manmade environments in South Africa, the effective harnessing of these indigenous bacteria to improve wastewater treatment would be an ideal outcome, if this work is further pursued. A key recommendation for future research is the use of seed anammox bacteria from an existing anammox process or the lengthening of the enrichment period to greater than 2 years.

Cost: R785 750

Term: 2008 - 2011

'Health for purpose' in wetlands treating waste streams

Cape Peninsula University of Technology

No. 1936

Constructed wetlands (CWs) form low-maintenance, cost-effective wastewater treatment systems that are environmentally friendly and aesthetically pleasing. The main objective of this research was to evaluate the potential of maintaining a viable 'healthy' microbial population capable of degrading target pollutants within pilot-scale constructed wetlands treating, specifically, winery wastewater. Within the scope of this project, two microbial fingerprinting methods (DGGE and T-RFLP) were modified and developed to study population changes in the systems. Using T-RFLP, DGGE and standardised influent and effluent analyses, it was demonstrated that autochthonous microbial communities within the CW were modified and were able to adapt to amendment with ethanol, winery wastewater and synthetic phenolic wastewater. The study demonstrated both temporal and spatial adaptation of these communities. Furthermore, a second procedure called incremental priming, where increasing concentrations of ethanol were used for amendment of the system also resulted in an increase in

biodegradative efficiency. From these conclusions simple guidelines were recommended for implementation in full-scale systems and/or in a research environment in order to maintain optimal microbial 'health'.

Cost: R865 722

Term: 2009 - 2011

Programme 2: Application of appropriate technologies and tools

Support to EU - EUROMBRA project: Development of an anaerobic membrane bioreactor

University of KwaZulu-Natal (Pollution Research Group)

No. 1661

The purpose of the EUROMBRA Project was to find sustainable solutions for municipal wastewater treatment based on membrane technology and the ABR system. This project formed part of a larger international study on Membrane Bioreactor Technology (MBR) with an EU Perspective for Advanced Wastewater Treatment for the 21st Century. The EUROMBRA team consisted of several leaders in membrane research in industry and academic institutions from around the world. The contribution of UKZN to the EUROMBRA Project was to investigate the application of membrane technology under anaerobic conditions, with the specific application being a gravity-driven (low-energy) membrane filtration step coupled to an anaerobic baffled reactor (ABR). The key focus was on testing the robustness of membranes, particularly the operational understanding around fouling. The conclusions were:

- A standardised test cell technique was developed by the EU team and tested by the SA team to determine the fouling propensities of the different fractions (particularly the soluble fraction) of different sludge sources. The results showed that the samples from starved pilot ABR had the lowest fouling propensity whilst the sample from a conventional anaerobic digester had the highest propensity.

- Different fouling mechanisms were observed between hollow-fibre and flat-sheet modules treating identical membrane feed (that is, the ABR effluent).
- Trial-and-error membrane experiments must be performed for each DEWATS unit as membrane fouling will be dictated by effluent composition which can vary due to the compartmentalised design and operating parameters of the ABR.
- Flux-time experiments revealed that gravitational membrane filtration units coupled to an ABR have low permeate rates (less than 1 L/m²·h). Consequently, membrane technology is not envisaged for large community-based systems as the area required for membranes will be too large but could be used at household or for small decentralised operations.
- A mathematical model was developed for the ABR using literature and calibrated with data from the pilot ABR in Project K5/1248. It was found that the literature model underestimated sludge production by 13%. This slight underestimation suggested that the model could be used to predict sludge accumulation in the ABR.

Cost: R693 280

Term: 2006 - 2011

Programme 4: Wastewater sludge and faecal sludge management

Sustainable and beneficial use of biosolids land application strategies: Quantifying nitrogen and phosphorus plant-soil mass balances

University of Pretoria

No. 1724

The project focused on laboratory and field studies as well as simulations to optimise the beneficial use of wastewater sludges from both industrial and domestic origins. It resulted in two reports: 1) Sustainable agricultural use of municipal wastewater sludge: matching nutrient supply and demand,

and, 2) The potential of sludge amended combustion coal ash residues as artificial plant growth media. The first report focuses on the beneficial utilisation of sludge in agricultural practices and details the quantification of responsible sludge application rates in an attempt to match nutrient supply from sludge to actual crop uptake for sustainable agricultural use. It also reports on the development of a mechanistic crop water balance model (SWB) to which N routines were added to provide a reasoning support tool to this end. The P fertiliser value of several sludges, and N mineralisation as influenced by sludge stability and water potential, were also investigated and reported on. The results critically appraise some of the recommendations of Volume 2 (2006) and 4 (2009) of the South African Sludge guidelines and also highlights the potential for P accumulation even at relatively low application rates. The second report focuses on the potential use of petro-chemically derived biological sludge in the vegetation of the large gasification ash dumps. It includes a laboratory column study in which weathering, elemental release and water-holding characteristics of co-disposed industrial sludge, fine and gasification mixtures are investigated to assess chemical and physical suitability as potential growing media for plants. The report highlights the benefits and risks of mixing various waste streams in certain ratios, as well as the expected end products as these mixes weather over time.

Cost: R1 150 000

Term: 2007 - 2011

Investigating the potential of deep row entrenchment of pit latrine and wastewater treatment works sludge for forestry and land rehabilitation purposes

Partners in Development (Pty) Ltd; University of KwaZulu-Natal

No. 1829

While South Africa struggles to meet its sanitation backlogs, a substantial amount of existing basic sanitation infrastructure, which includes both conventional pit latrines and ventilated improved pit latrines (VIPs), has reached or is reaching the end

of its design life. Urgent interventions are required to deal with the escalating accumulation of sludge in these basic units. The options for disposal of this sludge are few. Against this background, this study investigated the application of deep row entrenchment under South African conditions and aimed at providing guidelines for the optimal and safe implementation of this sludge management option. The study investigated plant growth, sludge degradation and leaching of pollutants into the groundwater. Two sites were established to pilot this approach, one in partnership with eThekweni Metro in Umlazi, where only pit latrine sludges were entrenched, and the other in partnership with SAPPI at its site in Hilton, where only municipal sludges were used. The study has shown that entrenchment of sludge is a relatively simple solution for sludge disposal which enables nutrients to be retained and accessed over time. Some of the constraints are the cost of transport of sludges and very stringent environmental legislation. Further work is still needed to better understand impact on tree growth over time, fate of nutrients in the soil (more measurements needed, mass balances needed) and the longer-term changes in sludge composition and fate of pathogens.

Cost: R2 300 000

Term: 2008 - 2011

Programme 5: Sanitation technology and innovations

Understanding the sludge accumulation in VIPs, UDS and other on-site sanitation systems, and strategies to manage desludging in the future when pits are full

Partners in Development

No. 1745

Disposal of pit latrine sludge has become a massive problem for some municipalities and, with a large number of pits in South Africa anticipated to reach capacity soon, is going to become an even greater difficulty. Disposal of dense pit sludge at wastewater treatment works has been found to quickly overload

the works in addition to being counterproductive in a number of respects. The policy of the South African Government stresses the value of human excreta as a resource although utilisation must be done within strict parameters due to the hazards of contamination. A number of possibilities exist for utilising faecal sludge beneficially. Data provided by Water Services Authorities indicates that most pits are filling in five to nine years. This suggests that, of the more than a million VIPs that have been built in the past decade, many will soon reach capacity. Studies of pit-filling rates across a number of communities indicate that pits generally fill at a rate of 40 litres per capita annum, with 60 litres per capita annum providing a safe margin for planning pit design and emptying programmes. If rubbish is kept out of pits the filling rate will be reduced significantly.

Cost: R1 900 000

Term: 2007 - 2011

Establishment of sanitation technology demonstration centre

CSIR

No. 1890

The aim of this project was to establish a sanitation technology demonstration centre at the CSIR in Pretoria. The purpose of the sanitation technology demonstration centre is to provide a facility where people can acquaint themselves with the various sanitation systems available, aimed at informing local, provincial and national authority officials, NGOs, CBOs, consultants, schools, universities, and importantly, communities themselves. Informative material, such as posters, pamphlets, brochures and information sheets, are available for distribution. The result is South Africa's first sanitation technology demonstration centre which displays many basic sanitation concepts such as VIPs and many commercial derivatives of different types of on-site and off-site technologies. The project is further supported by factsheets on technologies and a web service. The sanitation technology demonstration centre forms an integral part of a larger

CSIR development that will serve as a research, demonstration and training site for appropriate technologies (water, sanitation, roads, energy and building) associated with sustainable human settlements.

Cost: R716 000

Term: 2009 - 2011

An approach to reducing risks and hazards from human waste generated by informal settlements: Community-based risk assessment with municipal partnerships

Cape Peninsula University of Technology

No. 1901

Informal settlements continue to be a feature of South African urbanisation. Municipalities of cities and towns continue to be confronted by mounting backlog realities while national and provincial human settlement strategies seek alternative approaches. A major challenge in this context is that inadequate waste management within informal settlements produces downstream flows of human waste that either bypass overburdened infrastructure networks or contribute to their dysfunction. As a result, increasing pollution of deteriorating river systems poses a public health threat that goes beyond individual rights to basic services to the collective interests of broader society. An interactive approach to risk reduction was developed and then field-tested in different case study settings. Based on field research in two differing municipal regions with eight informal settlement case studies, the tools were refined. Diverse settings and conditions that are replicated across all eight case studies are covered in these selected case study processes. The approach responds to growing concern about human waste streams flowing beyond the boundaries of informal settlements into environmental, urban, and public landscapes that are shared by broader society. In particular where services delivery to unplanned settlements faces overwhelming constraints and challenges reducing the risk of deteriorating water quality that is directly

linked to poor waste management within informal settlements, may find cost-effective utility in applying this approach to interactive risk reduction.

Cost: R587 800
Term: 2009 - 2011

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 3: Quantification, prediction and minimisation of water use and waste production

Development of a zero-effluent mathematical model for wastewater minimisation in a pharmaceuticals facility

University of Pretoria

No. 1898

The quality and purity specifications of products from pharmaceutical industries require that the cleaning operation of the processing units is strictly controlled. Consequently, large amounts of solvents and cleaning agents are commonly used, thus leading to high liquid waste volume. From these observations, it is desirable to minimise the production of such effluent at worst and eliminate it at best. There are several publications on wastewater minimisation techniques for batch processes. However, these are only limited to short-term time horizons. Presented in this report is a mathematical formulation that seeks to address this shortcoming. The developed technique has been applied to much longer time horizons with great success. Another gap in the waste minimisation techniques for batch processes is the inclusion of a regeneration option within the recycle and reuse framework. This report also presents a methodology to address the problem of wastewater minimisation by extending the concept of water reuse to include a regeneration system. This study systematically presents mathematical formulations and detailed case studies where these techniques have been applied with freshwater savings in excess of 25%.

Cost: R466 480
Term: 2009 - 2011

Programme 4: Governance, policy, regulatory and economic instruments to improve industrial water management

Technical guidelines for the determination of municipal effluent charges to encourage industries to switch to cleaner production (CP) alternatives

Process Optimisation and Resource Management (PRO&RM)

No. 1832

This project aimed at developing technical guidelines for selected but relevant industries in the paper and pulp, metal finishing, starch producing and textile sectors. It was based on case studies for benchmarking the status of Cleaner Production in South Africa. Outputs from this exercise were then combined with the findings from a literature survey on international best practices on CP, to produce a prioritised list of CP initiatives for each of the selected sectors. The preferred CP initiatives were then designed and priced to quantify the potential cost and savings from the implementation. The study found that end-of-pipe was often wrongly considered to be a CP initiative. The South African legislative framework aimed at promoting the implementation of cleaner production (CP) initiatives is fragmented and is therefore difficult to enforce uniformly. References to CP initiatives can only be inferred from the various National Acts and is therefore open to interpretation by the industrial sector. Since industry sectors vary across such a wide spectrum in their operation, capacity and nature of effluent discharged, the implementation of a CP charge has potential in selected sectors only. Blanket application of a CP charge which will encourage industries to switch to CP could be hampered by the differences which exist between sectors and even within sectors. The differences which exist between sectors would be manifested in the unit processes which make up the overall plant. In spite of these differences, however, it may still be possible to determine a CP charge which is representative of

a sector. Differences within a sector are best illustrated with the example of the metal finishing sector in which plating processes can vary from factory to factory or a combination of several types of plating processes could be present within one factory.

Cost: R570 619
Term: 2008 - 2009

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Beneficiation of agri-industry effluents

Cape Peninsula University of Technology

No. 1937

In view of the large volumes of fruit-processing wastewaters, the feasibility of wastewater beneficiation depends largely on the concentrations of valuable by-products present and the efficiency of the extraction processes that can be applied. Apple and citrus wastewaters were obtained and were characterised and found to be unexpectedly dilute but did contain phenolics and sugars. Significant levels of antioxidant activity were observed. It is recommended that membrane-based concentration of the wastewaters be utilised as the first step in treatment. Particularly, it would be recommended to include a greater diversity of membranes, including polyamide membranes which would be more resistant to microbial digestion. The greater the degree of concentration achieved in the first step, the smaller the volumes of wastewater to be treated in subsequent steps. Of the adsorbents tested, it is recommended that either PVPP or activated carbon be used for the adsorption of phenolics. Ethanol is the recommended solvent for elution from either PVPP or activated carbon. More work is required to improve elution efficiencies since eluting a more concentrated antioxidant solution with a smaller volume of ethanol would be preferable. The addition of solid fruit waste to the wastewater was found to be a useful approach to increasing the carbon content of the water. Enzymatic pre-treatment of the solid waste is

recommended as this method releases sugars from solid apple waste with high or low sugar concentrations and is therefore well suited to a range of apples from different cultivars and at different stages of ripening. While fermentation of the sugars to ethanol by *Saccharomyces cerevisiae* was shown to be possible, for cost-efficient recovery, a goal concentration of 40 g/L ethanol in solution would be needed; below this level, the distillation costs involved in recovering the ethanol would be prohibitive. A distillation unit operation will be necessary in the proposed process, both for concentration of ethanol after fermentation and for concentration of phenolic extracts but through optimisation of all unit processes.

Cost: R531 908
Term: 2009 - 2011

THRUST 5: MINE-WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

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 Inc.

No. 1460

This project was undertaken to develop a procedure and methodology that mines, researchers and consultants can use to develop water balances for gold mine waste residue deposits. A wide range of measurements were made to characterise the water balance on two tailings dams and a gold waste rock dump. The water balance of tailings dams is complex since these facilities consist of variably unsaturated porous media with saturated and unsaturated zones. All of these components were studied and the report presents detailed recommendations on how water balance studies

should be undertaken for cases where a screening-level water balance is required and for cases where a detailed and accurate water balance is required. For a detailed water balance, some form of numerical modelling will be required and the report provides guidance on what models could be used, what parameters need to be determined and how the required data should be collected.

Cost: R913 500
Term: 2003 - 2005

Field-testing methods to determine the evaporation rates on brine solutions produced from mine-water treatment

Golder Associates Africa (Pty) Ltd

No. 1895

Improvements in membrane processes have made it economical to treat mine-water to drinking water quality. Membrane treatment results in brines with 17.5 - 51 g/L total dissolved solids which have to be managed. Evaporation ponds have been the preferred disposal option to date. One of the key factors influencing the design of ponds is the evaporation rate. Textbook evaporation rates for water are readily available; however the high salinity in the brine decreases the real evaporation rate. Field investigations were carried out in order to compare evaporation of synthetic solutions made up to represent various brine concentrations and potable water with three real brines, to verify that the synthetic solutions do represent actual brines. Initial results indicated that stratification occurred in the evaporation pans, impacting the results obtained. The experimental procedure was modified to include daily mixing in the pans. The average salinity factors of synthetic brines were good matches for the real brines; hence synthetic solutions can be used during the design phase of a project in order to determine a salinity factor, prior to the construction of a brine pond. However, while the synthetic brines mimicked real brines in terms of total salinity and total dissolved solids, the salinity factor was influenced by not only

the concentration but also the composition of the brine, and textbook salinity factors and evaporation rates must be applied with care and backed up by measurements of rates from samples of the specific brine to be evaporated.

Cost: R497 310
Term: 2009 - 2011

Programme 3: Minimising waste production

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 (Midrand)

No. 1628

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

Cost: R1 500 000
Term: 2005 - 2007

Programme 4: Mining in the 21st century

Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine drainage

Golder Associates Africa (Pty) Ltd

No. 1834

Sulphide can be biologically oxidised under anaerobic conditions by photosynthetic bacteria and denitrifying organisms, and in the presence of oxygen by colourless sulphur bacteria. These organisms have the potential to remove sulphide in passive acid rock drainage (ARD) treatment systems, such as the integrated managed passive (IMPI) treatment system, where sulphide oxidation is facilitated by a floating sulphur biofilm (FSB) in the linear flow channel reactor (LFCR). A scaled-up version of the LFCR was included in a demonstration-scale plant, based on the IMPI process, which has been constructed on the Middelburg mine site. However, the LFCR was not sufficiently robust and still required improvements in design and operation. The fundamental microbiology and chemistry of biological sulphide oxidation is relatively well-understood, but the integration of this information with fundamental engineering principles in the context of a treatment system, particularly the LFCR, required further work and underlies the rationale behind this project. Laboratory-scale LFCR reactors were constructed at the University of Cape Town (UCT) and Golder Associates Research Laboratories (GARL) and were used to characterise the hydrodynamics using tracer studies and assessing the effect of sulphide loading and hydraulic residence time on sulphide oxidation performance. Analytical techniques to quantify intermediate reduced sulphur species were developed and allowed the sulphur mass balance across the LFCR to be determined. Molecular biology was used to characterise the microbial populations in the bulk phase and FSB. The data were used to inform a refined conceptual model to describe biological sulphide oxidation in the FSB. The information was used to suggest modifications to and improvements in the management of the demonstration plant.

Cost: R1 345 000

Term: 2008 - 2012

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Strengthening the sustainability and effectiveness of Free Basic Water

Counterpoint Development

No. 1989

There is growing recognition across South Africa of the pivotal importance of sustainability in water services provision: sustainable funding and revenue to support ongoing service delivery, sustainable water resources management to meet current and future demand, and sound operation and maintenance of all associated infrastructure to sustain continuous provision of potable water to citizens and key sectors of the economy. But does provision of Free Basic Water support or undermine sustainable provision of water services? The need to provide support to households living in poverty to enable them to access at least basic water services affordably is not in question. But how sustainable is the provision of Free Basic Water, as currently implemented, if it sends out mixed messages about the real value of water in a context of growing scarcity, and if it is contributing to operating shortfalls in municipal revenue arising from unbilled water? What are the trade-offs in the current approach? Are there more effective ways of achieving the desired outcome of ensuring that even the poorest citizens can afford at least basic services? There is growing evidence that the administrative and financial requirements for providing Free Basic Water and Sanitation sustainably to those who need it have been underestimated. Free Basic Water is at risk of becoming increasingly anti-poor, because many municipalities lack the

capacity to implement it effectively or sustainably, are not able to manage their available funds optimally, and are funding service provision through under-spending on operation and maintenance. Inevitably these weaknesses compromise the quality of service provision, and it is the most impoverished households who are impacted most. In a context of chronic poverty, limited administrative capacity in many municipalities, and growing water scarcity, is the provision of Free Basic Water the most effective and sustainable way of giving force to the Constitutional right of access to adequate water? This study aims to review international good practice around financing water services and designing water tariffs for sustainable water servicing and to review approaches and funding mechanisms adopted by relevant middle-income developing countries with substantial poor populations to providing affordable water services to needy and vulnerable citizens.

Estimated cost: R1 400 000

Expected term: 2010 - 2012

Programme 2: Institutional and management issues – Water services

Guidelines on condition assessment of water services infrastructure

University of Pretoria

No. 1950

The management of physical assets involves a wide scope and range of processes including acquisition, control, use and disposal of the assets in a manner that satisfies the constraints imposed by business performance, environment, ergonomics, and sustainability requirements. The focus of this research was on condition assessment of the water services infrastructure components and the development of guidelines for the condition assessment of these components. The objective is to focus on what should be done and therefore detail of a prescribed protocol of how condition assessment for the

different system components should be conducted will not be provided. The methodology included the review of existing operational information to gain insight into the procedures followed to conduct asset management and to relate the operational experience to the remaining useful life by formulating a relationship between the status and remaining life. The outputs emanating from the study include: data requirements to define the water infrastructure components; conceptual model between performance and life expectancy; applicable non-destructive techniques for condition assessment of water transfer infrastructure; description of the economic evaluation techniques to compare replacement or refurbishment; development of software (spreadsheet) to determine the remaining useful economic life.

Estimated cost: R800 000

Expected term: 2009 - 2011

Development of protocols and guidelines for municipalities to undertake studies to determine the impact or influence of climate change on water service delivery

University of the Witwatersrand

No. 1953

The recent damages to water and municipal infrastructure due to weather-related/natural disasters raise many concerns for municipalities as to how to respond and plan for such occurrences brought about by climate change and its influences on nature. While the delivery of basic water services, (6 kl per household per month free), is driven by a national development goal, the responsibility of ensuring this right is ascribed to local Government. For this, the local municipality needs to ensure that water supplies meet the consumption demand, present and future. Technical and financial planning is therefore required to ensure that an undisrupted service is provided. The impact of climate change needs to be included in this planning. All municipalities need to consider how climate change will affect their water services and to show how the departments most

need to act or react. They must understand what climate change means for their work and future investments. In addition, a review of changes in weather and extreme weather events over the past few decades can help identify who and what is most vulnerable to some aspects of climate change. Various departments within the municipal Government also must become aware of the need to consider climate change in their plans – for instance for water supply. Poor response to dealing with the outcomes of these climate changes will only escalate and increase the problems for municipalities. Municipal officials are unlikely to act if they have little idea of what climate change means for their city. To address this, the study will review and develop an understanding of the regional climate change knowledge and its relevance to municipalities in South Africa.

Estimated cost: R700 000
Expected term: 2009 - 2011

Programme 3: Innovative management arrangements – Rural water supply

Franchising partnerships for operation and maintenance of water services

CSIR

No. 1952

Conventional wisdom, supported by research, indicates that the capacity of many local Governments in South Africa to adequately provide even basic levels of water services to all their citizens on a sustainable basis is in question. The challenge of exploring a range of options to support these organisations also represents an opportunity to selectively incubate innovations on an experimental basis, following a tradition of South African leadership in public sector-driven partnerships with the private sector, for optimum development impact. The development and growth of the small business sector is a key objective and stated policy of the South African Government. This project is directly addressing this objective, and furthermore, coupling it with the

added benefits relating to the ongoing provision of water services to needy communities.

Estimated cost: R4 800 000
Expected term: 2009 - 2011

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Development of a durable and reliable wave-energy reverse osmosis system

The Impact Free Water Group

No. 1716

Small, rural communities living at or close to the sea along the coastline of the country rarely have a good and reliable supply of potable water – nor do they generally have electricity. The project aims to further develop an innovative reverse osmosis system which utilises ocean wave power in order to produce the elevated pressures required in the desalination of seawater to potable standards. A few prototypes will be constructed to evaluate the effect of various wave parameters on the system performance and improve the system into a practical, working technology.

Estimated cost: R650 000
Expected term: 2007 - 2010

Application and performance of slow sand filtration

Cape Peninsula University of Technology

No. 1836

Slow sand filtration is generally highly recommended in small and rural community water treatment because of its simplicity in design, operation and maintenance. However, little awareness of the application of slow sand filters exists in South Africa. Very little is further known about the slow sand filters in operation

in South Africa and how they are performing. The project, therefore, aims to investigate the extent of slow sand filtration applications in the country and practical performance of these filters, covering both successful and failed examples. It will also investigate and document the types, application and performance of the various pre-treatment processes prior to slow sand filtration. A database of all sand filtration plants in the country will further be compiled.

Estimated cost: R760 000
Expected term: 2008 - 2011

Assessment of the prevalence of organic compounds in raw and treated water for potable purposes, their fate in current treatment plants, and compilation of a guideline on best available technology for the removal thereof

University of Johannesburg

No. 1883

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

contaminant chemicals in SA water sources used for drinking water, determine the efficiencies of removal – especially by small treatment systems – and their effects in the distribution system, and suggest improvements to the treatment processes and operational procedures in order to safeguard the people against these contaminants.

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

Wastewater reclamation for potable reuse

Umgeni Water

No. 1894

Water is a scarce resource, especially in South Africa where runoff exceeds rainfall and is unevenly distributed. South Africa has been classified as water stressed and water should therefore be conserved. The pressure exerted on surface and groundwater supplies should be reduced or at best maintained, rather than increased as the country's human population and industrial development increase. Wastewater reuse offers such a possibility, and reclaiming domestic wastewater from Darvill Wastewater Works for potable reuse using membrane bioreactor technology is therefore being investigated. This project is intended to pave the way for technology enabling South African water suppliers to produce consistent, acceptable drinking water quality through used-water reclamation. Initial feasibility work will be followed by a demonstration plant designed and operated over a long-term trial to establish operating guidelines that ensure reliable product water will be generated at all times.

Estimated cost: R650 000
Expected term: 2009 - 20112

Development of design and operating guidelines for high-rate clarifiers in the South African water treatment industry

Umgeni Water

No. 1942

High-rate clarification is a relatively unexplored technology in South Africa, even though this technology is being used extensively abroad. There is only one known water treatment plant using high-rate clarification in South Africa, i.e., the Bethlehem Water Works (a review of the performance of this plant is included as part of this project). This technology is not as widely used in South Africa as it is abroad due to poor marketing and a poor fund of knowledge on this technology. In conventional clarifiers, clarification rates of 1.0 m/h to 4 m/h are generally used, whereas in high-rate clarification processes clarification rates as high as 10-30m/h can be achieved. With the increased cost of construction and especially the doubling of the price of steel over the last year, it is critical that structures with smaller footprints, using 10-20 times less steel and concrete be critically considered in future designs. As a typical example, a 4m diameter clarifier operating at an upflow rate of 10m/h would produce 3 MI/d of treated water. In contrast a similar diameter clarifier operating at conventional upflow rates of 1.0 m/h would only produce 0.3 MI/d.

Estimated cost: R1 800 000

Expected term: 2009 - 2012

Development of a costing model to determine the cost-efficiency and energy-efficiency of water treatment technologies and supply options

Chris Swartz Water Utilisation Engineers

No. 1992

While considerable information is available on technical aspects (design; operation; maintenance) of water treatment technologies, there is still a serious lack of information on costs of water treatment systems and technologies, in particular life-cycle

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

Estimated cost: R763 000

Expected term: 2010 - 2012

An independent investigation into the purification capacity of small-scale water purification units manufactured and supplied in South Africa

University of Johannesburg

No. 1994

Recent outbreaks of cholera and other waterborne diseases in southern Africa have resulted in a public perception that tap water is not safe for drinking purposes. As a result, the use of small-scale water purification systems in the domestic and occupational

setting is increasing rapidly. Most of these units are sold over the counter and consumers buy the products in good faith on the basis of claims of their efficiency made during marketing and advertising campaigns, and with the expectation that the units will remove 90-100% of all harmful microorganisms. Very few independent studies have been published on the capacity of these units to remove microorganisms and the majority are only tested for a single organism or compound and/or a single product. Only two studies have been published where the units were tested for more than one compound simultaneously. The overall objective of the study is to assess small-scale water purification units manufactured and sold in South Africa for their capacity to provide safe drinking water for domestic, public and occupational use and to provide guidelines to enable consumers to make informed decisions when purchasing these units.

Estimated cost: R809 000
Expected term: 2010 - 2012

Programme 2: Water treatment for rural communities

Compilation of guidelines for the selection and use of home water treatment systems and devices

Tshwane University of Technology

No. 1884

At least 5.7 million people in South Africa still have no access to treated, potable water within reasonable distances from their dwellings and many thousands more take water from water sources and use it untreated because of problems experienced with adequate and reliable potable water supply. Surface waters have steadily become more polluted – especially with regard to microbiological quality, which exacerbates the situation of the immuno-compromised when drinking inadequately treated or poor-quality water. A number of home treatment systems and devices are being used internationally by small, rural communities without potable water services (decentralised systems). These units vary from the most simple – such as using material as a

filter – to the most sophisticated systems treating grey-water to potable standards. Although various systems and devices have been extensively reported on in the literature, and some exploratory work has been performed in South Africa, little is known locally about the existing options – and little has been done to assist local communities or their advisers in making informed choices on whether such a system or unit will be appropriate to their situation, or which unit should be selected. This project will meet the need to source and investigate appropriate units, to determine their efficiencies of contaminant removal under local conditions as well as their sustainability potential, and to provide guidance on the selection and use of these units under local conditions.

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

Programme 3: Drinking water quality

β -N-methylamino-L-alanine bioaccumulation and bio-magnification: Health risks and water treatment possibilities

Nelson Mandela Metropolitan University

No. 1885

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

potential risk by evaluating bioaccumulation, bio-magnification and toxicological effects of these in aquatic ecosystems. The aim is to investigate the potential for health risk to consumers via indirect exposure to cyanobacterial BMAA and to evaluate treatment processes for BMAA removal from water.

Estimated cost: R1 800 000

Expected term: 2009 - 2011

Nano-technology solutions for drinking water

Rhodes University

No. 1991

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

of electrospun nano-fibres with imidazoles and silver to impact antimicrobial activity. The project will conclude by fabricating point-of-use devices that incorporate the developed technologies.

Estimated cost: R1 800 000

Expected term: 2010 - 2012

Programme 4: Water distribution and distribution systems

Determining the change in hydraulic capacity of pipelines

University of Pretoria; Rand Water

No. 1820

It is generally accepted that the operational life of pipelines could well be longer than the 30 years which are used in the economic analyses of pipeline systems. Networks of Rand Water and other water utilities prove this, although there are a number of reported cases where pipelines fell short of the expected operational lifespan. Funding of new water projects in the near future will have to compete with the capital that is required for the renovation, replacement and upgrade of existing infrastructure. An informed status assessment of a pipeline can only be made if the operational performance history of the pipeline is known. Optimal capital expenditure and operational cost is based on the performance and the expected hydraulic performance decay rate of pipeline systems. Long-term performance data are essential for this assessment and an effort should now be made to gather information on a regular basis for a number of different pipelines in South Africa.

Estimated cost: R785 000

Expected term: 2008 - 2011

Practical application of residential water demand and wastewater flow end-use model in South Africa

University of Stellenbosch

No. 1995

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

Estimated cost: R659 500
Expected term: 2010 - 2012

Compendium of case studies relating to water loss and water demand interventions at the municipal level in South Africa

Resolve Consulting

No. 1997

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

Estimated cost: R600 000
Expected term: 2010 - 2012

Apparent losses in selected areas in South Africa

University of Cape Town

No. 1998

Water is an essential but limited natural resource which is indispensable for life and economic development. Water for human, commercial and industrial consumption is abstracted from natural water bodies, purified and distributed through water supply systems to users. There is renewed international awareness that water distribution systems world-wide are aging

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

Estimated cost: R400 000
Expected term: 2010 - 2012

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Mass balance modelling over wastewater treatment plants III University of Cape Town; University of KwaZulu-Natal **No. 1822**

The series of projects aims to develop a plant-wide wastewater treatment plant (WWTP) model used to accurately predict the outcome of the various biological, physical and chemical processes taking place in a WWTP. These tools can result in more economical wastewater plant design and operation and improved effluent quality. Significant advances have been made towards developing steady state mass balance-based integrated WWTP models which link primary sedimentation, nitrification-denitrification activated sludge and aerobic or anaerobic digestion of primary and waste activated sludges (K5/1338 and K5/1620). This project aims to determine the kinetics of P release from biological P-removal systems and determine the extent to which mineral precipitation takes place. The P release in anaerobic digestion will be compared to that observed in aerobic digestion. Certain aspects such as the mineral precipitation in aerobic digestion, the un-biodegradable fraction of primary sludge and the un-biodegradable fraction of the waste activated sludge from nitrification-denitrification systems will be confirmed. The research will determine whether the presence of primary sludge will assist in the hydrolysis of waste activated in anaerobic digestion.

Estimated cost: R998 950
Expected term: 2008 - 2010

Effects of urine separation and treatment on wastewater effluent quality

CSIR (Stellenbosch); AFRICON; University of Stellenbosch

No. 1824

The project deals with alternative sewage collection and treatment for both low- and high-income communities in urban settings. The concept includes the separate treatment of urine and the rest of the black/grey sewage to achieve better effluent quality. This project aims to demonstrate at pilot scale that the DWA Special Standards can be achieved through (partial) separate collection of urine. In addition, this increases the capacity of the receiving wastewater treatment plant which could delay extensions. The research will be reconfiguring toilets and urinals to allow (partial) urine separation on pilot scale. It will determine the composition of urine and demonstrate the effectiveness of treating wastewater with less urine than normal in varying quantities to achieve very low nutrient effluent concentrations (DWA special authorisation), as well as relatively low salt effluent concentrations. The study will assess the operational issues, such as struvite and other forms of scaling in urine drains, odours, etc. This project will assist in creating awareness for the potential positive impacts of urine separation and the feasibility thereof.

Estimated cost: R1 200 000

Expected term: 2008 - 2011

Biotech in sanitation: biopolymer production with *Natronococcus occultus*, a haloalkaliphile using municipal wastewater and other waste resources

University of Cape Town

No. 2000

Natronococcus occultus is a haloalkaliphile isolated from East African soda lakes, which are characterised by low Ca and Mg levels, with high Na, Cl and CO₃ concentrations and a pH of 10-11. *Natronococcus occultus*, produces a glutamic acid-rich polymer, poly-glutamic acid (PGA). This polymer has a wide range of uses

including hydrogels, flocculants and soil conditioners and may be used for medical applications. Preliminary work in CeBER (UCT) laboratories has shown more consistent growth in the high salt environment under non-sterile conditions. This project aims to study this organism using wastewater as a feed substrate to produce a biopolymer or environmentally friendly flocculants. It can also be cross-linked and blended with the treated sludge for a high-value soil conditioner. This project investigates the potential of municipal wastewater treatment plants to produce materials required by the plant for operation, from its own waste resources.

Estimated cost: R356 000

Expected term: 2010 - 2012

Co-digestion of sewage sludge and industrial concentrates

University of KwaZulu-Natal

No. 2001

The WRC has supported several laboratory-scale and feasibility projects on co-digestion of industrial effluent as a treatment strategy for toxic industrial wastes. eThekweni municipality has agreed to pilot full-scale anaerobic co-digesters at Amanzimtoti WWTW. The digesters are expected to be refurbished in 2010. As a support to this initiative, this project will look at using WEST software to assist in building and transferring knowledge on operation and training needs. The investigation will be undertaken in six phases that will overlap with one another. The project will look to develop an in-line model of the laboratory-scale AD which will be followed by the development of an unsteady state model for the anaerobic digesters at Amanzimtoti WWTW. This will be used to predict performance of the full-scale digester. The WEST model will also be developed to analyse tests undertaken with selected industrial effluents in order to determine the parameters necessary for describing the kinetic effects of co-digestion of different feeding rates of the effluent. The model will be assessed for its ability to predict and test the performance of several industrial concentrates at once. The project will also investigate scenarios to maximise methane production or toxic effluent

treatment and to demonstrate recovery from process upsets. Finally, the WEST model will be used to train the operational staff on how to react to different hypothetical upset conditions. If during the period of the project, upset conditions occur, data will be recorded so that a portfolio of case studies can be developed and procedures will be developed to determine the root cause of the upsets. Overall, this project will assist in developing a model to assist in the process control and training of support staff for the implementation of co-digestion at a full-scale AD.

Estimated cost: R1 050 000

Expected term: 2010 - 2012

Urban effluent treatment in a rhizofiltration system

Durban University of Technology; University of Stellenbosch; University of Cape Town

No. 2004

Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing

processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see highly variable flow rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material are selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

Estimated cost: R2 400 000

Expected term: 2010 - 2012

The optimisation of waste stabilisation ponds by combining duckweed-based and algal-based systems, together with rock filters

ARTechnologies

No. 2005

Waste stabilisation pond technology is the most cost-effective wastewater treatment technology for the removal of pathogenic microorganisms. The treatment is achieved through natural disinfection mechanisms. It is particularly well suited for tropical and subtropical countries because the intensity of the sunlight and temperature are key factors for the efficiency of the removal processes. Poor performance of WSP in developing countries can be attributed to both poor process design and poor physical design. This project investigates the combination of rock filters, duckweed and algal ponds for improved performance of current

systems. There is a worldwide trend to include a rock filtration system, often with aeration, as a polishing step to remove the suspended algal cells. Duckweed-based WSP systems have a distinctive floating mat of duckweed covering the surface of the pond; it has been shown that these systems are able to remove COD and nutrients effectively. Since they inhibit algal growth, the effluent is free from suspended material and therefore has a lower COD as compared with algae-based WSP systems. The disadvantage is that production of oxygen is limited to the surface layer associated with the mat of duckweed, and the water column remains essentially anaerobic. This project proposes to study the following treatment train: anaerobic or facultative ponds (for COD removal), followed by a duckweed system, combined with an algal-based system, together with an aerated rock filtration step before discharge of the effluent. The advantages of the algal system will mitigate the disadvantages of the duckweed system and vice versa. At present not all of the process design criteria have been developed for duckweed systems, and a detailed study on the kinetics and hydrodynamics of a duckweed system would greatly contribute to the knowledge base in this regard. The combination of the two systems is a novel idea, and information gained on the system design and operation will provide design and operating guidelines to use for new designs and upgrading of existing ponds.

Estimated cost: R1 000 000

Expected term: 2010 - 2012

The development of nanocomposite polysulphone membrane with reduced fouling properties for use in wastewater treatment

University of the Western Cape

No. 2006

Polysulphone (PSF) membranes are the most common membranes used in ultrafiltration of wastewater due to their mechanical robustness and structural and chemical stability. Unfortunately PSF is a hydrophobic material, making its surface

prone to fouling due to adsorptive mechanisms. Fouling can either be caused by cake formation on the surface of the membrane, or by adsorption of the foulants both on the surface and in the membrane pores. Cake fouling is generally reversible and can be removed by backwashing or water flushing. Foulant adsorption however is irreversible and can only be remedied by very harsh chemical cleaning. Many studies have been conducted to increase the hydrophilic properties of the polysulphone membrane surface. These studies can be divided into three categories: 1) blending PSF with hydrophilic nanoparticles such as SiO_2 , ZrO_2 and TiO_2 ; 2) grafting with hydrophilic polymers, monomers or functional groups; and 3) coating with hydrophilic polymers. Despite these efforts to minimise fouling of PSF membranes during wastewater treatment, there are still many unanswered questions regarding the mechanisms involved. This study will attempt to develop a novel PSF nanocomposite membrane with minimised fouling properties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 000

Expected term: 2010 - 2012

Programme 2: Application of appropriate technologies and tools

Denitrification in trickling filters

CSIR (Stellenbosch); Virtual Buro; Tshwane University of Technology

No. 1825

Many wastewater treatment plants in South Africa are equipped with trickling filters which could be obsolete if they cannot achieve denitrification. The researchers aim to demonstrate (at full scale) that trickling filters can denitrify by changing the effluent recycle over trickling filters and/or limiting the rotation speed of distribution arms. They will then model the processes of aerobic COD removal, nitrification and denitrification in a biofilm system

and calibrate the model with results from 2 trickling filters in order to gain a better mechanistic understanding of the combined processes. This will result in a set of practical operating guidelines to achieve denitrification in trickling filters.

Estimated cost: R930 500
Expected term: 2008 - 2010

Ultra-sensitive electrochemical nanobiosensors array devices for real-time determination of estrogenic endocrine disruptors in municipal wastewater (ENDOTEK)

University of the Western Cape

No. 1999

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

samples is of utmost importance. The proposed research is on the development of a nanostructured electrochemical DNA aptamer array biosensor for detecting and quantifying estrogenic endocrine disruptors in wastewater samples down to the femto- or atto-molar range. The idea is to determine individual estrogen compounds simultaneously in one measurement using multichannel microchip array signal transduction approach.

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

Evaluation of the DEWATS process for decentralised wastewater treatment

University of KwaZulu-Natal

No. 2002

Several WRC projects have looked at the anaerobic baffle reactor (ABR) as a decentralised technology option for wastewater treatment. The DEWATS system aims to provide a treatment train consisting of the ABR connected to a wetland or membranes to study final effluent quality. The aim is to reuse the effluent for agricultural trials and thus link the technology to agriculture and food security. This project will be piloted in KwaMashu, KZN and aims to: (1) understand the capabilities of the DEWATS system for municipal waterborne sanitation, (2) re-assess the provision of sanitation to poor households and its opportunities, (3) gain experience in using different wastewater streams in agriculture, and (4) gain knowledge in disinfecting treated wastewater using gravity membranes at a larger scale. The data from the performance of the ABR will be compared to that of the earlier laboratory and pilot-scale systems and the previously developed model will be assessed and improved where necessary. The performance of the anaerobic filter compartments will be assessed in a similar way to the ABR compartments. While failure is not expected to occur, the performance under different loading rates will be assessed and a model of this part of the system will be developed. Effluent from different stages of the ABR through the process will be supplied for

specific agricultural trials to assess suitability for agriculture. The suitability of the soil at the Permaculture Centre will be assessed for different qualities of irrigation water and a selection of appropriate crops made. Water and nutrient balances will be undertaken across different agricultural plots and the two planted gravel filters to assess the impact of using treated effluent. The removal of pathogens at different points through the system will be assessed and quantitative microbial risk assessments are to be undertaken for agricultural workers and for the use of different crops irrigated in different ways.

Estimated cost: R900 000
Expected term: 2010 - 2012

Microbial database-tool for evaluating the BNR processes in KZN

Durban University of Technology

No. 2003

Biological nutrient removal treatment processes are highly organised systems that depend on a synergy between microbial populations and plant configuration and operating parameters. These microbial populations comprise primarily of functional groups of organisms such as ordinary heterotrophs that facilitate COD removal and denitrification, nitrifiers that facilitate nitrification, phosphate-accumulating organisms that are responsible for biological phosphate removal and filamentous bacteria that are responsible for the formation of the core of the floc in activated sludge processes. There is a fine balance between these different groups that has to be maintained in order for optimal functioning of these processes. Selection of these populations is generally based on influent characteristics, operating parameters and process configuration and therefore the microbial population dynamics in full-scale treatment processes are closely linked to the former operational conditions. In South Africa, previous studies on these correlations were conducted a long time ago (Ekama et al., 1999), focusing primarily on engineering paradigms. The microbial population investigations

were based on conventional microbiological techniques. With the advent of novel molecular techniques, there has been a paradigm shift in microbial population dynamic studies allowing a high degree of accuracy. An IWA specialist group on activated sludge separation problems stated the general situation in conventional and BNR plants in South Africa (Pitman, 2006), but most of the referenced publications were over two decades old. Therefore there is need for more updated knowledge in population dynamics. The proposed research will focus on using these novel molecular techniques to accurately profile functional groups of microorganisms and correlate to plant operating parameters and influent characteristics with the aim of understanding microbial contributions. It is hoped that this will aid in optimising plant performance and prevent problems such as bulking and foaming. The approach will be unique in South Africa and findings will be relevant to the South African wastewater treatment systems

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 3: Stormwater and sewerage systems

Alternative technology for stormwater management

University of Cape Town; SRK; City of Cape Town; eThekweni Municipality; Johannesburg Municipality; City of Tshwane; IDS

No. 1826

Currently, stormwater planning and design in the urban areas of South Africa focuses on collecting runoff and channelling it to the closest watercourse, frequently having a significant impact on the environment through the resulting erosion and siltation. Whilst some local authorities reduce runoff peaks through the use of retention and detention ponds, few examples exist of quality improvement apart from pumping the base flow of the most polluted streams to sewerage, and the installation of litter traps. Internationally, numerous alternatives to the traditional stormwater management approach have been developed to manage the quantity and quality impacts associated with

urban runoff, generally by dealing with stormwater as close to its source as possible. This solicited project aims to identify and develop new and appropriate, practical and affordable alternative stormwater management technology/technologies for South Africa in line with water-sensitive urban design (WSUD) principles. The researchers will also evaluate the technology options in terms of the ability to improve stormwater management in urban areas, i.e. reduce impacts on receiving watercourses resulting from increased velocities and volumes of runoff and deterioration of runoff quality. Four large local authorities (CCT, eThekweni, JHB and Tshwane) have expressed interest in participating in pilot studies.

Estimated cost: R1 800 000
Expected term: 2008 - 2012

Improving sewerage for South Africa

University of Cape Town; City of Cape Town; eThekweni Municipality

No. 1827

With ever-increasing development and expansion of municipal sewerage networks it is important to ensure that the current rationale applied to the selection of new sewerage is sustainable over the longer term. The integrity of the existing systems also needs to be maintained through systematic replacement of sewers that have exceeded their design. It is therefore necessary to evaluate whether there is a better way of sewerage areas which would offer long-term benefits over current conventional practices. The primary objective of this solicited project is to establish whether there is a viable alternative to conventional reticulated sewer systems, which offers tangible improvements over current conventional reticulated systems. The focus will be on application in new development and unserved areas as well as the potential as a solution for the replacement of conventional sewers which have exceeded their design life. The research will critically evaluate impending technologies and provide practical guidance to implementers on where suitable circumstances exist

where these technologies will prosper. The project is supported by some major local authorities committed to assist with a pilot project to assess the operation of the new or proposed technologies.

Estimated cost: R1 500 000
Expected term: 2008 - 2012

Investigation into pumps and pressurised flow in separate sewer systems

University of Stellenbosch

No. 2007

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

academics (e.g. published research to disseminate knowledge among peers; lecture notes) and those in the engineering fraternity (e.g. acting as a design guideline).

Estimated cost: R1 000 000

Expected term: 2010 - 2012

Programme 5: Sanitation technology and innovations

Piloting and testing the pour-flush latrine technology for its applicability in South Africa

Partners in Development

No. 1887

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

Estimated cost: R1 000 000

Expected term: 2009 - 2011

Evaluation of the bucket eradication programme

Hlathi Development Services

No. 2016

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

Estimated cost: R920 000

Expected term: 2010 - 2012

Evaluation of the Mobisan technology as a sanitation option for informal settlements: Assessing performance, operational requirements and community perspectives

Cape Peninsula University of Technology

No. 2017

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

technology provided in the market; it will further provide an understanding of the operational and O&M requirements, and community perceptions of the technology.

Estimated cost: R716 750

Expected term: 2010 - 2012

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

A tunable immobilised lignocellulosic enzyme (TILE) system for treatment of industrial wastewaters

Cape Peninsula University of Technology

No. 2009

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

incorporating a selected group of enzymes which are immobilised together to effect depolymerisation of the lignocellulosic content of the waste and will include in-situ generation of peroxide and hence prevention of inhibitor build-up.

Estimated cost: R2 200 000

Expected term: 2010 - 2012

Programme 2: Integrated management

Environmental sustainability of inland industrial complexes

CSIR, Eco Innovation, University of KwaZulu-Natal, University of Stellenbosch, University of Cape Town

No. 1833

Significant economic activity and prosperity of South Africa is associated with a few large industrial complexes. Since these areas are important nodes of economic growth, it is in the interests of the country that they continue to generate wealth, but do so in a sustainable way. This project will examine several inland industrial complexes as case studies with a view to establishing factors/solutions that can enhance their long-term environmental sustainability, promote high percentages of reuse of industrially-generated waste streams, and lay foundational blocks in raising awareness on the significance of symbiotic industrial ecology for future economic sustainability through optimal utilisation of resources. More than one industrial complex will be selected since certain factors may be unique to a given complex.

Estimated cost: R3 000 000

Expected term: 2008 - 2011

Programme 4: Governance, policy, regulatory, and economic instruments to improve industrial water management

Protocol for quantitative assessment of industrial effluents for discharge permitting

University of KwaZulu-Natal

No. 1734

Local authorities manage industrial wastewater by:

- Using its wastewater treatment plants for remediation
- Issuing discharge permits with limits on discharge
- Charging a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system

An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of the WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000

Expected term: 2007 - 2011

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Pilot application of a dual stage membrane bioreactor for industrial effluent treatment

Alt Hydro cc

No. 1900

Over the past decade solutions are increasingly sought using membrane bioreactor technology. This is mainly due to recent refinements and lowering of costs associated with this technology. Significant improvement in process efficiency associated with the treatment of industrial effluent using a novel dual-stage side-stream membrane bioreactor has been previously reported. This dual-stage approach to wastewater treatment using this membrane bioreactor configuration greatly enhanced performance and increased the long-term adaptability and stability of the developed and retained microbial populations within the system by facilitating a continuous microbial ecology management strategy. Compared to conventional suspended culture wastewater treatment processes, this system facilitated a 75% improvement in acclimation efficiency of the resident microbial consortia, which translated directly to considerable improvements in the resultant effluent quality and consistent operation of the treatment process. However, variations in wastewater streams make it imperative to assess the performance of the system on-site and at the pilot-scale level, in order to accurately gauge the impact of real wastewater challenges on the robustness of the process technology. This pilot project therefore aims to develop on-site wastewater treatment solutions for industries typically targeted by DWA as it increases its monitoring and legislative framework capacity. As legislative enforcement is addressed, increasingly, industrial offenders responsible for further burdening already overloaded municipal WWTP infrastructure are now being forced to seek on-site wastewater solutions prior to discharge. This technology aims to address these increasingly prevalent needs by providing a mobile, adaptable solution to specific industry needs.

Estimated cost: R950 000

Expected term: 2009 - 2011

Recovery and beneficiation of nutrients, water and energy from brewery effluent by means of algal assimilation, hydroponics and aquaculture

Rhodes University (Ichthyology)

No. 2008

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

Estimated cost: R1 798 000

Expected term: 2010 - 2012

Development of hybrid membrane-chromatography system for simultaneous recovery of valuable products and water purification for recycle in the olive industry, with a view towards commercial application thereof

University of Cape Town

No. 2010

In South Africa, the olive oil industry uses up to 20m³ of potable water per ton of olives processed. A previous WRC project (K8/814) investigated a hybrid membrane-based system for simultaneous recovery of valuable products and wastewater purification to the extent that it may be recycled back into the olive production process. This process has been successfully demonstrated at laboratory scale (WRC Report No. K8/814). The wastewater has been fractionated through successive membrane separations to produce 3 separate streams: 1) a concentrated effluent containing high Mw polyphenols that can be discharged as per normal or composted, 2) a low Mw phenolic fraction containing the antioxidant extract which is rich in hydroxytyrosol, and 3) purified water containing salts and some organic acids, which can be recycled as make-up water for the fermentation and brining process. The large quantities of salt (NaCl) used are thus also recycled. Subsequent research has shown that it is possible to use only NF and chromatographic adsorption for the process if there is adequate pretreatment (i.e. particle filtration to remove suspended solids): in this case the high Mw polyphenols are rejected by the NF (Mw cut-off 270 Da), while the permeate is passed through the chromatography column to extract hydroxytyrosol, and can then be sent directly for recycle. The advantage of this approach is the recovery of a valuable product helps to offset the operational cost of wastewater treatment, and this is achieved in one operation. This project proposes to research and develop a scaled-up system though the construction and commissioning of a dedicated containerised wastewater treatment plant and research facility on-site at the Buffet Olives farm. It is intended that the plant will be a stand-alone skid mounted end-of-pipe system, which could then

serve as a demonstration model for commercialisation and roll-out to other farms.

Estimated cost: R892 000

Expected term: 2010 - 2012

THRUST 5: MINE-WATER TREATMENT AND MANAGEMENT

Programme 3: Minimising waste production

Preparation of magnetic nano-composite beads and their application to remediation of mine wastewaters

University of the Witwatersrand

No. 2014

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

Estimated cost: R378 500

Expected term: 2010 - 2012

Evaluating approaches to and benefits of minimising the formation of acid mine drainage through management of the disposal of sulphidic waste rock and tailings

University of Cape Town

No. 2015

One of the major environmental issues in the mining industry is that of acid rock drainage (ARD), caused by the disposal of voluminous sulphide-bearing wastes. The legacy of the ongoing generation of ARD from the disposal of low-grade dump rock, of tailings and from the mine site itself, may continue for decades following active metal extraction. Changes in legislation have put the burden of responsibility for perpetuity on mining companies. This has led to a change in process thinking, in order to reduce potentially harmful emissions from deposits and thus reduce long-term costs of tailings management and ARD remediation, and the re-examination of the manner in which waste materials are disposed from the mineral processing and extraction stages of metal recovery in order to relieve the environmental burden created and reduce the time frame of risk. Particularly, the delay in the time of ARD formation is no longer acceptable and the need to remove the risk completely accepted. In this project, previous work in WRC Project K5/1831/3 will be extended to address aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides (especially pyrite), specifically with the focus of reducing capacity to form ARD and thereby the ongoing risk associated with the disposal of sulphidic mineral ore wastes, through removal of the sulphidic component of the waste. In this project, we seek to use the understanding of the factors governing ARD generation from dump rock and tailings (similar to those governing mineral bioleaching) with the view to the improvement in planned disposal of its components to mitigate ARD generation. Having identified in our previous project the components responsible for ARD generation and characteristics of the waste for disposal, in order to ensure minimisation and control of this generation, this project will focus on the

methodologies used to minimise and control ARD formation and will provide an approach to evaluate the relative cost of ARD prevention based on treatments prior to disposal and ARD treatment following its generation.

Estimated cost: R1 435 250

Expected term: 2010 - 2012

Programme 4: Mining in the 21st century

Nanotechnology in water treatment

University of the Western Cape

No. 1897

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

Estimated cost: R1 483 000

Expected term: 2009 - 2012

Extended investigations into recovery of water and salts from multi-component hypersaline brines using eutectic freeze crystallisation

University of Cape Town (Precipitation & Crystallisation)

No. 2012

South African water users are facing challenges in terms of the declining availability of sufficient quantities of water and the deterioration of the quality of the available water. In addition, with the increasing use of water treatment, the result has been an increased generation of inorganic brines and concentrates. Treating these brines, either for the recovery of the salt, or for the reduction of waste streams via a concentration process, is energy intensive and thus costly. The standard design approach for inland desalination plants is one of bulk softening and subsequent concentration of mono-valent salts. This results in mixed brines and sludges of low (or even negative) value, often containing hazardous substances. As a result, brine and sludge disposal occur mainly through forced evaporation and crystallisation of mixed (and often hazardous) salts. The extremely large energy requirements to evaporate the water can be prohibitive and the salt product is still a waste that must be disposed of. Eutectic freeze crystallisation (EFC) is an alternative technology for the separation of highly concentrated aqueous streams. EFC is a technique that is capable of separating aqueous solutions into pure water and pure, solidified solutes and that is highly energy efficient, without the introduction of any solvents. A modelling and experimental programme focussing on the use of EFC has already been undertaken (WRC Project K5/1727), which has shown proof-of-concept for EFC as a feasible treatment for hypersaline brines. However, as for any novel technology, there are still many aspects that need to be investigated and these are the focus of this proposal.

Estimated cost: R1 571 490

Expected term: 2010 - 2012

Programme 5: Low-volume mined products

Application of emulsion liquid membranes in the recovery of platinum group metals from precious metal refinery wastewaters and mining effluents

Rhodes University

No. 2011

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

Estimated cost: R337 450
Expected term: 2010 - 2012

Development of an analytical sensor for the identification, quantification and detection of heavy metal pollution associated with precious metal refinery waste-water

CSIR

No. 2013

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

Estimated cost: R716 000
Expected term: 2010 - 2012

NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Mechanism for pricing and financing the implementation of the Green Drop Report to guide the strategic decrease of the risk factor of wastewater treatment works

Asset Research

No. 2085

During 2010 the Department of Water Affairs published its 2009 Green Drop Report. Only 32 of the 852 wastewater treatment plants obtained a Green Drop award, i.e., were considered to have performed and achieved a delivery of service at acceptable risk levels. It was found that most facilities in the rural areas and smaller towns are not adequately equipped with staff of appropriate skills and this constrained the performance of these systems in their overall Green Drop assessment. While the report wishes to promote incentive-based regulation and acknowledge excellence in wastewater quality management, it neither reflects on the financial cost and resources required for achieving this nor on the economic costs and implications of not achieving the desired turn-around in waste management and improvement in performance of the wastewater treatment works. This study wishes to address these issues.

Estimated cost: R597 500
Expected term: 2011 - 2013

Assessing the impact of expansion of bulk infrastructure on capital requirements of Water Boards

Palmer Development Group

No. 2086

Water Boards were established under the Water Services Act of 1997 to provide bulk water to other water services institutions and to serve as water services providers when contracted by municipalities. The 12 Water Boards currently operational serve approximately 24.5 million people in 90 municipalities, around 50% of the total population of South Africa. A number of initiatives are aimed at further expansion of the operations of Water Boards. In 2008, the Department of Water Affairs (DWA) Institutional Re-alignment Project raised the possibility of reconfiguring Water Boards, converting them to Regional Water Utilities aligned with provincial boundaries. Expanding their areas of activity will have an impact on the financial viability of Water Boards, most notably on their capital requirements, particularly if the Water Boards expand into areas with poor economic bases. The objective is thus to assess the capital investment that will be required by Water Boards as they expand their activities, and assess their ability to access the necessary finance.

Estimated cost: R475 000
Expected term: 2011 - 2013

Providing water services at tariff levels that cover cost and that are sensitive to demand

Nelson Mandela Metropolitan University

No. 2087

The benchmarks for municipal water service provision in South Africa have been set nationally and with reference to the level of income of the community – with a better service being provided to the well-off sections than to the poor. Historically, those users who were required to pay for the cost of providing the service were concentrated in relatively small urban areas. The tariff structure they faced was flat and determined with reference to a diverse range

of accounting principles and practices. The burden of covering the cost of provision was averaged for the well-off users, proportional to use. More recently there have been several important changes – an increase in the level of high-standard service provided to the poor (towards a uniform service for all) and a movement away from a flat tariff structure to an increasing block tariff. This project proposes to contribute insights on the latter issue. There are many relevant questions in this regard. Does existing pricing policy incorporate the full financial costs of managing water? Are economic costs taken into account in the pricing of water services?

Estimated cost: R1 250 000
Expected term: 2011 - 2014

Programme 2: Institutional and management issues – Water services

Adapting and piloting the new concepts of Community-Led Total Sanitation (CLTS) in the South African municipal environment

Cape Peninsula University of Technology

No. 2088

Community Led Total Sanitation (CLTS) focuses on behaviour change rather than toilet construction. CLTS mobilises a cooperative approach based on people deciding together how to create a hygienic environment that benefits everyone. Total sanitation ensures that everyone uses a hygienic toilet and safely disposes of their domestic waste, creating a safe and clean environment. The CLTS approach encourages responsibility by the community, taking its own action. Cooperation among households is a key element, as is spontaneous emergence from within communities of 'natural leaders' (NLs) as facilitators. The objective of this study is to adapt and test the concepts of CLTS in the South African environment and context.

Expected cost: R2 500 000
Expected term: 2011 - 2014

A comparative analysis of water management devices in Cape Town and prepayment meters in Johannesburg

University of the Western Cape

No. 2089

South Africa has made great strides in improving access to water supply. Many poor people previously supplied with water, and those with new connections, face the grim reality of water unaffordability, exacerbated by the installation of prepaid meters and water management devices. Yet it has also been argued that the unwillingness of water users to pay is a remnant of anti-apartheid rent boycotts. This study aims to take the debate on water metering technology and cost recovery methods further. It seeks to expose the differing experiences of two major technologies used in South Africa – prepayment meters and water management devices which are ostensibly different. While these technologies may operate differently on the surface, it is likely that their effects are the same.

Estimated cost: R500 000

Expected term: 2011 - 2013

Programme 3: Innovative management arrangements – Rural water supply

Strategy for large scale roll-out of community-based service provision

Palmer Development Group

No. 2090

Much research has been undertaken on community-based service provision in South Africa. The existing research points to the importance of community-based service provision in rural areas in order to achieve cost efficiency and sustainability. Community-based service provision offers the mechanism through which basic services can be delivered to rural communities, but also a model for the sustainability of these services through localised ownership and management, and a cooperative relationship with local Government. In addition, local communities are empowered to make positive

changes to their environment and local economies are stimulated. Yet, what limited evidence there is suggests that this approach is not widely applied, specifically with regard to rural water supply schemes. The lack of attention to management arrangements for water supply and sanitation services in rural areas is leading to a situation which is close to catastrophic. Thus the aim is to identify the key factors of success for the large-scale implementation of community-based service provision and develop a strategy for its roll-out.

Estimated cost: R645 500

Expected term: 2011 - 2013

Programme 5: Water services education and awareness

Social norms and moderation of water consumption in a major South African city

EPRU

No. 2091

South Africa has a fairly limited supply of water. This supply of water is coming under increasing strain as democracy and economic growth have seen the water consumption of a growing number of South Africans increase, as their livelihoods improve and basic services are extended ever further. Much of this increased consumption is occurring in South Africa's large cities, Johannesburg, Durban and Cape Town, where the greatest share of South Africa's growing businesses are located and which are consequently the epicentres of growth and magnets for people migrating within the country. This study proposes testing a demand-side management strategy, based on reporting comparative social norms for water consumption, within one of South Africa's major cities' households and businesses. The strategy is to test the process of people making decisions based upon information that is reported in a particular fashion, rather than upon contexts such as price increases or slow roll-out of basic services.

Estimated cost: R462 000

Expected term: 2011 - 2013

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Energy-efficiency in the South African water industry: a compendium of best practices and case studies

Chris Swartz Water Utilization Engineers

No. 2092

The objective is to develop a compendium of best practice (national) in the energy-efficient design and operation of water industry assets. The output of the project will be a compendium of best practices and case studies for use as a guidance document or 'benchmarking tool' that will be of value to the sector members to guide them towards improving their own ways of working from an energy-efficiency perspective. The scope of work will cover the principal activities of the water and wastewater businesses and will focus on the identification of current best practice, tools and technologies. International evaluations of the water sector show that the potential for energy-efficiency savings is between 5 and 30% of current demand. It is important to gain a status quo picture for South Africa. The study will evaluate both incremental improvements in energy-efficiency through optimisation of existing assets and operations and substantial improvements in energy-efficiency from the adoption of new (but proven at full-scale) technologies. It should also highlight new processes, plant types and systems, which realise more substantial energy gains, with provisos that: only technologies that are proven at full-scale are recommended; technologies at pilot-scale development are noted for future investigation; and areas where new technical development is required are also highlighted.

Estimated cost: R1 000 000

Expected term: 2011 - 2013

Programme 3: Drinking water quality

Scoping study and research strategy development on currently known and emerging contaminants influencing drinking water quality

University of the Free State

No. 2093

Emerging contaminants are substances that are characterised by a real or perceived threat to human health or the environment, for which there is no currently-published health standard, or for which the scientific basis of the standard is evolving or being re-evaluated. These substances can include, but are not limited to, nanoparticles, pharmaceuticals, personal care products, endocrine-disrupting compounds, and chemicals (including those in products and packaging) that find their way into the water system. New substances that could be of concern to SA drinking water plants and present in water resources will be identified, and investigated for removal during the normal processes to provide safe water. Recommendations on the most important substances that will be investigated and methodologies that are available, or should be selected and developed, will be covered in this project.

Estimated cost: R598 900

Expected term: 2011 - 2013

Verification and validation of analytical methods for testing the levels of PPHCP (pharmaceutical and personal health care products) in treated drinking water and sewage

UNISA

No. 2094

Increased urbanisation has introduced new challenges to drinking water treatment, waste disposal and sewage treatment facilities. The increasing use of HRT, OC, PM, including antibiotics and synthetic anti-viral drugs and general non-prescription over-the-counter health products is adding to the vast array of current endocrine-disrupting chemicals (EDCs) entering sewage and surface waters. The WRC has previously funded studies on EDCs which include the development of EDC activity testing and chemical analyses on some of these substances in water resources, as well as limited studies on hormones and related compounds at drinking water and sewage treatment plants. However, those studies did not include the development of methods to do chemical analyses of the aforementioned groups of substances or an in-depth study on the removal capacity of these substances during treatment. Analytical methods to detect these compounds in water (and sediment) are not readily available in South Africa but are internationally available and need to be verified and validated and standardised. This study will investigate the best available methods to conduct chemical analyses of the compounds of most importance in the Southern African context and test the suitability of the methods for South Africa in the laboratory and in water treatment works.

Estimated cost: R500 000

Expected term: 2011 - 2013

Programme 4: Water distribution and distribution systems

Energy generation from distribution systems

University of Pretoria

No. 2095

In South Africa we are facing an energy crisis which places additional importance on the harvesting of all available feasible renewable energies. The initial scoping investigation highlighted the potential hydropower generation at the inlets to storage reservoirs, i.e., the bulk water distribution systems. In South Africa there are 284 municipalities and several of the water supply utilities all own and operate gravity water supply distribution systems which should be considered for small-scale hydropower installations. Most of these water supply/distribution systems may be equipped with the pumps as turbines, replacing the pressure throttling valves allowing for the hydroelectricity generation. The hydro-energy may be used in the own plant, supplied to the national electricity grid or used to feed an isolated electricity demand cluster. This study aims to prove that it is feasible and technically possible to generate energy from distribution systems.

Estimated cost: R2 500 000

Expected term: 2011 - 2013

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Exploring knowledge on natural processes for novel approaches to constructed wetland design and performance for wastewater using biomimicry

Golder Associates

No. 2096

This study will look to exploit knowledge on natural wetlands, their processes and biodiversity to better engineer/design constructed wetlands to meet the challenges of current and emerging pollutants and pathogens. The study should also look to explore the potential of using constructed wetlands to support sustainable livelihoods. The first phase of this project is innovation-focused and will explore, through the process of biomimicry, novel approaches that can be used to improve constructed wetland design and implementation. The potential exists for this process to deliver innovative solutions for wastewater (both industrial, domestic) treatment, transformation and filtration.

Estimated cost: R3 000 000

Expected term: 2011 - 2016

Programme 4: Wastewater sludge and faecal sludge management

Investigation into the long-term risks associated with deep row entrenchment of pit latrine and wastewater treatment sludges for forestry and land rehabilitation purposes

Partners in Development (Pty) Ltd

No. 2097

While South Africa struggles to provide basic sanitation for all, a substantial amount of existing basic sanitation infrastructure

(conventional pit latrines and VIPs) has reached or is reaching the end of its design life. Urgent interventions are required to deal with the accumulation of sludge in these units. The low-cost options for the disposal of these sludges are limited. This project aims to establish whether deep row entrenchment of faecal sludges with agroforestry is a safe, cost-effective and beneficial sludge disposal option. It will add significantly to the understanding of how buried sludge changes in nature over time, in terms of its physical and biological structure. It will also improve understanding of how buried sludge affects groundwater.

Estimated cost: R1 000 000

Expected term: 2011 - 2014

Programme 5: Sanitation technology and innovations

An investigation into technical sanitation solutions for informal areas

Cape Peninsula University of Technology

No. 2098

Urbanisation, in fact, is a health hazard for certain vulnerable populations, and this demographic shift threatens to create a humanitarian disaster. The threat comes both in the form of rising rates of endemic disease and a greater potential for epidemics and even pandemics. The poor are especially affected by inadequate and substandard sanitation services and these effects are not only limited to the health impact resulting from daily exposure to polluted habitats. It is recognised that problems caused by informal settlements are multiple. The most difficult is the provision of adequate sanitation services that can sustain livelihoods and protect the general environment from pollution and health risks to humans. Technology is one element in the overall solution to sustainable sanitation for informal areas, but it is an important barrier to the spread of diseases, and also important for the provision of a clean environment. The chaotic settlement patterns and densities, as well as other factors, make

many solutions inappropriate and ineffective, and this is further compounded by the lack of institutional support. To date many solutions have been experimented with, with limited success, and we are yet to find the most appropriate solution for informal areas. This study aims to develop and establish new sanitation solutions for informal areas.

Estimated cost: R500 000
Expected term: 2011 - 2013

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Industrial brine minimisation: determining the physical chemical parameters that affect evaporation rates on multi-component hypersaline effluents

University of the Western Cape

No. 2100

Brines are a major waste by-product from industrial activities. This study aims to understand and provide solutions for the efficient minimisation of industrial brines. The study will evaluate evaporation rates and design and assemble climate-controlled enclosures for the study of evaporation processes of brines. The data will result in the development of protocols for the measurement of evaporation rates from brines which will lead to the development of empirical models for determining evaporation processes of industrial brines under controlled laboratory conditions and the development of theoretical models for determining evaporation rates of brines. Finally, it is envisaged that this understanding will result in the development of novel textured surfaces and absorbents for enhanced evaporation of industrial brines.

Estimated cost: R1 500 000
Expected term: 2011 - 2014

Evaluation of forward osmosis technology for the treatment of concentrated brines

University of KwaZulu-Natal (Durban)

No. 2101

Forward osmosis is a new technology for industry in South Africa and this scoping project is to assess the applicability for further application of concentrated inorganic brines. The study will aim to evaluate whether forward osmosis can be used as a lower energy consuming technology compared to reverse osmosis. It will evaluate the advantages, limitations and feasibility of using forward osmosis technology to concentrate various high ionic strength wastewaters and to assess the fouling characteristics of forward osmosis on various high ionic strength industrial streams which are known to be badly fouling.

Estimated cost: R354 000
Expected term: 2011 – 2014

Programme 2: Integrated management

Adapting water footprints for South Africa and exploring the value of integrating water, carbon and energy (environmental) footprints for the South African industrial sector

Pegasys Strategy and Development (Pty) Ltd

No. 2099

This study aims to review global and national practices in assessing water, energy and carbon footprints and the trade-offs that industries have to make to meet the goals set. It will investigate tools and methodologies that can be applied to determine water, energy and carbon footprints with the aim to provide a consolidated environmental footprint and a decision-support tool. It is hoped that the understanding will be developed through the use of industry case studies.

Estimated cost: R2 000 000
Expected term: 2011 - 2013

Programme 4: Governance, policy, regulatory and economic instruments to improve industrial water management

Evaluation of partitioning coefficients for South African soils to inform the new National Framework for the Management of Contaminated Land with emphasis on the protection of water resources

Golder Associates Africa (Pty) Ltd

No. 2102

The National Environmental Management: Waste Act of 2008 (Waste Act) Section 7(2) (d) provides for the setting of norms and standards for the remediation of contaminated land and soil quality. As part of the process of establishing this Framework, a number of uncertainties have come to light that may impact on the successful implementation of the Framework. Thus, this study aims to assess analytical methodologies for use in the setting of screening values for the protection of water resources and to determine partitioning coefficients for South African soils. In addition, the study aims to determine estimated baseline partitioning coefficient ranges for South African soils to assist in the setting of appropriate soil screening values for the protection of water resources.

Estimated cost: R480 000
Expected term: 2011 - 2013

Valuing water for South African industries: A production function approach

CSIR

No. 2103

The project aims to ensure more efficient use of water by industry, based on an improved understanding of the marginal value of industrial water, and of the responsiveness of industry to water pricing strategies. This is in keeping with the National Water Act's objective to price water correctly, and will look to feed in to the current DWA pricing strategy.

Estimated cost: R780 000
Expected term: 2011 - 2013

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Adapting constructed wetlands for real-world applications

Cape Peninsula University of Technology

No. 2104

This project builds on previous research and will use the new fingerprinting techniques that have been developed and customised to define the parameters which will allow the effective use of constructed wetlands to treat wastewaters using natural processes. It will also investigate the reproducibility of constructed wetlands adapted for specific waste-containing waters in varied environments by characterising the microbial communities in these environments, and to understand the extent to which microbial communities in constructed wetlands can accommodate changes in waste impacts and the rates at which they can adapt. Finally it will develop a matrix of parameters and thus guidelines to use to adapt wetlands.

Estimated cost: R1 100 000
Expected term: 2011 - 2015

Integrated photo-catalytic and anaerobic treatment of industrial wastewater for biogas production

Vaal University of Technology

No. 2105

This project aims to test, at a laboratory scale, the use of zeolite as a support material to improve biogas production and anaerobic reactor stability. In addition, the study will concentrate on synthetic industrial effluents and use a photocatalyst (titanium dioxide) to break down these complex chemicals to simpler ones and evaluate the anaerobic reactor efficiency. Knowledge from these tests can be used in future to improve anaerobic digestion

efficiencies by allowing microorganisms to come into contact with simpler compounds and prevent washout of the sensitive methanogenic bacteria.

Estimated cost: R500 000
Expected term: 2011 - 2013

A modern role for wastewater ponding systems in the beneficiation of 'specialist' effluents in industry

Blue Green Technologies cc

No. 2106

This study aims to evaluate industrial ponds treating specialist effluents. The study will determine the key performance parameters for effective operation of these systems and develop a set of design criteria for their effective management and operation, and will develop new technology (SMARTT) with regards to the design, layout and operation in order to reduce the overall footprint and improve unit efficiency by reengineering the microbial ecology of these systems. The final aim of the project is to provide guidance on how existing systems can be retrofitted to improve their performance with the same or even smaller land footprints.

Estimated cost: R280 000
Expected term: 2011 - 2013

THRUST 5: MINE-WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Toxicity evaluation of metals and metal oxides nanoparticles to aquatic invertebrates and algal species

CSIR

No. 2107

Since the beginning of the 1990s, nanotechnology has matured from a laboratory-based research and development phase into

full commercialisation of nanoproducts. For example, there are numerous novel consumer products and industrial applications of nanotechnology including: nanoelectronics, molecular assemblies, tissue engineering, biomedicine, nanocomposites, cosmetics, paints, pesticides and water purification modules. Among the nanomaterials, used in the nanoproducts reported above, with high potential of release in large quantities into aquatic environments are metals and metal oxides. In view of the rapidly increasing quantities of nanomaterials released into different environmental compartments – especially water and sediments – it is imperative that the potential risks that may be associated with nanomaterials attract attention, to ensure long-term safe, responsible, and sustainable development of this novel technology for optimal benefit of society. Due to the limited data, on potential risks of nanomaterials to aquatic organisms, which could support practical risk assessment and risk management after entry into the environment, this project will investigate the effects of nanomaterials on organisms at different trophic levels. Secondly, the mechanism by which nanomaterials cause toxic effects to the receptor organisms will be explored through use of DNA, reactive oxygen species (ROS) generation techniques.

Estimated cost: R495 000
Expected term: 2011 - 2014

Programme 3: Minimising waste production

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation

University of Cape Town

No. 2108

The main aim of this research is to further the understanding of the precipitation of metal sulphides in the treatment of acid mine drainage via sulphate reduction and metal precipitation. The project will characterise the effect of operating conditions on the physical characteristics of the formed metal sulphide precipitate by investigating the effect of metal to sulphide

ratio on precipitation behaviour, the effect of the operating pH on the precipitation process and using a technique based on moment transformations of the number density function $n(L)$ to make inferences about the mechanisms involved in the particle formation processes. The project will also investigate the factors affecting the solid-liquid separation characteristics of the formed particles. The effects of the processing conditions on solid-liquid separation characteristics of the formed precipitates will be quantified using particle size distribution measurements, settling characteristics and zeta potential measurements for surface charge determination. These studies will be carried out on a number of model metal systems. Finally, the project will investigate factors that potentially influence the solid-liquid separation characteristics of the formed particles. As a result of the investigations carried out, it should be possible to identify a number of factors, possibly different additives, which would influence the separation characteristics of the formed precipitates. Thus the effect of these ions (as well as other additives) on the coagulation and aggregation phenomenon will be quantified by measuring their effect on particle size distribution, surface charge and settling characteristics of the precipitate.

Estimated cost: R884 820
Expected term: 2011 - 2013

Development of a toolkit to enable quantitative microbial ecology studies of sulphate-reducing and sulphide-oxidising systems

University of Cape Town

No. 2109

The catastrophic effects of untreated minewater discharges are well-known and several high-profile events have been documented. Minewater has traditionally been treated using oxidation-neutralisation-precipitation which effectively removes metal, but the treated stream still contains

sulphate. Biological treatment systems, based on the activity of sulphate-reducing bacteria have received considerable attention. Their widespread application has been constrained by the provision of a carbon source/electron donor and the management of the sulphide-containing effluent. Both these issues are addressed in the Integrated Passive Treatment System (IMPI) technology which makes use of a mixture of complex, lignocellulosic carbon sources and incorporates a sulphide oxidation step. Both the sulphide-oxidation and sulphate-reduction processes are catalysed by a consortium of different microorganisms. Different components of the consortium have different tolerances to sulphate, sulphide and heavy metals. As a consequence, changes in feedstock can lead to major changes in the microbial community. This may have catastrophic effects on system performance. Until recently these changes were poorly understood and system management was based on empirical rules of thumb. The advent of molecular biology techniques has facilitated qualitative microbial ecology studies. While these have been useful in confirming the presence or absence of species or groups of species they provide limited information on dynamic changes in population structure, which could be extremely useful in predicting the response of a system to specific perturbations. This project will develop a molecular toolkit for performing quantitative microbial ecology work in sulphate-reducing and sulphide-oxidising systems. The toolkit will initially be used to characterise the microbial populations in the IMPI demonstration plant at Middleburg Mine. This technology has the potential to treat minewater effectively and economically over a sustained period of time.

Estimated cost: R487 500
Expected term: 2011 - 2013

Addressing the challenges facing biological sulphate reduction as a strategy for AMD treatment through analysis of the reactor stage: raw materials, products and process kinetics

University of Cape Town

No. 2110

Minewater generated during active mining or resulting from groundwater rebound at abandoned sites have major environmental and economic implications. Active chemical treatment of the water is the most widely employed technology. Recently there has been increasing interest in active and passive biological treatment processes. These systems rely on naturally-occurring biological and geochemical processes to improve water quality with minimal operational and maintenance requirements. Biological sulphate reduction is a well-understood and efficient process that has been frequently demonstrated at laboratory and pilot scale. However, its full-scale implementation has been limited. The challenges facing sulphate-reduction systems have been identified as: provision of a cost-effective carbon source; enhancing reaction kinetics when complex carbon sources are used; and management of the resulting sulphide. This study will undertake a critical review of existing technologies, from a technological and economic perspective. Furthermore the feasibility of using microalgal biomass as a carbon source/electron donor will be investigated. The study will also evaluate the requirements for algal cultivation at the scale required to sustain the SRB process. To address the issue of enhanced reaction kinetics the effect of decoupling the hydrolysis and acidogenesis reactions from the sulphate reduction will be investigated. The study will include a review of available technologies and investigate the application of cross-flow microfiltration membranes to recover and recycle biomass to both the hydrolysis/acidogenesis and sulphate-reduction reactors.

Estimated cost: R1 050 000

Expected term: 2011 - 2014

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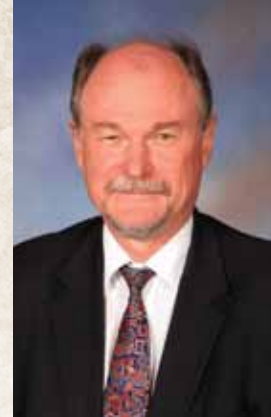
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KSA 4: WATER UTILISATION IN AGRICULTURE



*Dr Gerhard Backeberg:
Director*

SCOPE

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

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

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

Water users in all of the abovementioned subsectors, as well as organisations such as WUAs, cooperatives, agri-businesses and Government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life problems experienced primarily by water users and related organisations, for irrigated and rain-fed crop production, fuel-wood and timber production as well as livestock and fish production. The problems which may be experienced in practice for any aspect

of water use on the farm, irrigation scheme or river catchment vary from non-existence of knowledge, doubt regarding the applicability of existing knowledge, deviation of empirical observations from some relevant theoretical optimum, to an unclear outcome of possible alternative decisions and actions.

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

OBJECTIVES

The **primary objective** is to increase national and 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 abovementioned objectives and are summarised as follows:

THRUSTS AND PROGRAMMES

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.

Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in the assessment of the fitness-for-use of water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

This thrust includes two programmes:

- Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture
- Fitness-for-use of water for crop production, livestock watering and aquaculture

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

This thrust includes one programme:

- Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

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

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can be promoted further through participatory action research which improves knowledge, farming skills and leadership capabilities.

Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

This thrust includes two programmes:

- Sustainable water-based agricultural activities in rural communities
- Integrated water management for profitable farming systems

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.

Agricultural decisions to use land and to conserve rainfall or to abstract water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

This thrust includes two programmes:

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

RESEARCH PORTFOLIO FOR 2011/12

In this KSA a holistic systems approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to the outputs for Outcomes 7 and 10 in the Programme of Action announced by the Presidency; the Green Paper on National Strategic Planning; the DWA framework on *Water for Growth and Development* (Version 7); the DAFF Integrated Growth and Development Plan; the National Agricultural Research and Development Strategy; and the Comprehensive Africa Agricultural Development Programme of NEPAD. Work undertaken in 2011/12 aimed to continue to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following key activities of the research portfolio:

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

Over the past nine years a strategic shift has been made to achieve a balance between research projects in irrigated and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further toward practical application of results with technology transfer projects. An overview of completed and ongoing projects indicates the direction and priorities for future research. Emphasis is being

placed, through new projects, on determination of water use of irrigated crops with satellite imagery; improved water use efficiency through deficit irrigation of wine grapes; quantification of the water use of indigenous food crops; modelling of the water use of selected pasture crops for livestock grazing management; evaluation of the water use and nutritional productivity of food crops in the diet of rural poor people; assessment of water quality of rainwater and groundwater for domestic use and livestock watering; a scoping study on alternative treatment options for microbial-contaminated irrigation water in order to improve food safety; rehabilitation of invaded catchments and measurement of the water use of indigenous trees; empowerment of women through water use security and the required knowledge for skills development to achieve household food security; up-scaling of rainwater harvesting and conservation techniques and practices to communal croplands with complementary livestock water use productivity; optimisation of water use within entrepreneurial development paths for smallholder irrigation; indigenous coping strategies for drought adaptation; and vulnerability analysis for drought impact assessment related to climate change.

BUDGET FOR 2011/12

The approved funding of the research portfolio of current projects and projects commencing in 2011/12 leads to committed funding of R23 551 610. The consolidated budget for the research portfolio is presented below:

| Research portfolio | Approved 2011/12 (R) |
|--------------------|----------------------|
| Current projects | 23 261 155 |
| New projects | 2 827 000 |
| Total | 26 088 155 |

CORE STRATEGY

Strategic context

In the Programme of Action of The Presidency (2010), there are two outcomes which give further strategic direction to research in the Key Strategic Area of Water Utilisation in Agriculture (KSA 4). Under Outcomes 7 and 10, the following outputs are specifically relevant:

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all:

- *Output 1:* Sustainable agrarian reform
- *Output 2:* Improved access to affordable and diverse food
- *Output 4:* Improved employment opportunities and promotion of economic livelihoods
- *Output 5:* Enabling institutional environment for sustainable and inclusive growth

Outcome 10: Environmental assets and natural resources that are well-protected and continually enhanced:

- *Output 1:* Enhanced quality and quantity of water resources
- *Output 2:* Reduced greenhouse gas emissions, climate change impacts and improved air/atmosphere quality
- *Output 3:* Sustainable environmental management

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

- People are united in diversity while appreciating the common interest that bind them together
- Conditions have been created for full participation of women

- Effective programmes exist to reduce poverty and protect the most vulnerable in society
- Beneficial and sustainable use is made of human resources, natural resources and modern technology
- Common interests are promoted by investment and competitive returns for the private sector

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

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

The water resource base is therefore of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people.

Water utilisation can best be quantified as rainfall-dependent, surface water- and groundwater-dependent use. Approximately 12% and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grasslands, woodlands and forests respectively. Rainwater runoff and deep percolation

become available as surface water and groundwater of which approximately 62% is used for irrigation. It is abundantly clear that the biggest share of water is used for both extensive and intensive production in agriculture.

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

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

In South Africa, at most 35% of the economically active population are directly or indirectly dependent on agriculture, although this percentage is declining each year. This consists primarily of small-, medium- and large-scale enterprises, which provide employment opportunities for formal and casual labour. Furthermore, 42.7% of the population are rural survivalists with traditional agrarian lifestyles. Estimates also show that 48.5% of the population are living below the poverty line of which 70% are in rural areas. According to the HSRC (2009) about 4.5 million Black people (or 9% of the population) in South Africa participate in agriculture in some form, mainly livestock production. Many of these people are involved in low-input, low-output farming activity that provides supplementary food for households. Recent data from various surveys indicates that 52% of households experience hunger and with a monthly income poverty line of R1 200, 59% of households are food insecure.

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low at between 2 to 3% of gross domestic product (GDP). The forward

linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Until 2006 agriculture was also a net exporter of food, contributing 10% of total exports of which 50% are processed products. During 2007 imports exceeded exports, mainly due to import of processed food products. Since 2008 the trade balance is again positive.

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

Critical issues in the forthcoming years and the next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing consumer income levels. Expansion of agricultural production on land suitable for cultivation will be increasingly constrained by the availability of water. Increasing hazards of rainfall variability, with western parts of South Africa getting drier and eastern parts wetter, over the long-term, are caused by climate change. This requires adaptive management practices to reduce the vulnerability of people in rural areas and prevent disasters of crop failures, income loss and widespread famine. At the same time, there is a relatively high ratio of people

to cultivated land and a larger dependence on agriculture in rural areas to increase the material income and improve the social wellbeing, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts with research and development must be made to increase productivity growth and thereby the competitiveness of agriculture.

With this background it is important to emphasise that the strategic focus of water research in this KSA, which was also found to be relevant by the *July 2006 External Institutional Review*, continues to be on:

- Increasing the efficiency of water use for food, fibre, wood and timber production (i.e. improving the knowledge of biological, technical and economic processes of production)
- Increasing the household food security and 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)
- Ensuring sustainable water resource use in rain-fed and irrigated areas (i.e. improving the knowledge of natural processes and people-induced impacts of resource use)

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

Needs analysis

Previously identified needs, re-affirmed by recent reports, reviews and policies, continued to give direction to applied research.

During 2000 the Presidential Imperative Programme on Integrated Sustainable Rural Development was announced. The goal of the programme is to promote development and improve the quality of life of marginalised groups and communities. The objectives are to alleviate poverty through enhanced production, productivity, creation of employment opportunities and a more equitable distribution of resources. Outputs which are envisaged include agricultural production systems and sustainable utilisation and management of natural resources and the environment.

At the end of 2001 the Strategic Plan for South African Agriculture was released by the National Department of Agriculture, Agri SA and the National African Farmers Union (NAFU), and has since been revised. The strategic goal is to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural sector, contributing to a better life for all. This strategic goal is expected to guide all relevant partners in their quest to deliver and implement a range of programmes in accordance with basic premises of, amongst others:

- Fair reward for effort, risk and innovation
- Security of tenure for present and future participants
- The sustainable use of natural and biological resources
- Sound research, science, knowledge and technology systems
- Market forces which direct business activity and resource allocation

The outcomes which are envisaged to flow from successful implementation of programmes include:

- Increased creation of wealth in agriculture and rural areas
- Increased sustainable employment
- Increased income and foreign-exchange earnings
- Reduced poverty and inequalities in land and enterprise ownership

- Improved farming efficiency
- Improved national and household food security
- Increased investment in agricultural activities and rural areas

One of the three core strategies which are discussed in the strategic sector plan for agriculture is sustainable resource management which also impacts on water systems. Central to this strategy is, *inter alia*, the promotion of sustainable use of soil and water through increased crop and livestock productivity and intensified farming systems, while farmer participation is a key success factor. Degradation of soil and water resources is considered to be a serious threat and therefore programmes must be designed to overcome the causes of degradation. Such soil and water conservation programmes will focus on areas where there is a reasonable chance of success, as determined by, e.g. available technologies and access to markets, inputs and services.

On a regional level the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD) (2003), places the focus on land and water management as one of four pillars for priority investment. It is stated that 'water and its managed use has been an essential factor in raising the productivity of agriculture and ensuring predictability in outputs. Water is essential to bring forth the potential of the land and to enable varieties of both plants and animals to make full use of other yield-enhancing production factors. By raising productivity, water management (especially when combined with adequate soil husbandry) helps to ensure better production both for direct consumption and for commercial disposal, thereby enhancing the generation of economic surpluses which are necessary for uplifting rural communities'.

A call is made for increased investment in land and water and the point is made that 'protecting and improving water and the soil makes good business sense'. It is indicated 'that by enabling a rapid increase in production, irrigation can make food more readily available but that its impact on reducing hunger depends on appropriate arrangements for the poor to have access to irrigated

land'. The further point is made that 'while increased irrigation is not a panacea for all agricultural ills, it nevertheless makes possible other opportunities for agricultural growth such as better husbandry of soils and resources in general, and makes more worthwhile the use of fertilisers, improved plant varieties and upgraded infrastructure'.

The Development Report by the DBSA (2005) found that 'the poverty problem remains a predominantly rural phenomenon'. Furthermore farming still provides 'a source of income for many rural communities in South Africa' and therefore contributes to poverty alleviation. This role can be strengthened by investment in the drivers of agricultural development, namely human capital, biophysical capital, rural institutions and agricultural research. The conclusion is 'nonetheless, while agriculture plays a major role in poverty alleviation, promoting the growth of smallholder agriculture alone cannot solve the poverty problem in South Africa. More attention should also be given to the promotion of non-farm activities (e.g. agri-industries), particularly those that are linked to the smallholder agricultural sector. A strategy that strengthens farm/non-farm linkages is likely to yield better results with regard to employment and income generation'.

In the biannual *Overview of the World Food Situation* published by the International Food Policy Research Institute (IFPRI) at the end of 2007 it is stated that renewed attention must be given to agriculture, nutrition and health in adjusting research agendas. Strategies must be directed at poor members of society. In this regard social security measures must be taken that focus on early childhood nutrition, particularly of poor households. With increasing risks caused by climate change, more investments must be made in agriculture to improve productivity. This includes investment in agricultural science and technology to facilitate a production response to rising food prices.

At a conference on Nutrition and Food for Special Dietary Uses, held in Cape Town at the beginning of November 2008, the Minister of Health stated that 'food insecurity and high rates of malnutrition, coupled with high food prices, remain the biggest

threat to nutrition in Africa'. More research is thus needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices.

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

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

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

The consultation with stakeholders during 2009 highlighted the following priorities which are relevant to the KSA: water security; poverty alleviation; trade-offs between food and bio-fuel production; efficiency of water use and improved measuring tools; the water footprint of agriculture; water shortages and drought; and the impact of climate change.

The review of the strategic plan for **agriculture**, which was completed in 2008, identified a number of concerns: limited capacity within Government, slow pace of implementation and inadequate funding for critical programmes, such as food security. In the case of **forestry**, the multiple benefits of woodlands, forests and plantations and their contributions to the economy, society and environment are acknowledged. This requires flexibility to respond to community needs, incorporate water catchment management principles and utilise commercial and other opportunities for woodlands and plantation forestry. For **fisheries**, high demand for access to resources must be balanced with requirements of environmental sustainability, given the opportunities for economic and social development.

For the purpose of Integrated Growth and Development Planning (IGDP) (2010), a range of current realities and challenges are discussed. Amongst others, factors such as the lack of access to land, water, markets, finance, infrastructure, education, skills development and flow of information, will prevent marginalised members of society from making substantive progress in farming, forestry and fisheries across the entire value chain. It is argued that a driver of economic growth of these sectors and the related productivity has been the support provided through research and technology development for water resource management, risk management, natural resource management, seed and cultivar breeding programmes, due to public investment in research and development (R&D). However, existing organisations involved in R&D have major capacity constraints and experience difficulties in acquiring and retaining scientists. It is maintained that R&D projects are not coordinated, are not aligned to industry and Government priorities and that inadequate funds have been allocated to R&D.

The vision for the IGDP is 'an equitable, productive, competitive, profitable and sustainable agriculture, forestry and fisheries sector'. The mission will be developing and sustaining a sector that contributes to:

- Economic growth and development
- Job creation
- Rural development
- Sustainable use of natural resources
- Maintenance of biodiversity and ecosystems
- Sustainable livelihoods
- Food security

One of four sector challenges is environmental/ecological sustainability and the related sector goal is formulated as 'improved, sustainable natural resources management', with specific focus on the protection of scarce and threatened resources, e.g. water, soil and fish stocks. The interventions include recognition of the importance of freshwater systems to the sector and integrating them as a key component of the IGDP. Funding should be sourced for research directed at natural resource issues and conducting cooperative research to address the research implementation gap. In this regard, applicable activities are water conservation and water demand management for agriculture, forestry and fisheries, in particular water use efficiency systems for irrigation.

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

- Increasing the productivity of rainwater and irrigation water for crop and livestock production
- Uplifting rural economies through commercial food production
- Quantifying the water footprint in food value chains
- Eradicating hunger and reducing poverty
- Improving nutrition and health

- Generating alternative sources of renewable energy
- Preventing soil and water degradation and pollution
- Adapting farming systems to climate change

Overview of technological trends

In the book *The Necessary Revolution* (2008) it is argued that 'previously taken-for-granted aspects of daily life – food, water, energy, predictable weather – seem less and less reliable'. The reasoning continues that 'if we see each problem – be it water shortages, climate change or poverty – as separate, the solutions will be short-term, doing nothing to address deeper imbalances. The first imbalance concerns nature's capacities to regenerate resources and provide the 'eco-services' upon which human life depends – clean water, breathable air, fertile soil, pollination and a stable climate'. It is stated that the 'diminishing resources and growing waste underlie a host of economic stresses and reflect environmental and social imbalances that all but ensure that, without significant change, these problems will worsen'. Consequently a shift in thinking is required to start a revolution that can transform society. This pre-supposes that core capabilities must be acquired of observing and analysing systems in practice, collaborating across disciplinary boundaries and creating a new reality instead of finding opportunistic, 'quick-fix' solutions.

In the KSA explicit efforts will consequently continue to stay at the forefront of new technological developments and promote 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 continuously be found between research projects and technology transfer projects and also between research on appropriate technologies for irrigated and rain-fed agriculture. With a growing demand for water in the domestic and industrial water-use sectors, the competition for water currently used for agricultural production will increase in future. Technologies, models and methods are available to improve the efficiency of irrigation

water use in different stages of, e.g. water measurement, canal and on-farm water distribution, field application and irrigation scheduling. With the demand for food also increasing in a globalised trade environment, agricultural production will have to be competitive in both local and overseas markets. While irrigated agriculture contributes 25 to 30% of gross production, technological and managerial innovations are required in all subsectors of agriculture to reduce costs and to increase income.

In particular, attention continues to be given to rain-fed agriculture and the existing technologies which have been developed for water harvesting in Sub-Saharan Africa. The challenge for research is therefore to adapt or develop and apply technologies which will enable water conservation in rain-fed agricultural production on drylands, 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) initiative is to expand the extent and operation of integrated land and water management, with the main emphasis on the eradication of poverty in Africa. These trends have been reinforced by the *Comprehensive Africa Agriculture Development Programme of NEPAD*, published in July 2003.

According to the National Agricultural Research and Development Strategy by the Department of Agriculture (2008), a key area

for technology development is sustainable natural resource management. The statement is made that: 'Farmers maximise income and risk in a dynamic context and often under harsh conditions and serious constraints. Research must respond to these challenges through inclusion of technologies to address sustainable natural resource management. This would include technologies to address soil erosion degradation, nutrient depletion, loss of bio-diversity, prevention of invasion by alien species, maintenance of water quality and veld productivity, optimisation of water use efficiency under both irrigated and rain-fed conditions, capturing and storing rainwater (rainwater harvesting) and restoration or creation of new balances in biotic communities. Geographic Information System-based technologies, natural resource inventories and adequate characterisation and monitoring are considered essential.'

Together with a growing population and high degree of food insecurity, there is increasing competition for water and uncertainty about future water availability. Major questions arise, such as: what is the role of land use and water use changes on water availability and how does managed land use affect consumptive water use? There is a need to separate non-beneficial soil evaporation and beneficial plant transpiration. This also leads to questions on water productivity; in particular, how much food is produced in rain-fed and irrigated agriculture and what are the ranges of water productivity for food, forage, fibre and fuel crops? Water accounting from satellites is an innovative step towards standardised description of water resources. The water accounting framework links water users with the process and benefits of land use. Satellite images ensure data flow on changes in water use. This will enable quantification of beneficial and non-beneficial use for different land use classes. Under the heading 'Anticipating and addressing strategic issues and trends', published in the Green Paper (2009), the following national planning issues are mentioned which could be subject to ad hoc investigations:

- Long-term availability of water
- Energy consumption and production
- Conservation, biodiversity, climate change mitigation and adaptation
- Food security and sustainable rural development

- Innovation, technology and equitable economic growth
- Poverty, inequality and the challenge of social cohesion
- National health profile and developmental health care strategies

Different aspects of these strategic issues are currently being researched with funding through the KSA. The existing and future research output of the KSA is therefore positioned and geared to make a constructive contribution for this purpose.

Key stakeholders

This KSA clearly supports South African Government strategies and initiatives where water conservation, in particular water development and utilisation for agriculture, is of concern. Government departments, especially the Department of Water Affairs (DWA) and the Department of Agriculture, Forestry and Fisheries (DAFF) are important stakeholders. These links have also been formalised by the support of selected projects of mutual interest through leveraged funding. In addition, district municipalities, provincial departments of agriculture, water user associations (WUAs), catchment management agencies (CMAs), cooperatives and agribusinesses, are all stakeholders with whom the WRC is engaging. In all cases co-operation is achieved by invitations to review research proposals and to serve on the reference group of relevant research projects.

Key stakeholders and beneficiaries of this KSA remain as previously described. These are farmers who are represented by Agri SA and NAFU. It is estimated that there are 35 000 commercial farmers, 250 000 emergent farmers and 4.5 million subsistence farmers.

Communication channels exist with officials in the representative organisations on a national level. A more effective range of communication strategies has been designed by formalising stakeholder relationships. It is gradually being implemented to reach farmers and their representatives on a provincial and local level. The purpose is to obtain an accurate indication of practical problems which they are facing and what their assessment is of the priorities for research, technology transfer and extension.

Other players

Other organisations providing services to water users in agriculture have largely remained the same as in previous years, and are the provincial departments of agriculture (PDAs), the Department of Agriculture Forestry and Fisheries (DAFF), mainly through its Directorate: Water Use and Irrigation Development, and the Department of Water Affairs (DWA) through its Directorate: Water Use Efficiency. Current activities of relevance to the WRC are firstly, and *inter alia*, an initiative by the DAFF to give policy direction to development through integrated water management for agricultural use and implementation of the irrigation strategy; and secondly, the water conservation and demand management strategy in agriculture, the water allocation reform strategy and the broad-based black economic empowerment guidelines for water use that DWA is implementing.

Locally the Human Sciences Research Council (HSRC) has reorganised its research activities and regrouped its projects into interdisciplinary new priority areas (NPAs). The Integrated Development NPA is to undertake research which is designed to promote sustainable development in rural and urban areas. In addition various institutes of the Agricultural Research Council (ARC) obtain funding and undertake research on water-related subjects. Of particular relevance is water research in relation to soils and climate, engineering, field, horticultural and forage crops. At eight universities across South Africa there are faculties or departments of agriculture, many of whom have in the past mainly relied on WRC funding to undertake water research.

Globally the International Water Management Institute (IWMI), as a member of the Consultative Group on International Agricultural Research (CGIAR), has a sub-regional office for Southern Africa in Pretoria. Since the 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. Research

is done under four themes of water availability and access; productive water use; water quality, health and environment; and water governance.

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

Providers of research

The main suppliers of research projects are universities and colleges (currently Universities of KwaZulu-Natal, Pretoria, Free State, Stellenbosch, Rhodes, Fort Hare, Cape Town, Tshwane and Cape Peninsula University of Technology); science councils (various institutes of the ARC and CSIR Natural Resources and the Environment); as well as established and emerging private consulting groups.

IMPLEMENTATION PLAN

Research portfolio for 2011/12

As in previous years, the **primary objective** was to increase national and household food security, improve livelihoods of people and to increase efficient growth and equitable distribution of wealth on a farming, community and regional level, through efficient and sustainable utilisation and development of water resources in agriculture.

The **secondary objectives** were to:

- Increase biological, technical and economic efficiency of water use

- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection and reclamation practices

In this KSA a holistic systems 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 and a continuous effort is required to demonstrate impact. Selection and finalisation of research projects within thrusts and programmes of the KSA are therefore measured against the key components of the WRC Impact Areas:

1. **Water and Society:** Enabling participation in water management by subsistence, emerging and commercial farmers and improving livelihoods of poor rural households.
2. **Water and the Economy:** Providing secure access to water for food production and supporting sustainable rural economic development through beneficiation of raw materials in the food-value chain.
3. **Water and the Environment:** Taking precautionary measures to reduce pollution and degradation of water resources as a result of cultivation of land.
4. **Water and Health:** Preventing spreading of diseases through water and food, and improving health of all members of society through better nutrition.

A description of the research thrusts and programmes which determine the course of research and allocation of financial resources is given in Table 1.

TABLE 1**Overview and description of thrusts and programmes****THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION**

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

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|---|--|
| <p>Programme 1: <i>Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture</i></p> | <p>Scope: Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.</p> |
| <p>Programme 2: <i>Fitness-for-use of water for crop production, livestock watering and aquaculture</i></p> | <p>Scope: Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.</p> |

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

| | |
|---|---|
| <p>Programme 1: <i>Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations</i></p> | <p>Scope: In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.</p> |
|---|---|

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.

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| Programme 1: <i>Sustainable water-based agricultural activities in rural communities</i> | Scope: Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities. |
| Programme 2: <i>Integrated water management for profitable farming systems</i> | Scope: Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources. |

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Scope: The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use.

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|--|--|
| Programme 1: <i>Sustainable water resource use on irrigation schemes and within river catchments</i> | Scope: With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation. |
|--|--|

**Programme 2:
Impact assessment
and environmental
management of
agricultural production**

Scope: Agricultural decisions to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, has wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

RESEARCH PROJECTS FOR 2011/12

COMPLETED PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Guidelines for irrigation management in pasture production

CSIR (Natural Resources and the Environment)

No. 1650

The overall objective of this study was to promote efficient irrigation management of grass pastures (emphasis on ryegrass and kikuyu) by synthesising available knowledge and generating new knowledge for improving water use efficiency by pastures. Italian ryegrass (*Lolium multiflorum*) was planted in an experiment conducted at the KwaZulu-Natal Department of Agriculture at Cedara, located in the midlands of the KwaZulu-Natal mistbelt, one of the main milk-producing areas of South Africa. Another experiment with various treatments was also conducted under a rain shelter at the Hatfield Experimental Farm of the University of Pretoria. It was concluded that, at the expense of dry matter production, the highest WUE was achieved under water-limiting conditions. Based on the data from this experiment, by irrigating once a week and fertilising with a high N application rate after each harvest, optimum yield can be achieved with better quality

pasture and a better WUE. The data were used to calibrate the models used in this project. The Soil Water Balance (SWB) model was evaluated at the two sites for different irrigation treatments in two ryegrass growing seasons. A remote sensing tool (SEBAL) was shown to predict evapotranspiration at a spatial resolution (30 m) suitable for irrigation scheduling of kikuyu.

Cost: R2 117 600

Term: 2006 - 2011

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

Agro-forestry systems for improved food production through the efficient use of water

CSIR (Natural Resources and the Environment)

No. 1480

In South Africa, the focus in the past has been on intensive production of individual sectors (agriculture and forestry), as opposed to integrated agro-forestry practices to improve farming systems, restore degraded environments and supplement incomes. The aim of this project was to implement on-station agro-forestry systems to determine their impact on water and plant production in order to facilitate the adoption of agro-forestry locally. One silvopastoral and three alley-cropping systems were

established in on-station trials at the Ukulinga Research Farm of the University of KwaZulu-Natal, to determine their suitability for implementation by rural communities. The results from the alley cropping trials in this study clearly demonstrate that benefits of agro-forestry are generally not realised in the first two seasons after establishment. This may be one of the reasons for poor uptake of agro-forestry by rural farmers. The agro-forestry systems established in this study enabled the development of a hedgerow intercropping model.

Cost: R3 350 000

Term: 2004 - 2012

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

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

The effect of the introduction of agro-forestry species on the soil moisture regime of traditional cropping systems in rural areas. Phase II: On-farm trials of alternative agro-forestry systems

CSIR (Natural Resources and the Environment)

No. 1351

The major agricultural enterprises for small-scale farmers in the Upper Thukela region of KwaZulu-Natal are livestock (mainly cattle) and crops (mainly maize and dry beans). However, one of the most important constraints in rural farming systems is the shortage of adequate and good quality forage during the dry winter season. The aim of the study, among others, was to determine the effect of alley-cropping temperate pastures (Cocksfoot and Tall fescue) with leguminous trees (*L. leucocephala* and *A. karroo*) to increase fodder productivity and quality. The study was also conducted with the aim of determining the effect of intercropping maize with *Dolichos lablab* in different

spatial arrangements, in order to increase fodder productivity and quality. The on-farm field trials were conducted in a communal rangeland area in the Zwelisha ward of Bergville in KwaZulu-Natal Province, on a small-scale dairy farm. The alley crop field trial demonstrated the high potential of the use of temperate grass species and tree legumes for small-scale dairy systems. Intercropping maize with *Dolichos lablab* improved the quality (crude protein) of maize leaves by 39%, which therefore enabled the farmer to meet the maintenance requirements for his dairy cows. The results of the water use estimates of all three species in this trial were conservative when compared to other South African studies, but need to be seen against the silvicultural practice of pruning, which clearly had a major impact on leaf area and water use. In the on-farm trial the small-scale farmer received training on the establishment and management of different fodder production systems for dairy farming. Farmers' days were used to disseminate the results from the trials and demonstrate the viability of the fodder technologies to the wider farming communities.

Cost: R2 600 000

Term: 2002 - 2011

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the KwaZulu-Natal Province

Zakhe Agricultural College

No. 1465

Rainwater harvesting has the potential to improve food production for communities who have a high dependence on agriculture. The aim of this project was to select and implement water harvesting and conservation techniques that would assist the communities in the Umlazi River Catchment, situated in the eastern region of KwaZulu-Natal, to improve their livelihoods by increasing their food production. The research team identified and investigated a number of different systems of water harvesting and conservation techniques which were tested. The focus of this study was on

in-field (micro-catchment) rainwater harvesting for vegetable production at Ntembeni community and at Zakhe Agricultural College (Baynesfield farm) in KwaZulu-Natal. The studies showed that, regardless of the crop used, in-field water harvesting using ridges increased soil water content and biomass. The three communities (Ntembeni, KwaMncane and Baynesfield) in the study area were trained in rainwater harvesting and soil conservation techniques to improve their livelihoods through vegetable production. A baseline socio-economic study was conducted in 2005 and a socio-economic impact assessment was conducted in 2008. At the end of the study adoption of water harvesting techniques and practices by the farmers involved in the project was high (70–100%). This study clearly demonstrated that rainwater harvesting and soil conservation techniques can play an important role in improving the sustainability of food production in the Midland regions of KwaZulu-Natal by improving soil water storage, crop yields and extending the growing season into the dry winter months.

Cost: R3 000 000

Term: 2003 - 2011

Nutritional value and water use of indigenous crops for improved rural livelihoods

University of Pretoria (Centre for Nutrition)

No. 1579

African leafy vegetables are commonly perceived to be heat- and drought-tolerant, use less water than conventional crops and provide a host of health benefits, particularly nutritional benefits. If these attributes are true, these crops could contribute greatly to the diet of, especially, poor, food-insecure households, many of which occur in drought-stricken areas of the country. The research consisted of four main thrusts divided into specific research objectives. The review of nutritional status and strategies showed that under- and over-nutrition co-exist in the same communities and often same household. With respect to water requirements, there were distinct differences in water requirements between

the different plants which varied from 340 mm to 463 mm. The ALVs studied were found to be sensitive to water stress and the biomass production of the crops was influenced by the irrigation treatments. This is a significant finding as it indicates that the crops can only be produced with an adequate amount of water particularly if the yield is intended for human consumption. The final section on human nutritional issues showed that these plants can indeed contribute substantially to intake of Vitamin A and iron in both young children and women, two of the most vulnerable groups with respect to malnutrition. Where some plants provided more than 50% of the RDA for Vitamin A, all ALVs studied were good sources of Vitamin A. The plants also provide a varying amount of other important nutrients which again supports the use of a variety to address the nutritional health of vulnerable people. This extensive study contributed greatly to the understanding of the use, cultivation and nutritional contribution of these crops to human health and well-being. It was clear that cultivation poses some challenges, but none more than existing exotic species. The results therefore provide support for cultivation and increased consumption of these food crops.

Cost: R5 700 000 (incl. leverage)

Term: 2005 - 2012

Development of a comprehensive learning package for education on the application of water harvesting and conservation (WH&C)

Umhlaba Consulting Group

No. 1776

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a 'training of trainers' framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers); 2) facilitators at training organisations; and 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) a Technical Module covering water, soils and WH&C methods; 2) a Facilitation Module covering facilitation

techniques within a Participatory Innovation Development approach; and 3) a set of Farmer's Handouts with illustrated steps on how to implement the methods. Each of the technical and facilitation modules comprise two volumes. There is a detailed, annotated and illustrated manual for learners, and a Facilitation and Assessment Guide for course facilitators. These are set at the level of NQF 5 on the (new) 10-tier scale. The set of Farmer's Handouts are designed for people with low literacy and are illustrated 'how-to' instructions for the water harvesting and conservation methods. The materials were developed in close consultation with key stakeholders to ensure relevance of materials to likely organisations of learning, and to end-user needs. The draft materials were successfully piloted in a formal learning environment and were reviewed by seven agricultural colleges.

Cost: R1 950 000

Term: 2007 - 2011

Programme 2: Integrated water management for profitable farming systems

Participatory development of provincial aquaculture programmes for improved rural food security and livelihoods alternatives

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1580

The challenge for South Africa is how to provide Government support for sector development that addresses the needs of aquaculture enterprise development, both large- and small-scale. Aquaculture cannot be entirely private sector driven as the transaction costs of pioneer farmers are too high and there are barriers they cannot overcome, such as access to suitably zoned land and water. On the other hand, the experience of South Africa's provincial hatcheries shows that Government, without private sector participation, is a poor driver of sector

development. Thus the organisational challenge is to create a structure(s) whereby Government sets the development policy agenda and offers various forms of support and the private sector drives the actual production and market-related aspects of project implementation through vehicles such as PPP, or special-purpose vehicles which are market driven and independent of the bureaucratic constraints of the PDAs. However, even with the commercialisation of aquaculture, there is still a clear need for Government, particularly the PDAs, to play a role in supporting this industry by providing various services, e.g. veterinary services, quality fingerlings, technical support, industrial investment incentives and bulk infrastructure services. This requires a more coordinated, cooperative governance approach which is well beyond the mandate of the PDAs. Fortunately, the national departments of Agriculture, Forestry and Fisheries, Science and Technology, and Trade and Industry have collaborated to formulate a national aquaculture strategy to be considered by Cabinet. The roll-out of such a strategy would provide much-needed guidance and support to the PDAs and a key recommendation is that DAFF continue to fulfil the leading support role to the PDAs initiated in the present project. The major contribution of this project can thus be seen as creating awareness and buy-in for supporting aquaculture within the PDAs, and a programme and strategies for provincial aquaculture capacity development. Despite the constraints experienced, the PDAs are committed to aquaculture development and the challenge is to address the sometimes severe organisational constraints within these departments. Linking the PDAs into broader cooperative governance arrangements, whereby they are empowered to deliver the support services within their mandate, will result in them playing a more effective support role.

Cost: R4 500 000 (incl. leverage)

Term: 2005 - 2011

Technology transfer on the technical aspects and cost-estimating procedures of surface and sub-surface drip-irrigation systems

ARC (Institute of Agricultural Engineering); NB Systems;
University of the Free State

No. 1806

Research funded by the WRC and projects completed by the Agricultural Research Council's Institute for Agricultural Engineering on the performance of surface and sub-surface drip irrigation found that the emission uniformity as measured in the field declined over time for all dripper types. This indicates a decline in efficiency due to clogging or lack of maintenance. Correct planning, design, installation and maintenance is essential and it is recommended that regular water quality analysis be carried out to identify potential clogging problems. The results of all of these research projects created useful information on costing, choice, operation and maintenance of drippers and filters. It was concluded that this knowledge must be disseminated by means of technology transfer and training sessions for designers and farmers. Through this technology exchange project, a manual for designers and a manual for farmers has been developed. It provides guidance in the selection, planning and design of drip systems for designers and it enables irrigators with drip irrigation systems to apply good management and maintenance schedules. This enables them to adhere to the objectives of the National Water Resource Strategy (2004) regarding the efficient and beneficial use of water. The purpose of the manuals is to provide a comprehensive information document for irrigation designers and farmers operating in South Africa and other SADC countries. It should be read and used in conjunction with the KBase, (a database developed as part of the WRC project by NB Systems) which contains technical information on drippers and filters, and the IRRICOST spreadsheet model, a cost-estimating tool that was adapted specifically for the purposes of the WRC project by the University of the Free State. The manual covers the technical aspects and cost-estimating procedures of designing surface

and sub-surface drip irrigation systems. This manual includes recommendations and guidelines regarding the suitability and management of soil and water for drip irrigation, and the selection, costing, design, operation and maintenance of drip irrigation and filtration equipment. It is aimed specifically at drip irrigation in field and permanent crop applications, and does not apply to greenhouses or specialised fertigation units.

Cost: R1 485 400

Term: 2008 - 2011

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

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

Managing salinity associated with irrigation in selected areas in South Africa

University of the Free State (Department of Soil, Crop and Climate Sciences)

No. 1647

This project developed best practices and formulated guidelines for managing the salt load associated with irrigation at farm and scheme level. Monitoring of a range of management options in use by irrigators on the Orange-Riet and Vaalharts Irrigation Schemes over four cropping seasons provided insight into the mechanism of water and salt movement under a range of crops, soils and irrigation methods and also provided real-world data for simulating the longer-term response and implications of management strategies. It was found, *inter alia*, that the occasional heavier rainfall event would in most cases provide for sufficient leaching of accumulating salts even when no provision for leaching is made in irrigation applications. The best practice guidelines developed for implementation at field scale emphasise the necessity for efficient irrigation systems, the need for effective scheduling approaches, the need to monitor

root-zone salinity, the need to select crops with salt tolerance adapted to the situation and the potential for on-farm utilisation of shallow water tables and the interception and re-use of drainage water.

Cost: R2 480 000

Term: 2006 - 2012

Programme 2: Impact assessment and environmental management of agricultural production

Modelling non-point source (NPS) pollution in agriculture from field to catchment scale

Aurecon SA (Pty) Ltd

No. 1516

This project developed an integrated modelling approach to the prediction of agricultural NPS pollution from field to catchment scale for phosphorus, nitrogen, pesticides and sediments. A project team consisting of four individual Task Teams, comprising of one or more specialists within each of the domains of agricultural nutrients, sediments, pesticides, field-scale biophysical modelling, catchment-scale biophysical modelling, and agricultural economics, report on their activities in a series of five reports, namely:

- Modelling Agricultural Non-Point Source Pollution and Economic-Environmental Trade-offs of Control Measures
- Modelling Nitrogen and Phosphorus Dynamics in Cropping Systems at the Field Scale
- Modelling the Fate of Pesticides: Primary Processes, Non-Point Source Data Collection and Guidelines
- Modelling Nutrient and Sediment Dynamics at the Catchment Scale
- Modelling Economic-Environmental Trade-Offs of Agricultural Non-Point Source Pollution Control Measures

Cost: R5 105 000

Term: 2004 - 2012

The impacts of unpaved access roads on runoff, sediment fluxes and soil water movement within timber plantations

Aquagreen Consulting; University of KwaZulu-Natal

No. 1807

This study was aligned towards understanding the influence of forestry access roads on runoff, sediment production and soil water movement. Due to the existence of only a few past local studies much of the work was exploratory in nature and strong reliance had to be made on past international studies for guidance. Techniques and systems had to be refined or adapted to local site conditions and equipment had to be customised to meet the objectives of the study. The study was conducted under natural rainfall over two full summer seasons. Although an estimate of the rate of surface runoff production and sediment loss from road sections of varying gradient has been provided, a longer monitoring period of verification may be required. Supplementary studies using rainfall simulators may also prove valuable in assessing the timing of runoff and mechanisms of soil dislodgement from the road surface. However, should this take place, it will be important to operate the rainfall simulator at rainfall intensities close to that occurring naturally. The study showed that water flowing through the mitre drain from the road surface into the compartment may contribute to increased soil water content, particularly near the drain exit. This finding is significant as it could influence the manner in which road drainage is dealt with in the future. However, this aspect needs to be further investigated perhaps using a more direct or more sensitive technique. Allied with this is the issue of catchment connectivity, i.e. the movement of water from the road surface to the stream network which has been discussed in the literature but could not be fully evaluated within the current study. Mapping of water and sediment delivery pathways, perhaps coupled with tracer studies, could aid the realisation of this objective. At present, riparian buffer zones within forestry areas are relied upon to contain sediment. If information on sediment delivery pathways from roads to

streams is known then it may be possible to limit the travel of sediment by management of sediment at the source of origin. Optimisation of road drainage location and spacing may be a possible method to achieve this.

Cost: R1 700 000

Term: 2008 - 2011

Definition of process zones and connectivity in catchment-scale NPS processes (K5/1808)

University of KwaZulu-Natal (PMB)

No. 1808

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

Cost: R722 540

Term: 2008 - 2010

CURRENT PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of fruit tree/orchard crops

CSIR (Natural Resources and the Environment)

No. 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently-published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate, soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water-use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, sub-tropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic

importance, current hectareage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R5 567 500 (incl. leverage)

Expected term: 2007 - 2014

Water use of drought-tolerant food crops

University of KwaZulu-Natal (Crop Science)

No. 1771

A significant proportion of the South African population experiences food insecurity and malnutrition (micronutrient deficiency) despite living in a country that is a net exporter of food. One of the main food security challenges facing the country is the need to increase the ability of vulnerable groups to meet their minimum daily requirements for adequate nutrition. About 14.3 million people are vulnerable to food insecurity, particularly women, children and the elderly. There is therefore a need to increase the content of the South African food basket particularly for the poorest households living in rural areas. However, drought is one of the major hurdles facing agriculture in Sub-Saharan Africa. South Africa, like many countries in the region, is prone to severe water shortages which seriously impacts on the availability of food. One way to combat inadequate availability of water is to develop or select crops that are more tolerant to water stress. Indigenous edible plants that are resilient have sustained rural populations in developing countries for centuries. These traditional crops are native to specific localities and are therefore better adapted to the local environmental conditions and cultivated without the need for much external inputs such as agrochemicals or a high water requirement. However, information

on the utilisation of indigenous crops in South Africa is not well documented. Moreover, no comprehensive overview of the spectrum of food crops available for food production in South Africa in relation to drought tolerance, crop adaptability, economic importance and water use characteristics has been conducted. This project seeks to understand the water-use characteristics of drought-tolerant crops through the use of empirical measurement and crop growth models. The parameters needed for modelling will guide the empirical research.

Estimated cost: R4 350 000 (incl. leverage)

Expected term: 2007 - 2013

Water use of cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production

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

No. 1874

In South Africa, the establishment of an economically viable biofuels industry is increasingly becoming a possibility due to technological advances; global commitment to limit greenhouse gases and to reduce global warming; the need to diversify energy supply; and the need to accelerate rural economic growth by the agricultural sector. With diminishing fossil fuel resources and increasing oil prices, attention is being focused on producing alternatives to fossil fuel, with emphasis on the production of biofuels. The Biofuels Industrial Strategy of South Africa specifies the use of certain crops as feedstocks for bio-diesel and bio-ethanol production. The consideration of a range of crops and cropping systems as feedstocks is necessary, especially those which may produce food and fodder as well as fuel. Furthermore, the evolution of 'second generation' biofuel technologies which allow for the conversion of cellulose (biomass) for biofuel production must also be investigated in terms of water use and potential impacts on the country's food production. Studies on the water use impacts of the biofuels industry on South Africa's limited water resources are urgently required for both local and

national water resource planning. A scoping study on the water use of crops/trees for biofuel production (WRC Project No. 1772) provides preliminary results on the water use and growing conditions of limited biofuel crops based on broad climatic parameters and crop biophysical requirements. The report of this follow-on project will document the water use and optimal growing conditions for a comprehensive range of potential crops/trees. It will include detailed mapping of suitable production areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R5 000 000

Expected term: 2009 - 2015

Baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security

University of Pretoria (Department of Human Nutrition)

No. 1954

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

per m³). Both water and fertiliser management will determine the productivity of water and quality of crop food products. The contradiction between rural poverty, food insecurity, inadequate nutrition and under-utilisation of natural resources raises a number of fundamental research questions. Clearly, there is an important need to understand the aspirations of people to bridge the gap between, for example, usual and adequate nutrition, food intake and food demand. This scoping study seeks to understand the gaps in knowledge before formulating more focused research project(s).

Estimated cost: R1 000 000

Expected term: 2010 - 2012

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

A quantitative investigation into the link between irrigation water quality and food safety

University of Stellenbosch (Department of Food Science)

No. 1773

A large percentage of the South African population is not in good health due to HIV and TB infections, and the health status is further worsened due to under-nourishment. As such the affected members of society are especially vulnerable to diseases; in particular those caused by water and food-borne pathogens. The source of contamination of river water is failing sanitation in, e.g. informal settlements, and failing water treatment in, e.g. non-operating sewage works. This water is often used for irrigation and there is a direct relationship between irrigation water quality and food production, food spoilage and food safety. Food such as fruits and vegetables which are eaten raw, without peeling or washing, or with minimal washing, ready-to-eat and lightly cooked, are the vehicle for transmission of pathogens in the polluted irrigation water. Furthermore, there is increasing concern over the safety of pickers, handlers, packers and farmers, while there is also an increase in the susceptible individuals.

A decrease in the food safety of the final agricultural product will negatively affect the trading status of agricultural products, both locally and internationally. The problem of contamination of irrigation water and food products should therefore be seen in the context of stricter local and export requirements and may threaten the continued access to export markets. Biomonitoring of irrigation water quality is currently fragmented and not regularly published. Little is therefore known on a national level regarding the contribution of irrigation water and the associated potentially-contaminated raw produce to the burden of disease. Consequently little action is taken to remedy the situation. A clearer understanding of the problem is urgently required to make inputs for policy formulation and regulation to reduce contamination of irrigation water. This project will investigate the links between irrigation water quality (microbial and nutrient chemistry) and food safety in commercial as well as subsistence agriculture and give guidance towards treatment options of irrigation water to ensure food safety. This research project will therefore evaluate the extent of the problem regarding contamination of both irrigation water and raw food products, endeavour to establish links between the two and provide recommendations on the way forward in terms of treatment of irrigation water. To achieve this, the main tasks include a baseline study on the extent (types and quantities) of contamination found in irrigation water as well as contamination found on the irrigated raw produce (fruit and vegetables) before and after harvest at the selected sites. The final report will document the extent of contamination found in irrigation water and on the irrigated raw produce; the links between contamination on raw produce and irrigation water applied; and make recommendations for further research in respect of validation of results and treatment options.

Estimated cost: R5 232 500 (incl. leverage)
Expected term: 2007 - 2012

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact

University of Stellenbosch (Division of Aquaculture)

No. 1802

This project will investigate the feasibility and practical implications of using on-farm irrigation water storage dams for aquacultural fish production. A recently-completed WRC project (No. 1461) found that although this dual use of water is mostly beneficial, it can also impact on water quality. This is a follow-on project that will continue with monitoring the effects of aquaculture at a number of sites, follow-up on the environmental concerns (especially enrichment or eutrophication of dam water) and investigate management and other measures aimed at reducing the enriching effects associated with intensive cage aquaculture.

Estimated cost: R1 680 000

Expected term: 2008 - 2013

An investigation into the link between water quality and microbiological safety of fruit and vegetables from the farming to the processing stages of production and marketing

University of Pretoria (Department of Microbiology and Plant Pathology)

No. 1875

With decreasing water resource availability for agricultural purposes and increasing water pollution, contamination of food products may increase health risks. Poor health due to water and food contamination has negative impacts on the productivity of human resources in all sectors of the economy. This emphasises the importance of minimising food safety risks. Due to under-nutrition, consumption of fresh and raw fruit and vegetables

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

Estimated cost: R6 219 200 (incl. leverage)

Expected term: 2009 - 2015

THRUST 2: WATER UTILISATION FOR FUELWOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services

ASSET Research

No. 1803

Large parts of the South African landscape, especially the former homelands, are heavily degraded and denuded due to, amongst other factors, historical over-population, mismanagement and exploitation of natural resources. While the country does have a limited history of restoring natural capital, i.e. rangelands and grassland catchments, woodlands and natural landscapes, few comprehensive analyses have been done to assess the ecological, hydrological and socio-economic impacts of rehabilitation across a range of contrasted sites and contexts. Very few investigations have been conducted to determine the tangible contributions restoration has made and can make to rural landscapes and local economic development. This study will assess the ecological, hydrological and socio-economic impact of improving degraded landscapes across the country at a number of contrasted sites in an integrative and dynamic systems approach. This will be done using a carefully selected assemblage of parameters to study how restoration specifically improves water flow, water quality, land productivity and in some instances carbon sequestration as well as generally improving the agricultural potential of the land. In addition, the socio-economic benefits of restoring natural capital will be assessed by investigating the contribution to employment creation and income generation. The economic quantification of restoration is likely to provide critical data needed for the implementation of payment

for environmental services. A model will be developed based on information gathered by this study to assist in predicting the impact of future restoration projects on complex and dynamic socio-economic and ecological rural landscapes. This model will be used to consider the most effective and best ways to embark on future restoration projects. This decision-support tool will be very valuable to national programmes and projects such as *Working for Water, Working for Wetlands, Working for Woodlands* and the land-care project.

Estimated cost: R3 450 000 (incl. leverage)

Expected term: 2008 - 2013

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

CSIR Natural Resources and the Environment

No. 1876

Specific findings, recommendations and gaps in knowledge regarding the water-use efficiency (WUE) and economic potential of indigenous tree systems were identified in a previous WRC project (K5/1462) which was finalised in March 2008. These included the need for improved understanding of the WUE of a wider selection of indigenous tree species growing under a range of bio-climatic conditions in South Africa. This information is needed to explore the possibility of expanding and growing the local forestry industry using indigenous tree species. Potential benefits of this expansion include the expected lower water-use rates of indigenous species, and the high economic value of biomass products. Furthermore, it is important to place the water use of exotic commercial plantations in perspective, through comparisons with indigenous tree-production systems. There is also a need to establish a baseline water use by indigenous trees under natural conditions to facilitate the evaluation of likely water resource changes associated with a change in land use. Improved knowledge in these aspects will contribute to improving or enhancing rural livelihoods through the use of indigenous tree-production systems. In addition, possibilities exist to provide

alternative wood-production systems to replace alien invasive plants, as the process of alien plant eradication continues. Ultimately, the research output should enable formulation of recommendations regarding the use of indigenous natural and plantation tree systems, with emphasis on WUE, site-species matching and economic viability to support sustainable rural development.

Estimated cost: R6 799 100 (incl. leverage)

Expected term: 2009 - 2015

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

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

Sustainable techniques and practices for water harvesting and conservation and their effective application in resource-poor agricultural production in the Eastern Cape Province

University of Fort Hare

No. 1478

Approximately 74% of South Africa's rain-water is used by dry-land cropping, natural grassland, woodlands and forests. It is therefore clear that the biggest share of rainwater is used for extensive agricultural production. The critical issue in the near future will be the increasing pressure on agriculture, in particular food and fuel-wood production, due to population growth. At the same time, there is increasing dependence on agriculture in rural areas, which exert even more pressure on the rainwater resource base, particularly among the poor. The productivity of land and water in rain-fed agricultural areas can be greatly enhanced through water harvesting and conservation. Rainwater harvesting is defined as the process of concentrating rainfall as runoff from a larger area for use in a target area. Water harvesting and conservation techniques have had limited impact elsewhere, and

in some cases failed, despite good techniques and design. This is due to social, economic and management factors that are often overlooked, or inadequately integrated into the development of the system. The research project on 'water harvesting and conservation' promotes techniques and knowledge that improve the agricultural productivity of water at farming level. Attention will be given to production methods for crop cultivation in combination with livestock husbandry (and where possible utilising indigenous products). The intervention should also take into account social, economic and environmental factors. The perceptions of rural households and possible adjustments to water harvesting and conservation practices in order to improve food security and rural livelihoods will be analysed.

Estimated cost: R5 200 000

Expected term: 2004 - 2011

Assessment of the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities

University of the Free State (Department of Agricultural Economics)

No. 1648

A large percentage of the population in South Africa can be considered to be rural survivalists and follow predominantly traditional agrarian lifestyles (Burgess, 2002). Poverty is also widespread in rural areas. Consequently, individuals and groups in these rural communities are vulnerable to natural disasters such as droughts. Given the scarcity of water, rainwater harvesting and conservation (RWH&C) is a broad-based strategy to improve rural livelihoods of resource-poor and subsistence farmers. Substantial research work on biophysical aspects of in particular infield RWH&C has been done (see WRC Report No. 1176/1/03). A start has also been made to evaluate the social acceptability and economic viability of this technique (see WRC Report No. 1267/1/04). This last-mentioned study has shown that there are many gaps in knowledge on social, institutional and economic

dimensions for sustainable implementation of RWH&C. More research effort on various socio-economic aspects of RWH&C was highlighted during an international workshop organised by the International Commission on Irrigation and Drainage (ICID) and the United Nations Food and Agriculture Organisation (FAO) during 2004. In order to improve food security and material income through higher water productivity, RWH&C must be promoted in both high and low rainfall areas. Priority attention must be given to low-potential areas, which are often remote and less visible to the general public, with high rainfall variation but concentrated poverty. Furthermore it is important to use local knowledge and rely on indigenous practices or systems, and combine it with available scientific knowledge (Maxwell, 2001). Emphasis should be placed on empowerment of farmers and especially women, through training in RWH&C. Within the institutional arrangements in rural communities as determined by amongst others traditional authority and communal land tenure, secure use rights are the necessary incentives for increased food production. Depending on access to finance and alternative marketing opportunities, individual entrepreneurial initiative can lead to production of marketable surpluses above the needs for household consumption. In this process social-economic transformation and inclusion of farmers in the mainstream of the economy will be achieved if RWH&C can be shown to be socially and economically sustainable.

Estimated cost: R3 100 000 (incl. leverage)

Expected term: 2006 - 2012

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa

ARC (Institute for Soil, Climate and Water)

No. 1775

Almost half of South Africa's population can be classified as living in poverty while 25% of the population can be categorised as ultra-poor. Although the country is self-sufficient in food

production, about 14 million people are reported to be vulnerable to food insecurity and 43% of households suffer from food poverty. The majority (65%) of the poor are found in rural areas and 78% of those likely to be chronically poor are also in rural areas. Much of South Africa is covered by large areas of rangeland (veld) that is not privately owned but used communally by farmers for grazing domestic livestock and harvesting natural products such as fuelwood. Most of the communal areas are located in the former homeland areas in provinces such as Limpopo, Eastern Cape and KwaZulu-Natal. These rural landscapes are often also characterised by abandoned croplands that are infested by weeds and grasses. In communal areas, where individuals share land and water resources, understanding the complex norms, values and behaviours is very important. The success of community-based management of resources is dependent upon the functioning of the institutional arrangements. Water harvesting and conservation practices have not only been demonstrated to increase dry-land agricultural production but also to be environmentally sustainable. This project seeks to assess water harvesting and conservation techniques/practices for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research. It will investigate the institutional arrangements in these communities and assess the extent to which production was suppressed as a result of inappropriate working rules and how these can be approved. A guideline on best management practices for RWH&C for rangeland and crop lands in communal areas will be produced.

Estimated cost: R4 728 500 (incl. leverage)

Expected term: 2007 - 2013

Improving plot-holder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province

Tshwane University of Technology; ARC (Institute for Agricultural Engineering)

No. 1804

Livelihoods of plot-holder homesteads on small-scale canal irrigation schemes in South Africa are diverse and dynamic and the importance of irrigated farming in the livelihood portfolio of these homesteads also varies. Typically, the objectives of plot-holders on small-scale irrigation schemes range from production of food solely for own consumption to fully market-oriented production. While market-oriented farmers seek to expand the scale of their enterprise, subsistence farmers (food producers for own consumption) tend to have excess land. Most of the smallholder farmers on irrigation schemes require technical improvements to the prevailing production systems to enhance the financial viability of plot enterprises and increase the efficiency of water and land use. Effective management of shared resources such as water is essential to all farmers on the irrigation schemes and is dependent on collective action. Despite the multi-faceted challenges facing smallholder irrigation schemes, very little research has been successfully conducted on integrated production systems on these schemes. At this stage these schemes are also not included in RESIS of Limpopo Province, except if farmers are prepared to switch to sprinkler irrigation. Changing to sprinkler irrigation will not necessarily increase water-use efficiency, particularly if it is done without participation by farmers. This project seeks to enhance plot-holder scheme productivity and to strengthen collective action by improving the availability of irrigation water to farmers. It will seek to enhance the establishment of robust community-based institutional systems that reduce uncertainty and risk in land-exchange contracts. It will also endeavour to integrate crop and animal production in order to contribute substantially to local

resource use, value-adding and market access on smallholder irrigation schemes. In order to achieve these objectives, the project will adopt a participatory learning and action approach to collectively analyse the existing behavioural and communication patterns. It will employ both plot and field experiments in an effort to encourage the efficient use of water and improve plot-holder productivity. The final output of this project will be a comprehensive report that documents the holistic approach followed in addressing the challenges facing smallholder irrigation farmers and lessons learnt as well as practical crop and animal production manuals for smallholder farmers and their advisers. These outputs will contribute to national programmes of high priority that address issues of poverty alleviation and food security.

Estimated cost: R1 890 000

Expected term: 2008 - 2012

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods

Rhodes University (Department of Ichthyology and Fisheries Science)

No. 1957

In South Africa the potential of inland fisheries, which exists in the form of hundreds of water impoundments or storage dams throughout the country, is largely underdeveloped and underutilised. With exception of traditional practices in e.g. specific regions of KwaZulu-Natal and Limpopo Province, there is no culture of fish consumption in rural areas, despite the fact that fish is one of the best sources of protein. Due to the decline of production of marine fish stocks (which has been caused by overfishing) and a higher demand for fish, the price of fish is increasing. With increase in demand, the development and use of water resources in storage dams for inland fisheries have the potential to contribute to uplifting rural economic activity. There is a need for Government

interventions to formulate policies and strategies that support inland fisheries. These inland fisheries encompass community-managed subsistence fishery, commercial fishery and recreational fishery. The links between hatcheries, aquaculture and inland fisheries, such as culture-based fisheries, and the stocking of small farm dams and large storage dams, also needs to be explored. Inland fisheries can thereby create a fairly large support base for job creation, skills development and poverty reduction at a local level. Sustainable use of water resources with inland fisheries requires appropriate institutional arrangements, organisational structures and governance systems, for the application of technologies, management of water resources and service delivery to be successful. In this baseline and scoping study the current situation regarding water use for inland fisheries will be documented. Contributions will be made to formulate strategies for future development. The gaps in knowledge and priorities for further research will be identified.

Estimated cost: R4 000 000 (incl. leverage)

Expected term: 2010 - 2014

Programme 2: Integrated water management for profitable farming systems

Development of training material for extension in irrigation water management

University of Pretoria (Department of Agricultural Economics, Extension and Rural Development)

No. 1649

The revitalisation of irrigation schemes and irrigation management transfer is accepted policy in South Africa (Department of Agriculture, 2003). Implementation of this policy can, however, not succeed without extension support. In the process of integrated development planning (IDP), extension services are also the essential link between Government and rural communities who are dependent on

agriculture. In both cases extensionists therefore perform an important function to promote agricultural development, which in turn leads to community development. It is generally recognised that extensionists provide the link between research output and solving the perceived problems which farmers experience. All types of farmers, but specifically emerging farmers, are dependent on extension services as a source of information and knowledge. This has been confirmed by a survey amongst emerging irrigation farmers (WRC, 2003). Discussion forums organised by the WRC in all provinces between 2000 and 2003, in which a wide range of farmers participated, have highlighted that the extension link has deteriorated in recent years and has become less effective. Presently information is available on various biophysical and socio-economic aspects of irrigation management. Irrigation-related courses are also presented by universities and colleges. However, this information is not presented in the required format and the courses are not specifically targeted to be useful for extensionists in their work environment. Extensionists therefore do not have the appropriate knowledge base and skills to do their work. In many cases this results in a lack of confidence amongst extensionists, decline in their credibility and withdrawal from the community which they must serve. There is an urgent need to restore the self-esteem of individuals and improve the service delivery of the extension profession. Extensionists require in-service training on all aspects of irrigation management, to meet the demands of subsistence, emerging and commercial smallholder farmers. Training material must be developed or adapted for this purpose. This will enable extensionists to become more effective, with the benefits not being limited to farmers only, but having a positive impact on the community in which extensionists and farmers live.

Estimated cost: R2 370 000 (incl. leverage)

Expected term: 2006 - 2011

Awareness creation, implementation plans and guidelines for management of sustainable on-farm and on-scheme water measurement

WSM Leshika (Pty) Ltd

No. 1778

According to the National Water Resource Strategy of 2004, national water conservation and demand management (WC & DM) strategies are being developed. The strategy for irrigated agriculture provides a framework of regulatory support and incentives to improve efficiency, with a plan of action towards delivering amongst others the following outputs:

- Implement measures that reduce wastage
- Convince users to progressively modernise their water conveyance infrastructure and irrigation equipment.

The recently-published Water Conservation and Water Demand Management Conditions for Water Use Sector Authorisation (DWAF, 2006) imposes a duty to measure, record aspects of water use and requires that 'the licensee shall measure the amount of water supplied to each farm or user on a monthly basis using an appropriate flow measurement device'. The WRC has published reports and guidelines for the direct and indirect measurement of water on irrigation schemes in response to the practical need to measure and manage water effectively and efficiently. However, in most cases the water-management system currently in operation does not incentivise water measurement, and consequently measurement of water use and volumetric charging is not widely practised. This project will facilitate a process towards effective implementation of water measurement at river, irrigation scheme and farm level in South Africa. In order to achieve this, end users of water-measurement technology will be made aware and convinced to adopt the technology. Specific attention will be given to technical constraints and financial justification for implementation of the technologies for water measurement. This will require purposeful capacity building and training of end-users such as farmers while using the model of 'train-the-trainer', which has been found to

be most successful. In this process a common understanding of the practical requirements of water measurement by water users, water managers and regulators will have to be reached. Therefore it is necessary to obtain support of the DoA and DWA on training for adoption of water measurement. Since water user associations (WUAs) will increasingly provide an advisory role, the managers of WUAs and leader farmers whom they serve, will be targeted in order to achieve sustainable implementation of water measurement. The intention is to interact with these stakeholders as part of the preparatory phase; determine the incentives for water measurement as part of the analysis phase; and practically demonstrate how to undertake effective water management in the implementation phase. The final output of this technology transfer project will be an overarching report that documents the implementation process, the lessons learned and guidelines towards general implementation of water measurement.

Estimated cost: R800 000 (incl. leverage)

Expected term: 2007 - 2011

Assessment of the contribution of water use to value chains in agriculture

University of the Free State (Department of Agricultural Economics)

No. 1779

The contributions of agriculture to the economy are mainly food production, creation of employment and earning of foreign exchange. The strategic goal of the Agriculture Sector Plan in South Africa (2001) is more specifically to generate equitable access and participation in a globally competitive, profitable and sustainable agricultural industry. According to the Presidential Imperative Programme on Integrated Sustainable Rural Development, the goal is furthermore to promote development and improve the quality of life of marginalised groups and communities, amongst others by alleviating poverty through employment creation. In order to generate employment and income to reduce poverty, it is also recognised that a wide-

ranging programme is required to develop agriculture. This includes improved food security through livestock husbandry and rain-fed or irrigated crop cultivation, as well as improvement of skills to earn non-farming income in agro-industries. However, in the current dual agricultural economy, the question arises: how can emerging producers be included in the mainstream of the economy? Only by obtaining access to available resources or assets in agriculture, can an impact be made to improve rural livelihoods, in particular for vulnerable groups such as the rural poor. In this regard the concept of the value chain can be used to better understand the links between farming and non-farming activities in agriculture. This project will apply value chain analysis for optimising economically-beneficial water use in agriculture in order to integrate commercial and emerging farmers in the mainstream of the economy. It will investigate whether emerging farmers, who are producing a combination of rain-fed or irrigated field and vegetable crops, can obtain better market access. On the basis of water resources which are common to all, and water as a production input in farming and non-farming agriculture, it will be determined how emerging and commercial producers can be integrated through value chains and thereby promote economic development. The main outputs will be: firstly, a conceptual framework based on the literature review of the value chain analysis with specific reference to water utilisation and competitiveness in agriculture; secondly, demonstration of the application of the conceptual framework for commercial and emerging agriculture in the horticultural and field crop industries; thirdly, empirical analysis and modelling of selected value chains in commercial and emerging agriculture with specific attention to mapping of water use at critical points in the value chain, optimisation of water use in the whole value chain, mainstreaming of marginalised participants in the economy by integration in the value chain, employment creation and poverty reduction through the value chain, and improving competitiveness in the value chain.

Estimated cost: R2 430 000

Expected term: 2007 - 2012

The development and testing of an integrated set of models to evaluate the financial/economic impact of irrigation water curtailment decisions on participant farm case studies in the Crocodile Catchment

CPH Water; South African Sugarcane Research Institute; University of the Free State

No. 1805

Numerous options are being considered to address the over-allocation of water in catchments. This ranges from improvements in the efficiency with which water is used and managed, to the reduction of alien invasive plants in catchments, to the building of new dams or transfer schemes. However, even though the measures listed above will help address the over-allocation to some extent, it is likely that existing lawful users may need to be curtailed (i.e. have their water use licences reduced) in order to address the over-allocation. The general aim of the project is to evaluate the impact of curtailment of existing lawful water use on the economic and financial feasibility of irrigation farming. In the selected catchment of the Crocodile River in Mpumalanga Province, the current water situation will be assessed to determine the causes of water stress in the catchment. This will be done by reviewing available documents and reports and through discussions with DWA and the CMA. The ACRU and MIKE BASIN models will be configured to represent the current water users, water resources and operating rules in the catchment. This component can be described as catchment-scale hydrological modelling. The SKELETON model will be further developed to link with the MIKE BASIN irrigation module. In particular the influence of the variable availability of water on optimum crop combinations and farming viability will have to be determined. This part of the modelling can be described as the farm-scale economic modelling. The integrated ACRU/MIKE BASIN/SKELETON model will be applied to evaluate the outcome of various curtailment scenarios. A report will be produced to document the findings for the Crocodile River specifying the potential impact of curtailments and changes in operating rules to support sustainable irrigation farming in future.

Estimated cost: R1 790 000

Expected term: 2008 - 2012

Analysis of food-value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy

University of KwaZulu-Natal (Institute of Natural Resources)

No. 1879

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

Estimated cost: R2 999 989

Expected term: 2009 - 2014

Investigation of water conservation in food value chains by beneficiaries of water allocation reform and land reform programmes in South Africa

CSIR (Water Resources Governance System)

No. 1958

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

Estimated cost: R3 000 000

Expected term: 2010 - 2014

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

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

Methodology to monitor the status of water logging and salt-affected soils on selected irrigation schemes in South Africa

ARC (Institute for Soil, Climate and Water)

No. 1880

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

Estimated cost: R3 693 800
Expected term: 2009 - 2015

Development of technical and financial norms and standards for drainage of irrigated lands
ARC (Institute of Agricultural Engineering)

No. 2026

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

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

Programme 2: Impact assessment and environmental management of agricultural production

Applications of rainfall forecasts for agricultural-related decision making in selected catchments

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

No. 1646

The South African climate is highly variable over short and longer periods. This inter- and intra-seasonal variability is likely to be amplified by the global change in climate. Agricultural production is intrinsically linked to climate variability. Many agricultural decisions are made based on climate (short-, medium- and longer-term) information and assumptions. Farmers need information to help them plan for planting, irrigation and harvesting of their crops. Weather forecasting can aid users to make more informed decisions and assist in planning activities. They have the potential to reduce risk in the long term and improve water-use efficiency. Forecasting involves computer models, observation and knowledge of trends and patterns. Using such tools, meteorologists can reasonably forecast weather conditions up to 5 days in advance. Longer lead-time forecasts (weeks, months) are referred to as climate forecasts. Such forecasts, usually made in terms of categories (above, near and below normal) and probabilities, are becoming more skilful as research progresses. However, gaps exist between the weather and climate forecasts and linking them to agro-hydrology and applications in agricultural decisionmaking. The project aims to develop techniques and models for translating forecasts of up to 1 year in advance into applications for decision-support.

The WRC has funded several projects over almost 2 decades on research on climate variability with a focus on forecasting, modelling and database development. These include *inter alia*:

- Development of a Raster Database of Annual, Monthly and Daily Rainfall for Southern Africa (WRC Report No. 1156/1/04)
- A Flood Nowcasting System for the eThekweni Metro: Volume 1 and 2 (WRC Report No. 1217/1/04 and 1217/2/04)

- Spatial interpolation and Mapping of Rainfall (Simar): Volume 1 – 3 (WRC Report No. 1151/1/04; 1152/1/04 and 1153/1/04)
- Regional Model Development for Simulating Atmospheric Behaviour and Rainfall over Southern Africa (WRC Report No. 1261/1/05)
- Dynamic Modelling of the Present and Future Climate System (WRC Report No. 1154/1/04)

These and other projects have resulted in more comprehensive datasets and a better understanding of weather and climate variability and refined forecasting tools. It is therefore in the interest of the WRC to see this research utilised. The 2001 Strategic Plan for South African Agriculture states that one 'component of the comprehensive risk management strategy is an early-warning system that includes adequate access to and utilisation of timely, accurate, relevant, and free information about the weather'. Since the end of 2002, the National Department of Agriculture has been advising farmers on climate conditions and practices to follow, based on a long-term climate outlook. It is envisaged that this project will develop an early warning system with different lead-times that could reduce farmers' susceptibility to adverse weather conditions. Although the project will focus on 2 or 3 critical catchments, the findings of this study will be extrapolated to other catchments.

Estimated cost: R5 700 000 (incl. leverage)

Expected term: 2006 - 2012

Impact of wastewater irrigation by wineries on soils, crop growth and product quality

ARC (Infruitec, Nietvoorbij)

No. 1881

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation of agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and

mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well-known and their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

Estimated cost: R3 500 000

Expected term: 2009 - 2014

Adaptive interventions in agriculture to reduce vulnerability of different farming systems to climate change in South Africa

University of Cape Town (Climate Systems Analysis Group)

No. 1882

South Africa has a high-risk agro-hydrological environment which is likely to be exacerbated under conditions of climate change. It is widely recognised that ongoing changes in climatic conditions will generally have an adverse effect on, amongst

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

Estimated cost: R4 300 000 (incl. leverage)
Expected term: 2009 - 2016

Improving the livestock carrying capacity with rainwater harvesting and conservation on grasslands for extensive and/or intensive livestock production and biogas generation from manure in rural areas of South Africa

University of KwaZulu-Natal (Department of Grassland Science)
No. 1955

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

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

Investigation of the contamination of water resources by agricultural chemicals and the impact on environmental health

CSIR (Natural Resources and the Environment)

No. 1956

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825

Expected term: 2010 - 2015

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

Water-use efficiency of irrigated agricultural crops determined with satellite imagery

UKZN (Bioresources Engineering and Environmental Hydrology)

No. 2079

Advances in recent years in the use of remote sensing (RS) information now make it possible to assess crop water use, biomass and yield production (and WUE) spatially for each pixel (< 30 to 250 m) of a satellite image. For agricultural (field-scale) applications a number of models have been developed, including the Surface Energy Balance Algorithm for Land (SEBAL) model. Assessing the spatial WUE data over time can help farmers to detect, e.g. an uneven application of irrigation water (in a field or across a farm or irrigation scheme), a mismatch between irrigation water supply and that actually required (indicating over- or under-irrigation), potential seepage losses or drainage problems and other resources (e.g. fertiliser and energy) wastage. This project will build on research projects conducted in South Africa in recent years where the use of spatially-explicit data (from the SEBAL model) in irrigated agricultural water management has been evaluated. In South Africa, there is a need for information to be available operationally, so that WUE at field, farm and irrigation scheme level can be evaluated regularly, problems detected and addressed swiftly, crop WUE and other resource use (fertiliser, electricity, etc.) optimised, and water wastage minimised. This

project will aim at conclusively confirming the degree of accuracy of the SEBAL model (when compared to traditional methods) for estimating ET and WUE of selected agricultural crops. This project should therefore pave the way for the operational near real-time application of RS data in agricultural water management. There will be collaboration with potential users of the data (researchers, farmers, irrigation advisors, water managers on irrigation schemes) and the project will continue to build capacity (students, extension officers, researchers) in generating and using this data.

Estimated cost: R4 000 000

Expected term: 2011 - 2014

Investigating the possibility to improve water use efficiency and reduce canopy management inputs of wine grapes through deficit irrigation

ARC Infruitec-Nietvoorbij

No. 2080

At present, wine grape farmers are advised by viticulturists to follow certain canopy management practices, such as suckering, tucking in and topping of shoots. This is done to ensure that the grapes fall within a prescribed quality class. Under current economic circumstances, as well as with the rising cost of labour and fuel prices, these practices are becoming increasingly expensive to maintain, as farmers are not necessarily compensated for the additional expenses. Knowledge of how different canopy management practices at different deficit irrigation strategies will influence the combination of vegetative growth, production and wine quality is limited. A completed Winetech project investigated the effect of different deficit irrigation strategies on the water usage, production, growth, plant water potentials and overall wine quality, and crop factors were determined for a range of irrigations at different soil water depletion levels. The same canopy management was applied to the grapevines of all the treatments (two-spur winter pruning,

suckering twice during spring and the tucking in of shoots into trellis wires). The cost of these different management practice inputs has not been investigated. In previous irrigation trials conducted on wine grapes, a blanket standard canopy management was done on all the treatments as the object of these trials was to investigate the effect of the different irrigation strategies on the grapevines' yield and wine quality. In previous canopy management research, the same irrigation volumes were applied to the various treatments while their canopies were manipulated. The effect of different canopy management inputs in combination with different irrigation strategies, and the water requirements of these different canopies, has thus not previously been investigated. Depending on the outcome of the trial, the results could be used as subroutines in future economic models to calculate the profitability of wine grape vineyards.

Estimated cost: R2 072 000

Expected term: 2011 - 2015

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

Rehabilitation of alien-invaded riparian zones and catchments using indigenous trees: An assessment of indigenous tree water use

University of Pretoria (Plant Production and Soil Science)

No. 2081

Much of the tree water use research is based on forest hydrology and has focused on exotic tree species and their impacts on streamflow. In order to support the Government's rural tree programmes, there is a need to expand current research to include the water use of indigenous trees used

in forest expansion, the rehabilitation of degraded lands and the restoration of riparian zones. One of the biggest problems with current rehabilitation programmes is that exotic species (e.g. vetiver grass) are used to restore the ecosystem services (e.g. water production and reduced soil erosion). However this ignores the importance of ecosystem structure and functioning (e.g. biodiversity). Research and policy support in South Africa is required to promote and scale-up indigenous tree planting and growing initiatives in degraded areas and riparian zones. The impact of expanding the use of indigenous trees to catchment hydrology is of critical importance in a water-scarce country. It is therefore important to understand the plant water use (transpirational changes) brought about by introducing indigenous trees into degraded landscapes and alien-cleared riparian zones. There is a widespread belief in South Africa that indigenous tree species, in contrast to the exotic trees, are water-efficient and should be planted more widely in land restoration programmes. This is based on observations that indigenous trees are generally slow-growing, and that growth and water-use are broadly linked. However, tree water use is technically difficult and expensive to measure, and so there is scant evidence of low water-use by indigenous trees. This is even more so for pioneer tree species more suited to the rehabilitation of degraded lands and those found re-colonising riparian zones previously invaded with exotic trees (e.g. wattle). This study will therefore focus on determining the water use of potential indigenous, pioneer tree species suitable for rehabilitation programmes.

Estimated cost: R4 900 000

Expected term: 2011 - 2016

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

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

Empowerment of women through water-use security, land-use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, Limpopo Province

University of KwaZulu-Natal (Agriculture Sciences and Agribusiness)

No. 2082

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water-use security and lack of knowledge to achieve food security. Lack of water- and land-use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the abovementioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household level that impact on the empowerment of women and attainment of sustainable food production. It includes better understanding of institutional

and organisational impediments affecting the decision-making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc., on the one hand, and the observed under-utilised land and water resources at local level in rural areas on the other. Finally more empirical information must be documented on the existing and required knowledge, as well as skills, for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost: R3 000 000

Expected term: 2011 - 2015

Empowerment of women through water-use security, land-use security and knowledge generation for improved household food security and sustainable rural livelihoods in selected areas of, amongst others, the Eastern Cape Province

Umhlaba Consulting Group (Pty) Ltd

No. 2083

Although the South African Constitution enshrines gender equality, women in rural areas experience a lack of water-use security and lack of knowledge to achieve food security. Lack of water- and land-use security refers to physical, legal and tenure insecurity while lack of food security implies insufficient access by all people at all times to enough food for an active and healthy life. Empowerment of women through secure access to water and land, as well as by obtaining knowledge and developing skills must receive priority attention. This will provide the necessary incentives to take ownership of the process of productive use of water to achieve food security and improve rural livelihoods. Research is therefore required to bridge the divide between the above-mentioned current reality and Government policy intentions. This research must improve the understanding of social dynamics at the household level that impact on the empowerment of women and attainment of sustainable food

production. It includes better understanding of institutional and organisational impediments affecting the decision-making powers of women. Better understanding of what impact land reform and rural development policies have on women is of specific importance. This will lead to better understanding of the contradiction between actual poverty, under-nourishment, food insecurity, etc. on the one side and the observed under-utilised land and water resources at local level in rural areas on the other. Finally, more empirical information must be documented on the existing and required knowledge as well as skills for empowerment of women to take decisions which are affecting their immediate environment.

Estimated cost: R3 000 000

Expected term: 2011 - 2015

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Insights into indigenous coping strategies to drought for drought adaptation in agriculture: The Southern Cape scenario

Cape Peninsula University of Technology (Centre for Water and Sanitation Research)

No. 2084

Drought is a normal, recurrent feature of South African climate. In the past, droughts have resulted in significant economic, social and environmental impacts on the country. South Africa will continue to experience droughts and the likelihood of serious drought is greater with climate change. In the Western Cape Province, for example, climate change projections indicate that the province can expect less rainfall, particularly to the eastern parts of the province. Thus the future climate change projections mentioned indicate that droughts will become a more regular

phenomenon. The Southern Cape is the area most vulnerable to such extreme events and therefore the area of investigation. To develop drought preparedness strategies it is critical to capture local experiences. There have been limited studies capturing indigenous local knowledge of the impacts and experiences of past and current droughts in South Africa. Completed studies recommend three groups of drought-mitigation measures – supply-orientated, demand-orientated and minimisation of impacts and losses. However, these coping strategies and mitigation measures are not concerned with local practices, and certainly do not incorporate indigenous knowledge and practice. In any case, these concern drought experiences of two to three decades ago. It is therefore critical that the experience of the current drought in the Southern Cape be captured to adequately prepare and mitigate against future anticipated droughts in the region. The research is intended to capture and assess local coping strategies and experiences of a current drought within the agricultural sector to inform preparedness planning for future droughts. In this respect the research would contribute to an indigenous knowledge base for informing mitigation and preparedness planning in both disaster risk management and climate change adaptation for the agricultural sector.

Estimated cost: R712 000

Expected term: 2011 - 2014

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KSA 5: WATER-CENTRED KNOWLEDGE



*Dr Heidi Snyman:
Director*

SCOPE

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

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

The overall scope is further expanded in a number of thrusts:

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

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

This KSA provides support to the 'engine room' of the WRC, i.e. the four key strategic areas mandated to coordinate and

fund water research. It supports the management of research projects, enhances innovation and provides the tools and processes for protecting technological developments. It also links the financial processes with the technical fund management. This includes:

- Research business systems management
- Intellectual property management and contractual management support
- Printing and distribution

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

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

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

information requirements of the WRC and the water sector in general. It includes:

- Knowledge packaging
- Promote the public understanding of science
- Ensure that scientific knowledge is globally recognised and exchanged
- Knowledge sharing (Internal and External)
- Enhancing the effectiveness of knowledge dissemination

THRUST 3: STRATEGIC POSITIONING AND STAKEHOLDER RELATIONS

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

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

- Establish working relationships with industry, decision-makers and key stakeholders
- Establish and strengthen the relationship with a number of portfolio committees
- Support national, African and global initiatives
- Prepare positioning material such as the WRC Annual Report, strategic messages, Ministerial and Policy briefs
- Support the research community
- Promote the WRC at carefully selected opportunities
- Driving the implementation of the WRC communication strategy

THRUST 4: RESEARCH ADVICE

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

The WRC is mandated to lead and coordinate water research in South Africa. It is also tasked to promote effective knowledge

transfer and enhance knowledge and capacity in the sector. It is therefore important that the WRC understands all the elements driving the water knowledge cycle in South Africa.

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

CORE STRATEGY

Strategic context

The strategic context of **Water-Centred Knowledge** Key Strategic Area 5 (KSA 5) should be seen in the context of the WRC strategy as documented in the Strategic Plan 2011/12 – 2013/14. The WRC research portfolio addresses the full water cycle through the four Research Key Strategic Areas and links this to the knowledge cycle with the support from KSA 5.

The South African science sector recognises that knowledge uptake is problematic, and, in particular, the lack of appreciation for credible science-based knowledge and how this can inform policy. The path from research to policy formulation is no longer a causal linear process where research results in a product which is passed from researcher to policy maker. Policy formulation is a complex interaction of actors and includes several advocacy coalitions and networks. As with other science councils and research organisations in the country, the WRC too has to try to narrow the institutional gap between policy-makers and the scientific research community.

In the South African water sector, the challenge is compounded by the constant change in the environment, particularly in the

Governmental sphere which includes the political environment, institutional instability, high staff turnover, declining institutional memory, and mechanisms of decision making. However, the recent strategic approach developed by the South African Government, using an outcome-based approach, provides a conducive environment for knowledge uptake as the sector gears itself to improve the impact of its efforts. The WRC has aligned its research portfolio to Government's outcomes and outputs. This KSA supports the research KSAs in clearly communicating the link between research outputs and how these can assist Government in achieving the desired outputs.

Sector threats

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

- Functioning and pursuing continuous development in a resource-constrained environment
- The desperate and urgent need for solutions, threatening sustainability should short-term fixes not be informed by sound credible knowledge
- Working in a complex and multidisciplinary sector and often across institutions and disciplines
- Human resource capacity in the public sector – often qualified but less experienced people need to acquire a level of competence in a short period of time without the luxury of continuous mentorship
- Limited research capacity in certain of the water-related research areas and reduced ability to deliver – this will cause a medium- to long-term shortage of knowledge in these areas with knock-on effects on the quality of decisions made

- Shortage of South African students studying towards a higher degree in water knowledge – a balance is required between the need to continue research (creating knowledge) to ensure a sustainable water sector and the need to build capacity to export to other African states
- The lack of knowledge uptake in the sector

Relevance and impact

The perceived relevance of the WRC in the short term is to a degree dependent on the absorptive capacity of the sector. The WRC, through this KSA, has started to place more emphasis on understanding and enabling knowledge uptake rather than focusing purely on knowledge dissemination. Van Ryneveld and Sproule (2007) defined knowledge uptake as 'the **active** acquisition of disseminated information, the **comprehension** of the information and the ability of practitioners to **apply** the information in the field'. While the WRC continues to generate water-related knowledge-based products which contribute to addressing the knowledge gaps in the water sector, it also seeks to better understand the mechanisms of knowledge uptake. The role of KSA 5 is therefore important for the continued relevance of the WRC and for the sustainability of a knowledge-based water sector. The emphasis is moving to better understand knowledge flow and to developing and applying methodology to enhance the uptake and application of the water-related knowledge generated by the WRC to solve the water challenges that South Africa faces. KSA 5 therefore aims to lead a consultative knowledge flows programme to create a better understanding of what the knowledge uptake drivers are. It also strives to assist the research KSAs to enhance and encourage sector involvement from the early stages of appropriate research projects/ programmes to:

- Improve knowledge uptake with the aim to increase implementation
- Enhance sector involvement in the WRC research processes

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

- Supporting research management and providing logistic support
- Developing effective internal and external knowledge sharing and dissemination mechanisms/instruments
- Enhancing the credibility and relevance of the WRC locally, in the rest of the African continent and globally
- Ensuring the appropriate management of intellectual property
- Supporting the WRC with advice on research contract matters

Needs analysis

This KSA has both internal and external stakeholders. The WRC has completed a comprehensive stakeholder survey, a strategic scenario analysis and a communication strategy which contextualised the requirements of internal and external stakeholders.

Internal stakeholders

The research managers and staff of the WRC require:

- Coordination of the annual research cycle and research-related business systems
- An effective electronic fund management system for research projects and fund management
- Support related to intellectual property management and contract management
- Efficient layout, printing and publication stock control
- A dynamic interface with the local and global water sector (events, publications, media, etc.)

External stakeholders

The WRC loosely defines its external stakeholders as:

- **Research community:** This includes the researchers working on WRC projects, the reference groups, peer reviewers as well as the primary users of the WRC outputs – technical users, which includes students, lecturers, consultants, other researchers, etc.

- **Decision-makers:** This includes managers and policy-makers who use information to lead them to the selection of a course of action among several alternatives.
- **Sectoral users:** This includes all stakeholders that require new processes, solutions and technologies. It includes local Government, industrial and mining sector, agricultural sector, etc.
- **Interest groups:** This includes the media, non-Governmental organisations, general public, schools, etc.

An individual can dynamically move between these stakeholder groupings, for example a DWA official could require knowledge which effectively informs policy (decision maker), and a while later use WRC research to solve a technical problem (**sectoral user**) while serving on several WRC reference groups (**research community**). The ideal is to understand the needs of a stakeholder depending on which role they play at a particular time.

Through ongoing initiatives, regular stakeholder engagement and the stakeholder survey completed in 2010, the needs of the stakeholder groups can be summarised as follows:

Research community: Members of the research community require an effective institution that serves as a catalyst and a knowledge hub to ensure the constant generation of knowledge. Effectiveness, transparency and inclusivity in the WRC processes are important to the research community.

Decision-makers: Decision-makers need packaged solutions and need to trust the information (credibility). They always need the solutions 'now'. For this stakeholder group, it is important to communicate the mandate and role of the WRC in the South African water sector as well as the role of the sectoral users as intermediaries. The decision-makers group was identified as a group that will require a significant amount of effort in the future as current mechanisms to improve knowledge uptake addressing this group have often not achieved the desired result. This was found to be a general rather than a water sector specific issue.

Sectoral users: Sectoral users are primary knowledge users and partners which also play an important role in formulating new knowledge needs. They need to be part of the WRC processes, projects and require easy access to WRC research products.

Interest groups: Interest groups require accurate, credible, scientifically-proven information packaged in a manner that is easily understood.

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

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

KNOWLEDGE DISSEMINATION

The WRC aims to constantly improve its contribution towards knowledge as well as to enhance the sharing and dissemination of WRC-funded research findings. This is linked to Government outcomes/outputs related to building skills, by addressing the building of future research capacity and improving knowledge dissemination. The WRC strives to improve its contribution towards the water-centred knowledge base in South Africa by enhancing the WRC knowledge-sharing activities and positioning.

Enhancing public understanding of water research

The WRC continues to enhance public understanding of water research through the publication of *The Water Wheel*.

The WRC published six issues as well as a Special Supplement of *The Water Wheel* in the year under review.

- The May/June 2011 (Volume 10, No. 3) issue featured an article entitled 'Maintenance, skills still impede infrastructure services', and covered 13 new WRC reports in the 'New from the WRC' section.
- The July/August 2011 (Volume 10 No. 4) edition featured an article on the link between water and elephant management in nature reserves on the cover, and published information on 15 new WRC reports.
- The September/October 2011 (Volume 10 No. 5) edition featured a new WRC project on remote sensing using satellite technology in Mpumalanga on the cover, and covered 20 new WRC reports. The September issue also featured a Special Supplement celebrating the WRC's 40th anniversary.
- The November/December 2011 (Volume 10 No. 6) edition featured an article entitled 'Groundwater – from "inferior" to "superior"', and published information on 6 new WRC reports.
- The January/February 2012 (Volume 11 No. 1) edition featured an article entitled 'Water quality – The changing face of Rietvlei Dam', and published information on 8 new WRC reports.
- The March/April 2012 (Volume 11 No. 2) edition featured an article entitled 'Aquaculture in South Africa: From fingerling to prize catch', and published information on 13 new WRC reports.

Improved dissemination of water research through *Water SA*

Water SA is the WRC's accredited scientific journal which contains original research articles and review articles on all aspects of water science, technology, engineering and policy. *Water SA* has been in publication since 1975 and includes articles by both local and international authors. The journal is issued quarterly (four issues per year). In the year under review, the WRC published four issues in Volume 37 (three regular issues and one special edition), and one issue in Volume 38.

Briefs

This knowledge tool attempts to communicate, in a clear and brief format, the outcome of various research studies to the water sector, with special emphasis on non-technical professionals, policy- and decision-makers. For selected finalised research projects, 1-2 page briefing notes are produced, which are short communiqués highlighting research outcomes and sharing pertinent messages and recommendations. Another 36 briefs were produced during the year under review (for easy reference, the number in brackets refers to the report or project number; all technical and policy briefs and reports are available electronically on the WRC website: www.wrc.org.za):

Technical briefs

1. Guide towards the development of conservation plans for threatened fish species (K5/1677)
2. Understanding hydroclimatic variability (K5/1747)
3. Light-weight, moveable superstructures for VIP toilets (K5/1781)
4. Mercury levels in SA water resources (K5/1754)
5. Study shows WRC to be major funder of estuarine research (Report No. KV 257/10)
6. Sewerage system planning (Report No. 1828/1/11)
7. Potential impact of coal-mining on water in the Waterberg (Report No. 1830/1/10)
8. Enabling and constraining factors of ER implementation in the Lowveld (Report No. TT 477/10)
9. Guidelines on greywater reuse (Report No. 1639/1/10)
10. Madumbe crop impact on wetland vegetation (Report No. KV 260/10)
11. Cleaner production in the mining industry (K5/1553)
12. Development of a practical methodology for assessing the potential impacts of climate change on the yield characteristics of reservoirs (K8-870)
13. Deriving conservation targets for rivers (K5/1796)
14. Developing a method for determining the environmental water requirements for non-perennial systems (K5/1587)
15. Groundwater management framework (K5/1917)
16. Use of stable isotope analysis to describe aquatic foodwebs in the Kruger National Park (K8-890)
17. A review of studies on the Mfolozi Estuary and associated floodplain, with emphasis on information required by management for future reconnection of the river to the St Lucia system (K8-930)
18. Household on-site water as supplementary resource to potable municipal supply (K5/1819)
19. Sediment quality guidelines (K8-793)
20. Sediment yield prediction map (K5/1765)
21. Strategic Adaptive Management: A framework for implementing integrated water resource management (K8-861)

Policy briefs

1. Towards improved management of oestrogen activity in treated drinking water (K5/1749)
2. Light-weight, moveable superstructures for VIP toilets (K5/1781)
3. National survey of mercury levels in SA water (K5/1754)
4. Study shows WRC to be major funder of estuarine research (Report No. KV 257/10)
5. Towards sustainable water services provision (Report No. 1812/1/10)
6. Potential impact of coal-mining on water in the Waterberg (Report No. 1830/1/10)
7. Sewerage system planning (Report No. 1828/1/11)
8. Corporate water risk in South Africa – Implications for growth and development (K8-927)
9. Knowing, caring & acting: Making use of socio-cultural perspectives to support biophysical conservation (K5/1800)
10. The concept of public trusteeship as embedded in South Africa's National Water Act (K8-942)
11. The valuation of estuary services in South Africa specifically regarding changes to estuary services (K5/1413)

Four (4) additional Ministerial Briefs were prepared on request from the Minister of Water and Environmental Affairs:

1. WRC and climate change, finding solutions for tomorrow's challenges today
2. WRC and desalination, towards enough water for all
3. WRC and mine-water, sustainability addressing SA's mining legacy
4. Fracking in South Africa: State-of-the-art

Distribution of WRC research and technology transfer reports

Table 1 indicates the number of WRC reports distributed to various stakeholder groups in 2011/12 and Table 2 lists the eight most popular reports in 2011/12 in terms of numbers of print copies requested.

Table 1
WRC reports distributed to stakeholders in 2011/12

| | |
|----------------------------|---------------|
| FWR | 219 |
| Institutes | 1 098 |
| Municipalities | 325 |
| Private | 10 642 |
| Schools | 188 |
| State Library | 177 |
| Universities of Technology | 926 |
| Universities | 1 668 |
| WRC | 4 500 |
| WRC Board | 10 |
| TOTAL | 19 753 |

Table 2
Most popular reports distributed during 2011/12

| Report no | Title | KSA | Total |
|-----------|--|-----|-------|
| TT 490/11 | Introduction to integrated water meter management | 3 | 878 |
| TT 489/11 | Wastewater Risk Abatement Plan – W2RAPWET | 3 | 688 |
| TT 117/00 | Quality of domestic water supplies, Volume 2: Sampling guide | 3 | 597 |
| TT 458/11 | Towards standards for municipal invoices in SA | 3 | 453 |
| TT 481/11 | Waterborne sanitation design guide | 3 | 437 |
| TT 482/11 | Waterborne sanitation operation and maintenance guide | 3 | 423 |
| TT 405/09 | A simple guide to the chemistry, selection and use of chemicals for water and wastewater treatment | 3 | 300 |
| TT 346/08 | Learning and teaching about water in our classrooms: A series of lesson plans for Grades 8-12 | 2 | 300 |

Knowledge-sharing events

The WRC held a number of knowledge-sharing events in the year under review, including technical field visits and technical workshops aimed at enhancing knowledge transfer. Many of these were in collaboration with strategic partners in order to enhance research impact and knowledge uptake. Examples of technical workshops, seminars and launches held during the year under review were:

1. South African/French Water Research Partnership for Capacity Building, 23 May 2011, Gauteng
2. Climate Change Task Team Workshop, 8 April 2011, Gauteng
3. River Rehabilitation – Technologies, Methods and Policies, 28 June 2011, KwaZulu-Natal

4. Energy from Conduits workshop, 11-12 May 2011, Gauteng
5. Integrated Meter Management Training Events, 12 October 2011 (Durban), 19 October 2011 (Cape Town), 26 October 2011 (Gauteng)
6. Role of Aquatic Ecosystems in People's Livelihoods, 29 September 2011, Eastern Cape
7. Biomimicry Workshop, 14-15 July 2011, Gauteng
8. Pits, Pets and Faecal Sludge Management Dialogue, AfricaSan 19-21 July 2011, Rwanda
9. Community Led Total Sanitation in South Africa, National Seminar, 18 August 2011, Eastern Cape
10. Improving Knowledge Dissemination using the Electronic Water Knowledge Hub – Envisioning Workshop, 26 September 2011, Gauteng
11. Internal Workshop: Increasing Use of WRC products, 10 October 2011, Gauteng
12. Mine-water Management – workshop with the Department of Mineral Resources, 1 December 2011, Gauteng
13. Launch of the *Atlas of Freshwater Ecosystem Priority Areas in South Africa*, 14 November 2011, Gauteng
14. Launch of the Pierre van Ryneveld Hydropower Reservoir, 29 November 2011, Gauteng
15. 4th Training Course on Advanced Earth Observation Methods in Water Management, 5-9 December 2012, KwaZulu-Natal
16. Ecosystems and Livelihoods, 15 March 2012, Limpopo
17. The Importance of Water Quality Monitoring and Application of MiniSASS Kits, 26 March 2012, KwaZulu-Natal
18. Green Drop and Wastewater Risk Abatement Plan, 30 March 2012, Western Cape
19. WRC/DST Innovation Technologies Showcase, 20 March 2012, Gauteng
20. Sustainable Rural Water Supply, 6 March 2012, Gauteng
21. Direction of Hydrology Research in the Age of Global Change and Inauguration of Water Resources of South Africa 2012 Study, 6 March 2012, Gauteng

Exhibitions

As part of its knowledge-sharing and dissemination activities the WRC participated in a number of exhibitions at conferences, symposia and workshops, using these to disseminate information in the form of reports and other publications. Exhibitions in which the WRC participated included:

- Budget Vote, 14 April 2011, Old Assembly Chambers, Parliament, Cape Town
- 3rd Municipal Water Quality Conference, 27-30 June 2011, Cape Town ICC
- 2nd Regional Southern African Conference of Young Water Professionals, 3-5 July 2011, CSIR International Convention Centre, Pretoria
- Water Sector Leadership Group (WSLG), 21-22 July 2011, Protea Hotel, Stellenbosch
- SALGA Western Cape Conference, 3-4 August 2011, Diaz Strand Hotel, Mossel Bay
- Biennial Conference of the Ground Water Division: 2011, 18-21 September 2011, CSIR International Convention Centre
- IMESA Conference, 26-28 October 2011, Birchwood Hotel, Johannesburg
- South African National Committee on Large Dams Biennial Conference, 10 November 2011, Midrand
- Conference of the Parties (COP17), 28 November - 9 December 2011, ICC Expo, Durban
- Western Cape Water Quality Summit 2012, 8 March 2012, Kronenburg, Paarl
- Joint exhibition with Department of Water Affairs and Lesotho Highlands Water Project at World Water Forum, 12-17 March 2012, Marseille

Internal open day

The WRC staff visited the Alrode plant of the South African Breweries (SAB) on 28 October 2011. SAB have implemented some groundbreaking innovations in water purification and waste reduction. Forty staff members attended the open day and were shown various aspects of the beer-making and bottling process.

40-Year Celebration Conference

In an effort to enhance sector awareness of the scope of WRC research and impact, and in line with its communication strategy, the WRC decided to host a conference capitalising on the fact that the organisation celebrated its 40th year of existence in 2011. The WRC celebrated '40 Years of Excellence' with a technical conference held on 31 August and 1 September 2011 at Emperors Palace, Johannesburg. The conference attracted 397 delegates, and over 130 expert scientists presented and co-authored papers which reflected on existing research knowledge and knowledge gaps particularly related to the following themes:

- Water security in a water-scarce country
- Sustainability of the water ecosystem and energy nexus
- Water quality
- Water-use efficiency (water demand/water conservation)
- Water technology

The event showcased the significant contribution of the WRC and its researchers to knowledge over the past 40 years. During the event, the 40-year celebration book, *WRC – 40 Years of Excellence*, was launched. The book highlights the impact of the WRC over the past four decades. A special edition of *Water SA* was published (Vol. 37 No. 5) with peer-reviewed papers which emanated from the proceedings of the 40-year conference.

CONTACT PERSONS

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

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CATALOGUE OF AVAILABLE TT REPORTS

The Water Sector Institutional Landscape by 2025

Marius Claassen, Nikki Funke and Shanna Nienaber

The Water Research Commission initiated the research project to build knowledge about key drivers and uncertainties related to the future of the South African water sector institutional landscape. The focus was on water resource management in the country, with relevance also to the water services sector. The institutional landscape referred to the context in which water institutions would operate in the future, rather than different operational models or configurations for water institutions.

TT 514/11

ISBN: 9781431202027

Overseas price: \$15.00

Synthesis Report

**Barbara Schreiner, Shingirai Chimuti, Adelaide Cupido,
Marcia Gouws and Vandudzai Mbanda**

The effective regulation of the water sector is an increasingly critical focus of the work of the Department of Water Affairs. While the water services regulatory strategy has been fully developed, a comprehensive regulatory strategy for water resources management is still required - one that focuses on the overall regulation of water resources as a critical part of water resources management.

TT 497/11

ISBN: 9781431201396

Overseas price: \$30.00

Water Quality Data and Information: A Communicator's Manual

**Kevin Murray, James Michael Dabrowski, Martella du Preez,
Mamogala Kadiaka, Wilma Strydom**

This project arose out of a perceived need to provide recommendations for the way in which data and information relating to water quality can best be communicated to various target audiences. Improving this communication allows the full value to be realised of the generally considerable investment in data acquisition. The project products are a user's manual and a separate report describing the research methodology. The manual is aimed primarily at people responsible for communicating water quality information in both the public and private sectors.

TT 394/11

ISBN: 9781431202492

Overseas price: \$35.00

Guideline for the accreditation of routine aquatic toxicity testing laboratories

Alétia Ann Chapman, Elizabeth Annette Venter, Hesmarie Pearson

The aims of this project were:

- To compile a quality assurance manual to guide South African aquatic toxicity testing laboratories;
- To develop an implementation plan for DWAF for routine toxicity testing; and
- To develop a guideline to promote a sustainable network between toxicity testing laboratories.

TT 504/11

ISBN: 9781431201693

Overseas price: \$30.00

Integrated Water Quality Management: a mindset change

Lee Ann Boyd, Robyn Lesley Tompkins, Daveshini Padayachee, Oliver Obakeng Maletle, Ralph Gregory Melville Heath

This work streamlined, tested and assessed a new and practical approach to Integrated Water Quality Management (IWQM) which reduces management to relatively small and well-defined management units and establishes a vertical and horizontal reporting framework. Simple measures of compliance (yes or no) to targets are communicated between neighbouring management units. Accountability was therefore localised and explicit. The general receptiveness of many stakeholders and the effectiveness of the core model were evident.

TT 501/11

ISBN: 9781431201549

Overseas price: \$50.00

The long-term impact of acacia mearnsii trees on evaporation, streamflow and groundwater resources

Clulow Alistair David, Everson Colin Stuart and Gush Mark Baudert

The Two Streams catchment experiments have been used over the last nine years to study the impact of trees on hydrological processes. Burger (1999), for example, estimated total evaporation using the Bowen ratio energy balance method and showed that annual total evaporation exceeded annual rainfall when measured over *Acacia mearnsii* at Two Streams during the exponential growth phase.

TT 505/11

ISBN: 9781431200203

Overseas price: \$40.00

Water Resources of South Africa, 2005 Study (Wr2005) - 2011 Update: Executive Summary (version 2, 2011)

Bailey Allan

The enhancements to the WR2005 system entailed using the information from existing WR2005 calibrations to patch and calibrate streamflows for all 19 water management areas (WMAs). Problem areas with the data in all the streamflow datafiles were captured so that the users will have more confidence in accepting patched streamflow data as opposed to re-doing calibrations to gain sufficient confidence. Consequently streamflow records were assigned a good, average or poor rating.

TT 512/11

ISBN: 9781431201983

Overseas price: \$30.00

Water Resources of South Africa, 2005 Study (Wr2005): User's Guide (Version 2, November 2011)

Bailey Allan Keith

The enhancements to the WR2005 system entailed using the information from existing WR2005 calibrations to patch and calibrate streamflows for all 19 water management areas (WMAs). Problem areas with the data in all the streamflow datafiles were captured so that the users will have more confidence in accepting patched streamflow data as opposed to re-doing calibrations to gain sufficient confidence. Consequently streamflow records were assigned a good, average or poor rating.

TT 513/11

ISBN: 9781431201990

Overseas price: \$40.00

ATLAS of Freshwater Ecosystem Priority Areas in South Africa

JL Nel, AL Driver, WF Strydom, A Maherry, C Petersen, L Hill, DJ Roux, S Nienaber, H van Deventer, E Swartz, LB Smith-Adao

The National Freshwater Ecosystem Priority Areas (NFEPAs) project was a multi-partner project between the Council for Scientific and Industrial Research (CSIR), South African National Biodiversity Institute (SANBI), Water Research Commission (WRC), Department of Water Affairs (DWA), Department of Environmental Affairs (DEA), Worldwide Fund for Nature (WWF), South African Institute for Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks).

TT 500/11

ISBN: 9781431201464

Overseas price: \$70.00

Biology and ecology of the Orange-Vaal large and smallmouth yellowfishes in the Vaal River

Gordon O'Brien

Large and small yellowfish are flagship in the Orange-Vaal system, which provide a reliable biological indicator of the state of the river. Knowledge of their requirements will benefit the management of the river and the species.

TT 508/08

ISBN: 9781431201655

Overseas price: \$30.00

A framework for the classification of drainage networks in Savanna landscapes

Carola Cullum and Kevin Rogers

The character and behaviour of rivers depends on the nature of their catchment. Hillslopes and channels are generally studied separately. A holistic approach is needed. Landscape patterns of water, soil, vegetation and topography are not easy to disentangle, but in semi-arid environments the distribution of vegetation and soils often occur in patterns that are both cause and consequence of topographically controlled water fluxes. A hierarchical framework, based on an integration of aquatic and terrestrial perspectives, was developed to facilitate the synthesis of knowledge across many disciplines focusing on spatial and temporal scales relevant to conservation management (10^1 - 10^3 km² and seasons to decades).

TT 498/11

ISBN: 9781431201662

Overseas price: \$40.00

Sustainable Use of South Africa's Inland Waters

King JM and Pienaar HH (Editors)

Opportunities and challenges in relation to methods and implementation of the Reserve in South Africa are identified. Issues relating to the background and implementation of the Reserve (Ecological and Basic Human Reserves) are discussed. The book offers ideas for the way forward, to resolve the challenges for South Africa. Dr Jackie King and Mr Harrison Pienaar are the editors of the book.

TT 491/11

ISBN: 9781431201297

Overseas price: \$70.00

Volume 5: What we and our children need to know: health and hygiene awareness

Professor Natasha Potgieter

This guideline document presents the fifth in a five volume series aimed at addressing the question of how best South Africans can protect themselves from water-related microbial diseases. It provides practical guidelines and awareness of hygiene and sanitation practices at the household level from the point of view of the family and the range of actions which the family members need to undertake in order to protect themselves from infectious and emerging diseases. If every member in the family understands how to prevent infections through proper hygiene practices and improve hygiene behaviour, the transmission of diseases will be eliminated and healthier life styles will be achieved. Several sources worldwide have been used in the preparation of this guideline document. Other aspects (and actions) related to action to promote hygiene are also included.

TT 460/11

ISBN: 9781431201440

Overseas price: \$30.00

Guidelines on Water Services Infrastructure Risks Management

Unathi Jack, Philip de Souza and Grant Mackintosh

Despite the availability of numerous asset management texts, a general current lack of effective asset management (and associated water service delivery) still exists at many WSIs. A need therefore exists to further support WSIs through provision of simple, easy to use guidelines and associated tools which enables WSIs to initiate asset management good practice at their institutions.

TT 507/11

ISBN: 9781431202058

Overseas price: \$40.00

Ferrocement Reservoirs – A South African Perspective

David Still, Andrew Butler

Ferrocement is the name given to a composite material made from a high-strength mortar cement mix reinforced with steel mesh and wire. It is distinct from reinforced concrete. Since the early 90s several hundred ferrocement reservoirs in the size range 5k to 220k have been built in South Africa. The largest ferrocement reservoirs built to date in South Africa were two 450k tanks built at Osindisweni, some 20 kilometres west of Verulam. Large ferrocement reservoirs have therefore been in use in South Africa for up to 20 years. Based as they are on a thin shell design they are cheaper to build than standard reinforced concrete. What most engineers want to know, however, is whether they can be trusted to stand up in the long term.

TT 499/11
ISBN: 9781431201426
Overseas price: \$00.00

Introduction to integrated water meter management

Jacobus Ernst van Zyl

There is currently a lack of proper water meter management in South Africa, with many bulk water suppliers and municipalities without optimal and integrated meter calibration, replacement, reading, and information management systems. Often the divided responsibility between billing and meter management results in poor billing, incorrect information capture, and poor maintenance. This is further compounded by the fact that where initiatives of water demand management and conservation are required, the data is not easily accessible to the departments responsible for this task, and the frequent lack of integration between domestic and bulk water metering. It was envisaged that this project will provide clear and practical guidance on the operating principles of water meters, and the way they should be managed in a water services institution.

TT 490/11
ISBN: 9781431201174
Overseas price: \$60.00

Mine-water Research Impact Assessment

Frost and Sullivan

The WRC provides leadership for research and development through the support of knowledge creation, transfer and application. It engages 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. To this end,

research projects in the whole of the water field are funded at a large number of institutions, utilising funding from levies on national water sales. In achieving this mission, the WRC faces many challenges. These challenges include the creation of appropriate new water-centered knowledge, its dissemination and application, building knowledge networks and building the knowledge base by building capacity.

TT 486/11
ISBN: 9781431201150
Overseas price: \$40.00

Incentivising Young Social Science Perspectives in the SADC Water Sector

Inga Mary-Jo Jacobs and Shanna Nienaber

The project's main research questions as perceived by young professionals in the water sector are articulated as the main challenges facing the water sector in Southern Africa in a period of emerging global change. Traditionally, technical and scientific communities have been called on to produce the responses and solutions to previous sectoral challenges. However, new and emerging challenges and complexities, such as climate change, eutrophication, acid mine drainage, skills flight and social inequality, are demanding more integrated levels of ingenuity and expertise from a diverse set of disciplines. Given this realisation, there is growing recognition of the need for more transdisciplinary responses to the challenges facing the water sector. But there are still very few social scientists working on water issues, there are few truly transdisciplinary research initiatives being pursued, and the challenge of creating the space for scientists, Government officials and other stakeholders to work together around common areas of concern, remains difficult. Additionally, young social scientists are often unaware of how their skills can be applied, and indeed, are needed in the sector.

TT 487/11
ISBN: 9781431201044
Overseas price: \$35.00

A gap analysis of water testing laboratories in South Africa

Faye Balfour, Hanlie Badenhorst and Debbie Trollip

There are a limited number of laboratories that undertake water quality testing in South Africa. More significantly, many of these laboratories have capacity limitations. These laboratories are a critical link in the value chain that ensures safe drinking water for consumers and unpolluted water in our water resources. Until recently there has been little focus on the quality control of the laboratories utilised in the testing of water. This has resulted in municipalities and the Department of Water Affairs (DWA) using both centres of excellence and those with little evidence of being able to produce reliable results. However, the most startling issue is that although the problem was acknowledged within the sector, it could not be quantified. How many laboratories are there? Where are they? What quality control measures do they have in place? Do they have suitably qualified staff? This WRC project has begun the process of quantifying these gaps in the sector. This project developed a database of existing laboratories that undertake water quality testing and, through survey, obtained information on their capability and credibility. Nearly 200 laboratories were identified and 50% of these completed the survey.

TT 488/11
ISBN: 9781431201051
Overseas price: \$30.00

Wastewater Risk Abatement Plan – W2RAP

Marlene van der Merwe-Botha and Leonardo Manus

In South Africa, current problems associated with the operation, maintenance and management of wastewater treatment works are the biggest contributor to risks threatening public health and environmental integrity. Given that it is possible to produce treated wastewater of almost any quality, managing the associated risks is essential for good governance and long-term sustainability of the country's water resources.

W2RAP draws on many of the principles and concepts from other risk management approaches, in particular the Water Safety Plan, the multi-barrier approach and Hazard Analysis and Critical Control Points (HACCP). The W2RAP guideline is however, amongst the first worldwide initiatives that plans for and applies a risk-based approach to raise and sustain wastewater performance. The formulation of this guideline document builds on existing good practice in outlining a systematic and transparent approach to ensure consistent compliance and good practice to rendering wastewater services (reticulation, treatment and scientific services) along the value chain. Emphasis is on wastewater planning and management, not on testing, with documentation and communication being a key component of the process.

TT 489/11
ISBN: 9781431201167
Overseas price: \$40.00

Cleaner Production: A Guidance Document for the Mining Industry in South Africa

Susan Barclay, Graham Trusler, Harro von Blottnitz, Christopher Andrew Buckley, Bas Kothuis, Claire Janisch

This project introduced Cleaner Production (CP) technologies to the mining industry by using a number of CP tools. A scoping

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

TT 485/11

ISBN: 978431200979

Overseas price: \$35.00

Water-related research projects in Agriculture undertaken in South Africa

David Winter and Kudzanayi Bangure

The Water Research Commission (hereafter referred to as WRC) is a statutory organisation established in 1971 by an Act of Parliament. The organisation represents a dynamic hub for water-centred knowledge, innovation and intellectual capital. The WRC provides leadership for water-related research and development through the support of knowledge creation, transfer and application.

The WRC is also a networking organisation, linking researchers in South Africa and internationally. In order to build a water-related knowledge base, the WRC invests amongst others in water research and development, forms strategic partnerships and makes best use of nationally and globally available information.

One focus area for the WRC is the Key Strategic Area (KSA) Water Utilisation in Agriculture, which concentrates on increasing the efficient use of water for production of food, fibre, fuelwood and timber; ensuring sustainable water resource use; reducing poverty and increasing wealth of people dependent on water-based agriculture.

TT 503/11

ISBN: 9781431201587

Overseas price: \$35.00

Participatory development of provincial aquaculture programmes

Qurban Rouhani and Peter Jacobus Britz

The challenge for South Africa is how to provide Government support for sector development that addresses the needs of aquaculture enterprise development, both large- and small-scale. Aquaculture cannot be entirely private sector-driven as the transaction costs of pioneer farmers are too high and there are barriers they cannot overcome, such as access to suitably zoned land and water. On the other hand, the experience of South Africa's provincial hatcheries shows that Government, without private sector participation, is a poor driver of sector development. Thus the organisational challenge is to create a structure(s) whereby Government sets the development policy agenda and offers various forms of support and the private sector drives the actual production and market-related aspects of project implementation through vehicles such as PPPs, or special purpose vehicles which are market-driven and independent of the bureaucratic constraints of the PDAs.

TT 502/11

ISBN: 9781431201556

Overseas price: \$45.00

Water Harvesting and Conservation - Volume 2 part 4: Facilitation and Assessment Guide for the Facilitation Manual

**Jonathan Denison, Heidi Smulders, Erna Kruger, Hlubi Ndingi,
Marius Botha**

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a 'training of trainers' framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers) 2) facilitators at training organisations 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) A Technical Module covering water, soils and WH&C methods 2) A Facilitation Module covering facilitation techniques within a Participatory Innovation Development approach 3) A set of Farmer's Handouts with illustrated steps on how to implement the methods. Each of the technical and facilitation modules comprised two volumes. There is a detailed, annotated and illustrated manual for learners, and a Facilitation and Assessment Guide for course facilitators. These are set at the level of NQF 5 on the (new) 10-tier scale. The set of farmers handouts are designed for people with low literacy and are illustrated 'how-to' instructions for the water harvesting and conservation methods. The materials were developed in close consultation with key stakeholders to ensure relevance of materials to likely organisations of learning, and to end-user needs. The draft materials were successfully piloted in a formal learning environment and were reviewed by seven agricultural colleges.

TT 496/11
ISBN: 9781431201341
Overseas price: \$35.00

Water Harvesting and Conservation – Volume 2 Part 3: Facilitation Manual

**Jonathan Denison, Heidi Smulders, Erna Kruger, Hlubi Ndingi,
Marius Botha**

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a 'training of trainers' framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers) 2) facilitators at training organisations 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) A Technical Module covering water, soils and WH&C methods 2) A Facilitation Module covering facilitation techniques within a Participatory Innovation Development approach 3) A set of Farmer's Handouts with illustrated steps on how to implement the methods. Each of the technical and facilitation modules comprised two volumes. There is a detailed, annotated and illustrated manual for learners, and a Facilitation and Assessment Guide for course facilitators. These are set at the level of NQF 5 on the (new) 10-tier scale. The set of farmers handouts are designed for people with low literacy and are illustrated 'how-to' instructions for the water harvesting and conservation methods. The materials were developed in close consultation with key stakeholders to ensure relevance of materials to likely organisations of learning, and to end-user needs. The draft materials were successfully piloted in a formal learning environment and were reviewed by seven agricultural colleges

TT 495/11
ISBN: 9781431201334
Overseas price: \$35.00

Water Harvesting and Conservation – Volume 2 Part 2: Facilitation and Assessment Guide for the Technical Manual

**Jonathan Denison, Heidi Smulders, Erna Kruger, Hlubi Ndingi,
Marius Botha**

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a ‘training of trainers’ framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers) 2) facilitators at training organisations 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) A Technical Module covering water, soils and WH&C methods 2) A Facilitation Module covering facilitation techniques within a Participatory Innovation Development approach 3) A set of Farmer’s Handouts with illustrated steps on how to implement the methods. Each of the technical and facilitation modules comprised two volumes. There is a detailed, annotated and illustrated manual for learners, and a Facilitation and Assessment Guide for course facilitators. These are set at the level of NQF 5 on the (new) 10-tier scale. The set of farmers handouts are designed for people with low literacy and are illustrated ‘how-to’ instructions for the water harvesting and conservation methods. The materials were developed in close consultation with key stakeholders to ensure relevance of materials to likely organisations of learning, and to end-user needs. The draft materials were successfully piloted in a formal learning environment and were reviewed by seven agricultural colleges.

TT 494/11
ISBN: 9781431201327
Overseas price: \$35.00

Water Harvesting and Conservation – Volume 2 Part 1: Technical Manual and Farmer Handouts

**Jonathan Denison, Heidi Smulders, Erna Kruger, Hlubi Ndingi,
Marius Botha**

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a ‘training of trainers’ framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers) 2) facilitators at training organisations 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) A Technical Module covering water, soils and WH&C methods 2) A Facilitation Module covering facilitation techniques within a Participatory Innovation Development approach 3) A set of Farmer’s Handouts with illustrated steps on how to implement the methods.

TT 493/11
ISBN: 9781431201310
Overseas price: \$40.00

Water Harvesting and Conservation – Volume 1: Development of a comprehensive learning package

**Jonathan Denison, Heidi Smulders, Erna Kruger, Tim
Houghton, Marius Botha**

The comprehensive learning package for water harvesting and conservation (WH&C) was developed within a ‘training of trainers’ framework targeting three user groups: 1) learners at training organisations (who will later work with gardeners and farmers) 2) facilitators at training organisations 3) resource-poor gardeners and farmers. The learning package comprises three main parts: 1) A Technical Module covering water, soils and WH&C methods 2) A Facilitation Module covering facilitation techniques within a Participatory Innovation Development approach 3) A set of Farmer’s Handouts with illustrated steps on how to implement

the methods. Each of the technical and facilitation modules comprised two volumes. There is a detailed, annotated and illustrated manual for learners, and a Facilitation and Assessment Guide for course facilitators. These are set at the level of NQF 5 on the (new) 10-tier scale. The set of farmers handouts are designed for people with low literacy and are illustrated 'how-to' instructions for the water harvesting and conservation methods. The materials were developed in close consultation with key stakeholders to ensure relevance of materials to likely organisations of learning, and to end-user needs. The draft materials were successfully piloted in a formal learning environment and were reviewed by seven agricultural colleges.

TT 492/11

ISBN: 9781431201303

Overseas price: \$40.00

Sustainable Use of Greywater – Guidance Report

Nicola Rodda, Kirsty Carden and Neil Armitage

This project was undertaken to provide guidance regarding the conditions under which greywater use should be allowed or propagated and to provide guidance to users about its sustainable use in small-scale agriculture and gardens. Two main products were produced, viz a user-friendly Guidance Document and a supporting Technical Background Document which captures the technical information on which the Guidance Document is based and describes the extensive process that was followed to develop the Guidance Document. The Guidance Document is aimed at Municipalities, NGOs and informed members of the public who wish to implement greywater irrigation. The focus of the Guidance Document is to minimise the risks of:

- illness in handlers of greywater and greywater-irrigated produce, or consumers of greywater-irrigated produce.
- reduction in growth or yield of plants/crops irrigated with greywater.

- environmental degradation, especially reduction in the ability of soil irrigated with greywater to support plant growth.

TT 469/11

ISBN: 9781431200917

Overseas price: \$30.00

Agricultural water use in homestead gardening systems

Christiaan Matthys Stimie, Marna de Lange, Charles Terrence Crosby and Erna Kruger

The overall objective of this project was to improve food security through homestead gardening, by developing and evaluating the appropriateness and acceptability of training material for agricultural water use, training of household members in selected areas. Particular attention was given to the development of the 800-page resource material for facilitators and food gardeners on "Agricultural use in Agricultural water use in homestead gardening systems.

TT 431/10

ISBN: 9781770059184

Overseas price: \$60.00

Agricultural water use in homestead gardening systems

Christiaan Matthys Stimie, Marna de Lange, Charles Terrence Crosby and Erna Kruger

The overall objective of this project was to improve food security through homestead gardening, by developing and evaluating the appropriateness and acceptability of training material for agricultural water use, training the trainers and training of household members in selected areas. Particular attention was given to the development of the 800-page resource material

for facilitators and food gardeners on "Agricultural Water Use in Homestead Gardening Systems". The development of the resource material followed a participatory approach and was field tested and refined with the assistance of food secure and insecure households in rural villages. The resource material succeeded in drawing widely from local and international materials and experience. Its usefulness in practice has been substantiated by facilitators who were not part of its development. It is anticipated that a variety of stakeholders will draw on this resource material to develop course material for their own purposes. A significant demand for the material exists from universities and agricultural colleges that are aware of the material.

Best management practices for smallholder farming on two irrigation schemes.

TT 430/09

ISBN: 9781770059177

Overseas price: \$40.00

Manual for rural freshwater aquaculture

Qurban Rouhani, Niall, Nicholas James and John Case

In 2004, the Rural Fisheries Programme of the Department of Ichthyology and Fisheries Science, Rhodes University completed a project on behalf of the Water Research Commission (WRC) to assess the contributions of rural aquaculture to livelihoods. It became apparent that although the current contributions were low, the potential was significant. To exploit this potential, Project K5/1580//4 was targeted solicited by the WRC in 2005 and is co-funded by the Department of Agriculture, Forestry and Fisheries (DAFF).

This project was formulated to address a number of issues, such as developing provincial aquaculture strategic plans, revitalising state hatcheries, training of extension officers and the

development of a manual to complement the training. An inclusive process to develop an aquaculture training manual for extension officers was followed. The provincial Departments of Agriculture made inputs on the content and structure of the manual and drafts were then sent to DAFF and other stakeholders for review and comments. It is envisaged that this manual will continue to be modified and reviewed as aquaculture in South Africa grows in order to reflect the needs of the extension officers over time. The manual is not only intended for the training of extension officers, but is also resource material to be used in the field when interacting with farmers.

The manual consists of 13 chapters with information and supportive illustrations on introduction to aquaculture; fish biology; aquaculture species; types of fish-farm: ponds, cages and tank systems; water quality; production and shipping; feeds and feeding; harvesting; fish health and diseases; fish husbandry; cage culture; increasing production; and business and financial planning.

TT 463/P/10

ISBN:9781770059924

Overseas price: \$28.00

Pearson Nyari Stephano Mnkeni; Cornelius Chiduzo; Albert Thembinkosi Modi; Joseph Benjamin Stevens; Nomakaya Monde; Isobel van der Stoep and Richard Dladla

The project was a collaborative undertaking by five organisations namely: the Universities of Fort Hare, KwaZulu-Natal, Zululand (which withdrew in 2006), and Pretoria, as well as Zakhe Agricultural Training Institute. It was conducted in the form of two case studies based in Zanyokwe Irrigation Scheme (ZIS) which uses sprinkler irrigation and Tugela Ferry Irrigation Scheme (TFIS) which uses a short-furrow irrigation system. Its main objective was to carry out research in Zanyokwe and Tugela Ferry irrigation schemes with a view to develop and implement technologies and knowledge useful for farmers in order to improve their livelihoods and those of surrounding communities.

Participatory research methodologies were employed where the smallholder farmers and other stakeholders were involved in project activities. Important agronomic and socio-economic (including organisational and institutional arrangements) constraints to crop production on the two schemes were identified and action was taken together with the farmers to address the problem. The need for training of extension staff in irrigation management in order to better support farmers was highlighted.

TT 478/10

ISBN: 9781431200498

Overseas price: \$40.00

Estuaries, Economics and Freshwater: An introduction

Duncan Hay, Stephen Hosking and Margaret Mckenzie

People are attracted to and value estuaries. They are much more than important ecosystems. They are also important social and economic systems – they play an important part in the lives of thousands of people living along our coast and inland.

TT 470/10

ISBN:9781431200023

Overseas price: \$15.00

Guidelines for improved efficiency of irrigation water use Volume 3

Felix Britz Reinders

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

- Efficiency refers to the state of a water balance for a defined spatial and temporal area rather than to the value of a performance indicator; and

- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

TT 467/10

ISBN:9781431200245

Overseas price: \$40.00

Guidelines for improved efficiency of irrigation water use Volume 2 of 3

Felix Britz Reinders

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

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

TT 466/10

ISBN: 9781431200238

Overseas price: \$40.00

Guidelines for improved efficiency of irrigation water use Volume 1 of 3

Felix Britz Reinders

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

- Efficiency refers to the state of a water balance for a defined

spatial and temporal area rather than to the value of a performance indicator; and

- Improved efficiency is achieved through a process of assessment and targeted actions, rather than general practices.

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of “measure; assess; improve; evaluate”. It promotes an investigative approach to improving efficiency, rather than relying only on water accounting.

TT 465/10

ISBN: 9781770050221

Overseas price: \$30.00

Process design manual for small wastewater works

David Joseph Nozaic and Susan Delia Freese

‘A Guide to the Design of Sewage Purification Works’ was first published in 1973 by the then Southern African Branch of the Institute for Water Pollution Control (IWPC) and over the years this useful reference document has become known as the ‘Black Book’. This guide was revised and republished in 1987 and was intended to be less of a guide to design, and more of a manual to assist firstly designers, and secondly engineers and/or chemists who may be required to approve the designs for smaller domestic sewage works treating up to 5 Ml/d. Since publication of the revised edition of the Manual for Design of Small Sewage Treatment Works in 1987, no further revision has been carried out, despite that fact that since then there have been a number of new technologies introduced into wastewater.

TT 389/09

ISBN: 9781770058262

Overseas price: \$45.00

Guide for management of waste stabilisation pond systems in South Africa

Philip de Souza, Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in the Eastern Cape and Free State.

TT 471/10

ISBN: 9781431200344

Overseas price: \$25.00

Guide for operations and maintenance of a waste stabilisation pond system

Philip de Souza, Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in the Eastern Cape and Free

State. The Free State and Eastern Cape systems assessed are within the Upper Orange-Vaal catchment area. There are a few other systems assessed in the Eastern Cape that do not fall under this catchment area.

TT 472/10

ISBN: 9781431200351

Overseas price: \$25.00

Manual for using electronic water quality management system (eWQMS) and waste-stabilisation ponds assessment tool

Philip de Souza, Unathi Jack

The waste stabilisation ponds of the Free State have generally performed well for many years, effectively preventing environmental pollution and associated health impacts. Nevertheless, concerns were raised as to the current operational state of waste-stabilisation ponds of the Free State and their impact on both the natural environment and human health. Considering the above, a preliminary study of waste stabilisation ponds was initiated by the Free State DWAF office. Based on these findings, the Water Research Commission (WRC) decided to extend the study by conducting an in-depth study of selected waste stabilisation ponds systems in the Eastern Cape and Free State. The Free State and Eastern Cape systems assessed are within the Upper Orange-Vaal catchment area. There are a few other systems assessed in the Eastern Cape that do not fall under this catchment area.

TT 473/10

ISBN: 9781431200368

Overseas price: \$25.00

Water-related microbial disease guidelines

Ian Bailey

Many studies on the effects of water development on human health over the past fifty years have been criticised as to their validity and usefulness. Lack of adequate control, poor project design, many confounding variables, cultural bias, health indicator recall, health indicator definition and failure to analyse by age have been cited as rendering study results meaningless. Eminent researchers in the field, such as Cairncross and Birley, are equally skeptical. While instinctively it is accepted that water and sanitation do improve health, there are many opinions as to how and why.

TT 429/10

ISBN: 9781770055216

Overseas price: \$30.00

Domestic water quality research impact assessment

Sostina Shiri, David Winter

The WRC provides leadership for water-related research and development through the support of knowledge creation, transfer and application. The WRC engages stakeholders and partners in solving a wide variety of water-related problems, which are critical to South Africa's sustainable development and economic growth.

TT 416/09

ISBN: 9781770058828

Overseas price: \$20.00

Development of a model for determining affordable and sustainable sanitation demand in dense settlements of South Africa

Richard Martin

The level and quality of the services that communities are to receive must be discussed with and accepted by the community members. Quite important are also the economic considerations of these principles, namely that services must be provided economically and efficiently in order to give citizens the maximum value for money. Experts have long noted the importance of determining the “effective demand” for services such as sanitation as expressed by the willingness of users to pay for these services. Too often the solutions proposed are inappropriate in terms of what the people want. As a result sanitary facilities are misused, badly maintained or even vandalised. If they are too expensive, the bills will not be paid which may give rise to the discontinuation of services and consequently to riots and/or violence. If the solutions do not meet the social norms, they will not be used. Finding the right solution is therefore fundamental in our quest for sustainability.

TT379/08

ISBN: 9781770058040

Overseas price: \$25.00

Towards standards for municipal invoices in SA

Sarah Slabbert

The domestic water accounts (or consolidated accounts) that municipalities send out to consumers on a monthly basis are a key interface between local Government and citizens. A municipal account is a unique one-on-one communication event between the municipality and the individual consumer (or customer) to whom the account is addressed. As such, municipal accounts offer a unique opportunity for municipalities

to inform, educate and influence their customers and to establish their communication as clear, accurate and customer friendly. The research assessed current South African and international regulation, guidelines and research relating to accounts/invoices/bills, with special reference to domestic water accounts. This was supported by a survey of current municipal account practices, as well as a critical analysis of a representative sample of domestic water (or consolidated) accounts.

TT 458/10

ISBN: 9781770059832

Overseas price: \$25.00

Guidelines on domestic water accounts – towards a consistent approach in the RSA

Sarah Slabbert, Carmel Joseph, Annerie Allers

The domestic water accounts (or consolidated accounts) that municipalities send out to consumers on a monthly basis are a key interface between local Government and citizens. A municipal account is a unique one-on-one communication event between the municipality and the individual consumer (or customer) to whom the account is addressed. As such, municipal accounts offer a unique opportunity for municipalities to inform, educate and influence their customers and to establish their communication as clear, accurate and customer friendly.

TT 457/10

ISBN: 9781770059825

Overseas price: \$30.00

“Going with the franchising flow”: An exploration of partnerships for the operation and maintenance of water services infrastructure

Kevin Wall, Oliver Ive

The rapid rate of construction and commissioning of new water services infrastructure is severely challenging the public sector institutions in South Africa responsible for operating and managing this infrastructure. Innovative approaches are required. But even if all the existing water services institutions were coping with the responsibility, there would be good reason to investigate alternative institutional models, on the grounds that it needs to be found out if alternatives could be more cost-effective, and/or could offer a range of other advantages (including greater local economic development).

TT 432/10

ISBN: 9781770059627

Overseas: \$25.00

Guidelines for facilitating Cooperative and Adaptive Management of Freshwater Ecosystems

Dirk Johannes Roux, Kevin Murray, Liesl Hill

Water resources management is characterised by complex problems, considerable uncertainties, limited predictability, the need for integration across disciplines, and the need for coordination and cooperation between agencies with overlapping mandates. There are multiple stakeholders and their expectations can be diverse and guided by different mental models based on different knowledge forms.

TT 404/10

ISBN: 9781770059788

Overseas price: \$15.00

Seaman MT, Avenant MF, Watson M, King J, Armour J, Barker CH, Dollar E, du Preez PH, Hughes DA, Rossouw L

The South African National Water Act, Act 36 of 1998, requires that the environmental reserve be determined for each significant water body before water-use licences may be issued. Methods currently available for the determination of environmental water requirements in South African rivers are based on perennial rivers and are seen to be needing verification for use on non-perennial rivers. This research programme began by identifying which existing methods, i.e. those being used on perennial rivers, might initially seem to be suitable for use and where further work needs to be done (see Rossouw et al., 2005). It then took this research a step further with an overarching objective to develop a prototype methodology for determining the environmental water requirements for non-perennial rivers. This would be based on field-based knowledge acquired during comprehensive research on a range of nonperennial system.

TT 459/10

ISBN: 9781431200115

Overseas price: \$40.00

The effects of stream flow manipulation on the invertebrate hosts of malaria, bilharzia and liver fluke disease

Leo Quayle, Chris Appleton and Chris Dickens

This report details the results of a desktop investigation into the relationship between regulated river flow, flow manipulation and the invertebrate hosts of malaria, bilharzia and liver fluke disease in South Africa. Literature review yielded several international case studies which informed the study, and together with expert input, all information was gathered and documented in order to understand the relationship and suggest possible flow manipulation mechanisms which may be used to control transmission of these diseases through control of their

invertebrate hosts. The possible effectiveness of these flow-related control mechanisms has also been assessed and the number of 'people at risk' who may benefit from flow-related control is estimated.

TT 456/10

ISBN: 9781770059801

Overseas price: \$30.00

Framework and manual for the evaluation of aquatic ecosystems services for the resource directed measures

AE Ginsburg, JG Crafford, KR Harris

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

TT 462/10

ISBN: 9781770059979

Overseas price: \$35.00

This Framework and Manual explores how these scenarios and their associated trade-offs should be evaluated

Water Quality Overview and Literature Review of the Ecology of the Olifants River

Ralph Heath, Trevor Coleman, Johan Engelbrecht

In the light of the ongoing water quality problems in the Olifants River, Mpumalanga, a review of water quality studies done on the system was commissioned to provide this information for other studies on this system. An overview of the economic activities in the catchment provides the background for the water quality problems to which the system is exposed. Resource Quality Studies, Dept. of Water Affairs, started monitoring the catchment in 1983 and have monitored a number of parameters in their routine monitoring programme. The review also covers water quality results from specific studies in the catchment.

TT 452/ 10

ISBN: 9781770059894

Overseas price: \$25.00

Public participation in the drafting of catchment management strategies made simple

Derick du Toit, Sharon Pollard

The focus of the document is to guide CMA personnel and others working on their behalf in the structuring of public engagement in the drafting and implementation of the CMS. The document is made up of simplified step by step guide. Each section is taken directly from the CMS guideline which is a national official document published by DWA in 2007 and each task is developed in terms of steps. The requisite level of public engagement is suggested on the left and the 'how' for each task is presented. There are 10 TASKS, each with step-by-step tables.

TT 455/10

ISBN: 9781770059795

Overseas price: \$35.00 (excl. postage)

Guidelines for improved efficiency of irrigation water use Volume 2 of 3

Felix Britz Reinders

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

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

The resulting approach that has been documented in the final report therefore still complies with the original proposed improvement process of “measure; assess; improve; evaluate”. It promotes an investigative approach to improving efficiency, rather than relying only on water accounting.

The main output of the project was the compilation of guidelines for improved irrigation water management from dam wall release to root zone application. The guidelines are aimed at assisting both water users and authorities to achieve a better understanding of how irrigation water management can be improved, thereby building human capacity, allowing targeted investments to be made with fewer social and environmental costs. Using lessons learnt during the WRC project, best practices and technologies were introduced and illustrated.

TT446/10

ISBN: 9781431200238

Overseas price: \$35.00 (excl. postage)

Integrated Management of Water Hyacinth in SA

Marcis Byrne, Martin Hill, Mark Robertson, Anthony King, Ashwini Jadhav, Naweji Katembo, John Wilson, Ryan Burdvig and Jolene Fisher

Water hyacinth, *Eichhornia crassipes* (Martius) Solms-Laubach (Pontederiaceae) is South Africa's most damaging floating aquatic weed. Despite notable successes with the biological control of other floating aquatic weeds, and a concerted biological control effort against water hyacinth, its populations continue to reach newsworthy proportions on major rivers and dams. Hill and Olckers (2001) ascribed the variable success of the biological control programme on water hyacinth in South Africa to variable climatic conditions, eutrophication of aquatic ecosystems, interference from integrated control operations, the hydrology of infested systems and techniques for establishing biological control agents. The research presented in this report addresses the effect of temperature and nutrients on the growth of water hyacinth and some of its biological control agents and investigates the interaction of herbicide application with biological control. This has been done in light of discovering a sublethal dose of herbicide which will retain water hyacinth plants in a system to maintain populations of the agents. In addition, a management plan has been developed to guide water managers as what action should be taken in terms of combining biological control with herbicidal control under different climatic and nutrient conditions.

TT 454/10

ISBN: 9781770059757

Overseas price: \$35.00 (excl. postage)

Ecohydraulics for South African Rivers: A Review and Guide

James C.S. and King J.M. (Editors)

This project was aimed at synthesising existing knowledge on ecohydraulics in South Africa and then packaging it in the form of a Review and Guide document. The Guide provides theories and techniques related to ecohydraulics as well as the ecological context and perspective for the application of ecohydraulics. Thus building capacity amongst engineers and ecologists and contributing towards the effective management of our aquatic environment. The Guide will also provide an overview of the current state of ecohydraulics research in South Africa, serving as a useful point of reference for identifying and prioritising future research needs for ecohydraulics in South Africa.

It is of importance to note that the techniques and theory presented in this document deal exclusively with ecology and ecohydraulics within a river context, with the intention that environmental hydraulics in its broader sense, which typically include biological and chemical aspects in lakes, estuaries and wetlands, will be addressed in subsequent research projects. Furthermore, it is necessary to point out that the hydraulic theory that is presented in this document assumes that the user of this Guide will have a graduate level of understanding of river hydraulics. However, the content is presented in such a way as to ensure that water resource practitioners and managers as well as researchers across a wide spectrum of disciplines, should find the document informative and useful.

TT 453/10

ISBN: 9781770059603

Overseas price: \$35.00

Application of Ecological informatics Modelling Techniques for predicting harmful Algal Blooms

Carin Elizabeth van Ginkel, Sandra du Plessis, Johannes Jacobus Bezuidenhout

The study showed that eutrophication and the associated problems is a real threat to South African fresh water resources but that modelling methods can assist in managing the problem. The list of recommendations needs to be taken further by a number of stakeholders, e.g. the Department of Water Affairs, future CMAs, Universities and other researchers in order to:

- a) Determine the necessary variables and monitor these for future modelling exercises.
- b) Include total microcystin monitoring in impacted fresh water resources at least during the summer periods to enable resource managers to issue warnings to all potential impacted stateholders.
- c) Initiate and test available management options to minimise serious eutrophication levels in South Africa.
- d) Manage the risk imposed by the cyanobacterial blooms and the associated toxins produced in the water resources, on drinking water facilities and the health of recreational users.
- e) Develop short-term forecasting tools, for the algal blooms of Microcystis and Ceratium, with on-line water quality monitoring for early-warning and real-time forecasting for reservoir managers.
- f) Investigated the cause and effects for changing composition of the phytoplankton of these five reservoirs.
- g) Monitor at different depths to determine the best depth for abstraction for treatment purposes.

The successful use of the hybrid Evolutionary Algorithm Method to develop predictive tools for algal blooms indicated the necessity to develop capacity (both human and equipment) in South Africa to use the Hybrid Evolutionary Algorithm (HEA) RULE set development in all research spheres, as the method is

applicable to any type of numerical data and can be applied to any research field.

TT451/10

ISBN: 9781770059535

Overseas price: \$35.00 (excl. postage)

Integrated water quality management: A new mindset

Lee Ann Boyd, Robyn Lesley Tompkins, Ralph Gregory Melville Heath

The conceptual model is based on the premise that good water quality is in everyone's best interests. This "Change of Mindset" IWQM management approach "breaks down" the management of water quality into smaller management units. At the same time, both the horizontal and the vertical reporting framework is established. This structure is aimed at addressing the problem of implementation of quality standards across the country, and also improving enforcement by reducing the volume of reports that should highlight problem areas and allow for prioritisation of regulatory or remedial action. A further benefit of the IWQM management framework is that responsibility for water quality is based on significantly smaller geographical areas, and accountability to the adjoining areas (horizontal accountability) and to the next level of management (vertical accountability) is established with the creation of the management unit. This allows accountability for water quality to be focused on smaller management units, rather than diffused upper higher levels of management.

Finally, the IWQM approach allows water quality information to be packaged for a broader audience, as reporting is simplified to provide information on whether or not a management unit is within the specifications of its critical control points (CCPs) or not; rather than extensive technical reports to national level through the management chain.

TT 450/10

ISBN: 9781770049529

Overseas price: \$35.00 (excl. postage)

Financial and economic feasibility of drainage

Robert Jack Armour and Machiel Frederick Viljoen

It was strongly suggested and agreed upon at a final Reference Group meeting for WRC project 1352, that the project team prepare a consultation proposal to meet with relevant stakeholders for technology transfer of the results produced in the project. This is due to the fact that this research successfully integrated and linked models and results from different disciplines (soil science, hydrology and agronomy) with economic models at micro (per hectare, sub-WUA and WUA) level and social welfare models at the regional level. This enabled the researchers to determine the long-term impact (cost and benefits) of different salinity management options and provided valuable information required for decision making at different levels.

In this regard the results show that for the different levels:

- Drainage installation and consequent leaching, is a better option financially, environmentally and socially than changing to more salt tolerant crops at farm, WUA and regional level;
- The project results clearly show that to reduce the risk of income loss due to irrigation salinity, drainage and leaching are necessary;
- At regional level the direct and indirect effects of modeled improved drainage (and subsequent investment in higher value crops) proved far greater than the costs of the drainage; produced the highest index for socio-economic welfare (ISEW); and an increase of employment in irrigation farming and related industries over the long term.

To reinforce the message of the technology transfer results to be presented, brochures will be handed out at the technology transfer meetings and a webpage will be introduced that will

include links to the relevant WRC reports, the user-friendly technology transfer report, and other updated and interesting salinity and drainage related information.

TT 448/09

ISBN: 9781770059511

Overseas price: \$35.00 (excl. postage)

Impact assessment of the water administration system

David Winter

Since 1985 the Water Research Commission has been working closely with the DWAF together with NB Systems in developing water management systems that simplify the task of managing canal water for irrigation purposes. This has resulted in the production of a broad range of research reports that have been focused on the development of the Water Administration System (WAS).

The WAS programme is designed to be a water management tool for irrigation schemes, Water User Associations (WUA's), Catchment Management Agencies (CMA's) and water management offices that need to manage their water usage, distribution and accounts. It is an integrated database-driven system with many water management capabilities that include handling any number of farmers, abstraction points and measuring stations on canal networks, pipelines and rivers. The system involves simplified and controlled ways of managing water allocations, use, distribution and billing.

The main objective for developing the WAS programme was to minimise water losses for irrigation schemes that work on the demand system and that distribute water through canal systems. The programme consists of seven modules that are integrated into a single programme that can be used on a single PC or multi-user environment. These seven modules can be implemented

partially or as a whole, depending on the requirements of a specific scheme or office.

TT 447/09

ISBN: 9781770059504

Overseas price: \$25.00 (excl. postage)

Assessing the impact of in-field rainwater harvesting and conservation research

James Nelson Blignaut and Xolani Rudolf Sibande

The Water Research Commission (WRC) has been supporting the Agricultural Research Council (ARC) at Glen near Bloemfontein and various other organisations over the past 15 years to conduct research and development for in-field rainwater harvesting (IFRWH) techniques and the dissemination of knowledge among the members of 42 villages surrounding Thaba Nchu. The WRC approached ASSET Research to conduct an investigation, using the McMaster University's research impact assessment tool, as to the uptake and impact of IFRWH in those villages.

TT 444/08

ISBN: 9781770059436

Overseas price: \$25.00 (excl. postage)

Wetland valuation volume IV: A protocol for the quantification and valuation of wetland ecosystem services

JK Turpie and M Kleynhans

VOLUME 11: WRC REPORT TT 443/09

WETLAND VALUATION VOLUME IV: A PROTOCOL FOR THE QUANTIFICATION AND VALUATION OF WETLAND ECOSYSTEM SERVICES

This study builds on three earlier volumes on wetland valuation

and includes a review of current understanding of wetland ecosystem services to provide a protocol for the quantification and valuation of wetland ecosystem services. The report is written for planners and decision-makers wishing to understand the purpose and potential for use of wetland valuation in a variety of decision-making contexts, and to guide them in the setting of terms of reference for specialist studies. In addition, the report aims to guide student and professional resource economists in their understanding of the purpose of and trade-offs in valuation studies, the choice of their detailed methodological approach and the role of biophysical specialists in wetland valuation. Although the report provides advice on how to achieve relatively rapid estimates of wetland values, it does not offer a shortcut tool for rapid valuation by non-professionals.

TT 443/09

ISBN: 9781770059351

Overseas price: \$30.00 (excl. postage)

Wetland valuation volume III: Assessment of the livelihood value of wetlands

JK Turpie

VOLUME 10: WRC REPORT TT 442/09
WETLAND VALUATION VOLUME III: A TOOL FOR THE
ASSESSMENT OF THE LIVELIHOOD VALUE OF WETLANDS

Millions of South Africans are directly dependent to some extent on natural systems to sustain their livelihoods, and wetlands are considered particularly valuable in terms of the variety and abundance of services they provide. Understanding the degree to which wetlands contribute to people's livelihoods may be vital in steering decisions that minimise negative impacts or enhance the benefits that wetlands have for communities, such as their contribution to household income. This study developed

a simple index for the assessment of a wetland's importance to people's livelihoods through understanding the level of dependence of surrounding communities on a wetland. The tool outlines the way in which the index parameters are estimated at a rapid, intermediate, or comprehensive level, depending on the budgetary constraints or the level of confidence required. Since the index produces a result which is in comparable units, the results can be used to assess the relative importance of a wetland compared to others in the catchment or even nationally, and to rank, or prioritise, different wetlands in terms of management priorities.

TT 442/09

ISBN: 9781770059344

Overseas price: \$30.00 (excl. postage)

Wetland valuation volume II: Case studies

JK Turpie

VOLUME 9: WRC REPORT TT 441/09
WETLAND VALUATION VOLUME II: WETLAND VALUATION
CASE STUDIES

This report, one of the outputs of the Wetland Health and Importance (WHI) research programme and one of four on the value of wetland ecosystems, documents five case studies selected to fill some important gaps in wetland valuation in South Africa, as well as to provide examples of studies carried out at different levels.

TT441/09

ISBN: 9781770059337

Overseas price: \$32.00 (excl. postage)

Wetland valuation volume I: Services and their valuation

Jk Turpie, K Lannas, N Scovronick and A Louw

VOLUME 8: WRC REPORT TT 440/09
WETLAND VALUATION VOLUME I: WETLAND ECOSYSTEM SERVICES AND THEIR VALUATION: A REVIEW OF CURRENT UNDERSTANDING AND PRACTICE

This report, one of the outputs of the Wetland Health and Importance (WHI) research programme and one of four on the value of wetland ecosystems, reviews the wetland valuation literature to ascertain how wetland valuation has been approached internationally, and how international and local experience can guide best practice for approaching wetland valuation in South Africa. Wetlands are recognised as being valuable ecosystems which provide water, food and raw materials, services such as flood attenuation and water purification, and intangible values such as cultural and religious value. Despite this, and legislation to protect them, they are increasingly threatened, with more than half the world's wetlands having been lost already. Wetlands may be degraded due to market failure (where markets do not reflect true values or costs) and Government failure (perverse incentives, lack of well-defined property rights leading to open access and ignorance of decision-makers as to the value of wetlands). Economic valuation helps to compare the real costs and benefits of ecosystem use and degradation, and allows more balanced decision-making regarding the protection and restoration versus degradation of wetlands.

TT 440/09
ISBN: 9781770059320
Overseas price: \$30.00 (excl. postage)

Assessment of two wetlands in the Kamiesberg uplands

Donovan Charles Kotze, Heather Louise Malan, William Nolan Ellery, I Samuels and L Saul

VOLUME 7: WRC REPORT TT 439/09
ASSESSMENT OF THE ENVIRONMENTAL CONDITION, ECOSYSTEM SERVICE PROVISION AND SUSTAINABILITY OF USE OF TWO WETLANDS IN THE KAMIESBERG UPLANDS

There is a long history of use of the wetlands in the Kamiesberg area. Even for the present generation they represent an important resource to a community that is relatively poor.

This study, a joint initiative between the WRC-funded Wetland Health and Importance Research group and the Agricultural Research Council (ARC): Range and Forage Unit, reports on an investigation of the geomorphology, vegetation and utilisation by humans, of two wetlands (Langvlei and the Ramkamp) which are situated just outside of Leliefontein in the Kamiesberg area of the Northern Cape. The historical settlement patterns and land-use in the area are described, and the information collected was used to establish the environmental condition of the wetlands, the ecosystem services they are likely to deliver and how sustainable the use of those systems is likely to be. Sustainability was assessed both from a sociological, and an ecological, point of view.

TT 439/09
ISBN: 9781770059313
Overseas price: \$30.00 (excl. postage)

Assessing the sustainability of wetland use

Donovan Charles Kotze

VOLUME 6: WRC REPORT TT 438/09
WET-SUSTAINABLE USE:

A system for assessing the sustainability of wetland use WET-SustainableUse has been developed to assess the ecological sustainability of wetland use, focusing on grazing of wetlands by livestock, cultivation of wetlands and harvesting of wetland plants for, for instance, crafts and thatching. WET-Sustainable Use asks to what extent the use of the wetland has altered the following five components of the wetland's environmental condition: (1) the distribution and retention of water, (2) the erosion of sediment, (3) the accumulation of soil organic matter (SOM), (4) the retention of nutrients and (5) the natural species composition of the vegetation in the wetland. WET-SustainableUse assists the user in answering these questions by providing a set of indicators for each of the five components, and a structured way of scoring these indicators and deriving an overall score for each component.

TT 438/09
ISBN: 9781770059306
Overseas price: \$30.00 (excl. postage)

Assessing cumulative impacts on wetlands at catchment scale

WN Ellery, S Grenfell, M Grenfell, C Jaganath, HL Malan and DC Kotze

VOLUME 5: WRC REPORT TT 437/09

A method for assessing cumulative impacts on wetland functions at the catchment or landscape scale. This volume, part of the series on Wetland Health and Importance, describes methods

which enable the assessment of the effects on wetland functionality of the cumulative impacts of human activities at a landscape scale. It uses two metrics - the land cover change impact metric and the loss of function metric to produce a functional effectiveness score that is translated to functional hectare equivalents. The land cover change is based on the recognition that wetland structure and function are fundamentally affected by the hydrological regime. The loss of function metric describes the relationship between the magnitude of impact and wetland functionality for a total of 6 ecosystem services: A) flood attenuation, B) stream flow regulation, C) sediment trapping, D) nitrogen removal, E) phosphate removal or F) toxicant removal. These metrics are based on limited field testing and need verification.

TT 437/09
ISBN: 9781770059290
Overseas price: \$30.00 (excl. postage)

Aquatic invertebrates - indicators of human impacts in SA wetlands assessment of temporary wetlands

M Bird

VOLUME 3: WRC REPORT TT 435/09

Aquatic invertebrates as indicators of human impacts in South African wetlands. The recent emphasis on wetland protection and management has created an urgent need to develop assessment tools to establish and monitor human impacts in wetland ecosystems so as to prioritise wetlands for conservation and rehabilitation actions and to monitor the effects of these actions. Biological assessment or "bioassessment" is one of the means of investigating wetland condition and involves the evaluation of a wetland's ability to support and maintain a balanced, adaptive community of organisms having a species composition, diversity and functional organisation comparable with that of minimally disturbed wetlands within a region. Potential indicator groups

for bioassessment purposes include macrophytes, algae and diatoms, aquatic invertebrates, birds and fish.

This volume describes the use of macro-invertebrates for the assessment of the condition of a wetland.

E Day, JA Day, V Ross-Gillespie and A Ketley

TT 435/10

ISBN: 9781770059276

Overseas price: \$30.00 (excl. postage)

VOLUME 2: WRC REPORT TT 434/09 THE ASSESSMENT OF TEMPORARY WETLANDS DURING DRY CONDITIONS

This volume, part of the series on Wetland Health and Importance, describes methods which enable the user to assess the condition of temporary wetlands when they are dry. In extreme cases, a seasonal wetland may not be obvious, and methods are provided to aid in the recognition of wetlands in such cases. The soils underlying most wetlands are exhibit characteristic colouration and this is described. Certain invertebrates, in particular Branchiopod crustaceans, characteristically inhabit this type of wetland and methods for the determination of the presence of these are described. In addition, certain plants are characteristic of this type of situation, and these are also described. However, no single indicator provides adequate information about wetland presence, type, hydroperiod, biodiversity, function and principle ecological and hydrological drivers. In extreme cases the most cryptic of wetlands may show none of the indicators.

TT 434/09

ISBN: 9781770059269

Overseas price: \$30.00 (excl. postage)

VOL 1: HANDBOOK TO THE WETLAND HEALTH AND IMPORTANCE RESEARCH PROGRAMME

E Day and HL Malan

VOLUME 1: WRC REPORT TT 433/09

TOOLS AND METRICS FOR ASSESSMENT OF WETLAND ENVIRONMENTAL CONDITION AND SOCIO-ECONOMIC IMPORTANCE: HANDBOOK TO THE WHI RESEARCH PROGRAMME

Volume 1 of this series, one of the outputs of the Wetland Health and Importance (WHI) research programme, distils the major findings of the different components of the project and their implications for future work in the management or assessment of wetland environmental condition and socio-economic importance in South Africa. This series of 11 volumes addresses the assessment of wetland environmental condition using aquatic invertebrates and macrophytes as well as the assessment of temporary wetlands during dry conditions. There is a metric for the broad-scale assessment of impacts and ecosystem services and methods and case studies on the assessment of socio-economic and sustainability studies. (Volume 4 publication expected late 2010.)

TT 433/09

ISBN: 9781770059252

Overseas price: \$30.00 (excl. postage)

Towards The Realization of Free Basic Sanitation: Evaluation, Review and Recommendation

Nozibele Mjoli, Gillian Sykes and Tracy Jooste

Access to a basic sanitation service as a right is enshrined in the Constitution of South Africa (Act 108 of 1996). In terms of Section 24(a), 'everyone has a right to an environment that is not harmful to their health or well-being.' This clause has been interpreted as a

right to basic sanitation for all. Municipalities have a constitutional mandate of ensuring access to water and sanitation services for all including the poorest households. Despite the drafting of a Free Basic Sanitation (FBSan) strategy by the Department of Water Affairs & Forestry (DWAF) in mid-2004, the process of approval for this strategy has been slow due to the realisation by Government that provision of free basic sanitation service was more complex than free basic water. Municipalities are faced with a challenge of balancing financial resource allocation to the eradication of basic sanitation infrastructure backlog by 2010 and provision of free basic sanitation services to the poor. Therefore, there is a need to identify successful and cost effective approaches of implementing subsidies for basic sanitation infrastructure and provision of free basic sanitation services. Financial models and innovative strategies are required to assist the municipalities to provide sustainable free basic sanitation services to poor households and to finance ongoing O&M for these services. Good practice must be identified and scaled-up where possible. The aim of this study was to assess the experience of municipalities in the implementation of FBSan services and to develop economic and financial models for sustainable FBSan service. Based on the findings of the study recommendations were made for improving the delivery of FBSan services to poor.

TT 420/09

ISBN: 9781770059009

Overseas price: \$30.00 (excl. postage)

The basement aquifers of Southern Africa

Titus RA, Beekman HE, Adams, S and Strachan L

The report consists of several reviewed papers. The papers were sourced from various researchers that have worked on basement aquifers in southern Africa. The resulting synthesis document will be used by the hydrogeological community as a basic reference to basement aquifers. The paper titles and authors are:

- Basement aquifers of southern Africa: Overview and Research Needs - Shafick Adams
- A tectonic and geomorphic framework for the development of basement aquifers in Namaqualand: a review - Rian Titus, Andreas Friese, Shafick Adams
- Groundwater exploration and development - Karim Sami
- Groundwater exploration and development of basement aquifers in Botswana - Flenner Linn
- Groundwater chemistry of basement aquifers: A case study of Malawi - James Chimphamba, Cosmo Ngongondo, Prince Mleta
- A methodological approach to recharge estimation of semi-arid basement aquifers – the central Namaqualand case - Shafick Adams, Rian Titus, Yongxin Xu
- Basement aquifer Groundwater recharge, storage and flow - Jürgen Kirchner
- Factors that control sustainable yields in the Archean basement rock aquifers of the Limpopo province - Martin Holland, Kai Witthüser
- Hydrogeochemistry of fluoride and salinization mechanism of groundwater in the Singida region, central Tanzania - Hudson H. Nkotagu
- Hydrogeochemical processes that influence the groundwater chemistry of basement aquifer systems, Namaqualand - Rian Titus, Shafick Adams, Kai Witthüser, and Yongxin Xu
- Towards sustainable utilisation of basement aquifers in southern Africa - Eberhard Braune, Shoni Mutheiwana
- Current practices and future needs for managing basement aquifers in Zimbabwe - Sam Sunguro, Hans Beekman
- Challenges of basement aquifers in southern Africa - Christopher J. Lovell
- Groundwater management in southern Africa - Mutsa Masiyandima
- Aspects of groundwater management that is pertinent to basement aquifers in the southern African development community (SADC) - Kevin Pietersen

TT 428/09
ISBN: 978 1 77005 8989
Overseas price: \$25.00 (excl. postage)

Enabling effective learning in catchment management agencies: A philosophy and strategy

D Roux, K Murray E van Wyk

It is the responsibility of catchment management agencies (CMAs) to manage water resources in their respective water management areas. The nature of the functions they have to perform and the complicating and complex internal and external realities within which they operate create very demanding circumstances. It is therefore imperative that CMAs are effective learning organisations. This means they should be adept at acquiring knowledge, creating knowledge, transferring knowledge and, importantly, adapting when necessary.

This document provides some historical background to the knowledge movement and describes different types of knowledge. It also provides an encyclopedia of terms that define various commonly-used terms and concepts in this field.

TT 421/09
ISBN: 978 1 77005 8958
Overseas price: \$20.00 (excl. postage)

A Planning Framework to Position Rural Water Treatment in South Africa for the Future

Chris Swartz

A number of recent WRC projects (738, 1531, 1599) showed that serious problems exist with the treatment of drinking water for non-metropolitan areas. These problems are acute in rural areas, and include lack of capacity, poor operation and maintenance, lack of management involvement, commitment and resources,

as well as a general lack of knowledge and understanding of the importance of effective drinking water treatment.

TT 419/09
ISBN: 978 1 77005 8897
Overseas price: \$25.00 (excl. postage)

Review of Regulatory Aspects of Water Services Sector

Daniel Malzbender, Anton Earle, Hameda Deedat*, Brian Hollingworth*, Palesa Mokorosi

The purpose of regulation is to ensure that the service providers or operators of water services deliver in accordance with the law and the policy of the Government. This research examined the international literature and case studies where the concept of a "regulator" is more understood as referring to an entity that is separated from the line departments of Government. Whether the institutional form is Government as regulator or an independent entity as regulator conceptually makes no difference to its objectives or its basic task. The international focus on independent regulators relates largely to effectiveness. The limited survey conducted as part of this research suggests that within South Africa, stakeholders, outside of national Government, appear to favour an independent regulator because, it is said, that DWAF will be unable to fulfill simultaneously the three roles it defines for itself as regulator, supporter and enabler. The unfavorable side of an independent regulator is the cost and the requirement for skills that are in short supply. The research found that the legislation, regulations and policy that a regulator would have to apply are already well-defined. Further, it was found that there are a number of core skills such as finance, economics and engineering that are required irrespective of the range of aspects that will be regulated. Depending on the functions and mandate, regulation will require between 48 and 80 direct staff and cost between R40 and R67million per annum. A similar estimate for an independent regulator suggests staff of

between 65 and 112 and annual costs of between R63 and R99 million per annum.

TT 417/09

ISBN: 978 1 77005 8866

Overseas price: \$20.00 (excl. postage)

Effective Groundwater Management in Namaqualand: Sustaining Supplies

Kevin Pietersen, Rian Titus and Jude Cobbing

The purpose of this guide is to translate the scientific and technical knowledge gained through research on the hydrogeology of basement aquifers into a user-friendly format for the Department of Water Affairs and Forestry (DWAF), local authorities and the end-users. The guide is not intended for operators of water supply schemes, but rather for water resource planners. The guide has two overarching sections that deal with the issues of groundwater exploration and exploitation in a systematic manner. It is subdivided as follows:

1. What is groundwater?
2. The importance of groundwater in Namaqualand
3. Namaqualand aquifer systems
4. Locating groundwater resources in Namaqualand
5. Selecting drilling targets
6. Borehole design
7. The drilling process and the importance of data collection
8. Determining the sustainable yields
9. Understanding the water balance
10. Managing the water resource
11. Water quality considerations

TT 418/09

ISBN: 9781770058880

Overseas prices: \$25.00 (excl. postage)

Manual for Index of Habitat Integrity (Section 2, Model Photo Guide) Module G Volume 2

Mark Graham; Marina Delana Louw

The manual consists of the following modules:

Module A: Ecoclassification and Ecstatus Models

Module B: Geomorphological Driver Assessment Index (GAI)

Module C: Physio-Chemical Driver Assessment index (PAI)

Module D: Fish response assessment Index (FRAI) Volume 1 & 2

Module E: Macro-Invertebrate Response Assessment Index (MIRAI) (Volume 1)

Module F: Riparian Vegetation Response Assessment Index (VEGRAI)

Module G: Index of Habitat Integrity.

TT 378/09

ISBN: 978 1 77005 8019

Overseas price: \$20.00 (excl. postage)

Basic sanitation services in South Africa Learning from the past, planning for the future

David Still, Nick Walker and Derek Hazelton

The purpose of this study has been to investigate whether the improvements made are working, and whether they are financially sustainable. In its coverage the study is biased towards rural sanitation, as the overwhelming majority of South Africans without proper sanitation live in rural areas. The study finds that with few exceptions the practice since 1994 has been to provide funds for the initial capital costs of sanitation projects and not for operation and maintenance. The reason for this is that funding for new infrastructure is typically provided to municipalities by central Government as grant funding, while the funding for operation and maintenance is required to come from the municipal coffers. Strictly speaking the funding for operation and maintenance is covered by the Equitable Share grant, in terms of which most

poor municipalities receive an operations subsidy of between R20 and R60 per month for sanitation for every poor family in their area. However the equitable share is an unconditional grant and in practice this is not seen by local Government as funding that has to be spent on operation and maintenance of services. Research indicates that the funding is typically used to finance the municipal overhead costs, as well as to finance other infrastructure projects not covered by the MIG grant. This practice, of building sanitation infrastructure while not allowing for adequate maintenance in the future, whether it is basic VIP sanitation or full waterborne sanitation, is shortsighted and will result in South Africa facing a sanitation crisis in the medium term.

TT 414/09

ISBN: 978 1 77005 8804

Overseas price: \$30.00 (excl. postage)

Development of a toolkit for strategic asset management

Peter Dunn, Ronnie McKenzie, Caryn Seago

A key element for ensuring greater understanding of strategic asset management and its needs is a toolbox of advocacy and awareness materials targeting customers, officials and policy-makers. This element has been identified as a priority action which received little attention in many international initiatives, and that which has as a result led to poor uptake. It is therefore key that the linkages of SAM are made to the daily operations of water services, maintenance, planning and strategic decision making.

TT 413/09

ISBN: 978 1 77005 8750

Overseas price: \$10.00 (excl. postage)

Productive use of domestic piped water for sustaining livelihoods in poor households

Nicky Naidoo, Ciaran Chidley, Gene Main, Michele Vrdoljak

The major question raised by the research is whether water for productive use should be subsidised. This research report has demonstrated that water is being used for productive use and the various uses to which this water is being put. The research report also highlights that poor households using water for productive use 122% more than poor households that do not. The levels of water debts are high and that 40% of the households surveyed indicate that they pay for water, when possible, demonstrates both that water affordability can be low amongst the poor and that the provision of more water to households for beneficial use may experience financial sustainability challenges.

This research indicated that the majority of water users surveyed have stated that they would use water if it were available. It is suggested that wanting to use water in such a manner and actually using the water are not the same thing. This research also indicates that households with higher levels of service use more water for productive use than those with lower service level standards.

TT 412/09

ISBN: 978 1 77005 8743

Overseas price: \$25.00 (excl. postage)

Nitrate in groundwater

Gideon Tredoux, JFP Engelbrecht, Sumaya Israel

Groundwater constitutes the main water resource in the rural areas and on farms. Surveys show that nitrate in groundwater is common in arid and semi-arid regions of southern Africa often exceeding drinking water specifications. High nitrate levels is the most frequent reason for groundwater sources to be

declared unfit for drinking, i.e. exceeding 10 mg/L as N (Marais, 1999). Hence, a large percentage of newly drilled boreholes are rejected for human consumption due to excessive nitrate but communities in many rural areas still consume water with nitrate N exceeding the World Health Organization limit of 10 mg/L. Such non-potable groundwater gives rise to a health threat. Based on the latest information, groundwater in South Africa has high nitrate values, often exceeding 50 mg/L (as N), mostly in a band 100 to 250 km wide, stretching from east to west along the northern boundary of the country, across the four northernmost provinces. Anthropogenic inputs constitute the major source of high groundwater nitrate but research has shown that in certain cases nitrate also originates from the natural soil organic nitrogen pool. The indications, also from our neighboring countries, are that the present situation is unsustainable and anthropogenic nitrogen inputs need to be managed and reduced. Managing anthropogenic nitrogen inputs presents a great challenge for the sustainable use of groundwater.

Report No: TT410/09
ISBN: 978 1 77005 8736
Overseas price: \$15.00 (excl. postage)

Water Resources of SA: 2005 Study: Executive Summary

Middleton B.J. Bailey A.K.

The knowledge and processes involved in accounting for water resource availability continues to benefit from new insights, knowledge and data. The Water research Commission has been very instrumental in providing support and a platform for water practitioners to take part in regular research to develop water resource assessment techniques, collate the data and assess the nation's available water resources at varying intervals since the late 1970s. The last water resource assessment research project was carried out in 1990. This old study addressed surface water availability assessments and used time series data which

ended in 1989. To date the outputs of this 1990 project are at the centre of national and regional water resource planning. This research project, which is commonly referred to as WR2005 is the best attempt to capture the latest available water assessment techniques, improved hydrological simulations, integrate water resource data which included data on groundwater, surface water, wetlands, water quality, soils, land use, improved catchment delineation, population, return flows, and several other variables that have a bearing on the quantification and assessment of the available water resources.

TT 380-82/08
ISBN: 978 1 7700 58132
Overseas price: \$70.00 (excl. postage)

Enabling effective learning in catchment management agencies: A philosophy and strategy

D Roux, K Murray E van Wyk

It is the responsibility of catchment management agencies (CMAs) to manage water resources in their respective water management areas. The nature of the functions they have to perform and the complicating and complex internal and external realities within which they operate create very demanding circumstances. It is therefore imperative that CMAs are effective learning organisations. This means they should be adept at acquiring knowledge, creating knowledge, transferring knowledge and, importantly, adapting when necessary.

This document provides some historical background to the knowledge movement and describes different types of knowledge. It also provides an encyclopaedia of terms that define various commonly-used terms and concepts in this field.

TT 421/09
ISBN: 978 1 77005 8958
Overseas price: \$20.00 (excl. postage)

Civil Society Dialogue in Water Resources Management: Lesson from four local-level experiences of river systems

Ernita van Wyk, Tamsyn Sherwill, Charles M. Breen and A.B. Nkhata

Increasingly civil society is expected to participate in and even lead processes that direct behaviors' in relation to the sustainable use of natural resources. Within this context, civil society groups and organisations are encouraged to enter into dialogue with others to expose issues constructively and to promote shared understanding and learning. The ability of such groups to use dialogue to reflect and learn and to apply the learning to subsequent actions becomes an important way of coping with change and uncertainty. Civil society groups have a particular opportunity in that, even though they may be structured informally, formal and even statutory, they are able to operate as communities of practice and to conduct their business with a degree of flexibility and innovation.

The rules that guide natural resource allocation and use follow a common property regime. This means that the resource and its users are co-dependent in complex ways so that the rules for resource protection and use have to be continually reinforced or renegotiated over time. Within such a regime, civil society groups who act to influence the resource or society in relation to the resource, do so within the context of shared rules defined by the values that society attaches to the resource and the services that emanate from the resource. Thus in order for civil society groups to sustain their operations in ways that are seen as legitimate, such groups, their rules and actions, must be sanctioned by society.

TT 383/09
ISBN: 978 1 77005 8224
Overseas price: \$25.00 (excl. postage)

Guidelines for the Utilisation and disposal of wastewater sludge, Volume 4, Requirements for the beneficial use of sludge at high loading rates

Jacoba Elizabeth Herselman, Lucian Willem Burger and Priya Moodley

Seeking innovative solutions for the handling of wastewater sludge requires a paradigm shift in our perception and understanding of wastewater sludge as a resource and not a waste product. Such a shift creates an opportunity for local authorities to generate a range of economic and social spin-offs to the benefit of their local communities. The Water Research Commission (WRC), and the Department of Water Affairs and Forestry (DWAF) developed this guideline series to support sustainable wastewater sludge management in South Africa. The aim of the project was to develop a series of guidelines to encourage the beneficial use of wastewater sludge but also provide solutions in cases where beneficial use is not feasible. Rather than develop a single guideline to address the range of sludge management options (beneficial and non-beneficial uses), 5 separate Guideline Volumes were developed. Volume 1 and 2 were published in 2006 as part of project K5/1453 while Volume 3, 4 and 5 were completed through a follow-up project K5/1622.

TT 350/09
ISBN: 9781770057104
Overseas price: \$25.00

WET-Origins

William Ellery, Michael Grenfell, Suzanne Grenfell, Donovan Kotze, Terence McCarthy, Stephen Tooth, Piet-Louis Grundling, Heinz Meckedahl, David le Maitre, Lisa Ramsay

Three main branches of research into wetlands were identified during a workshop held in early 2002, wetland rehabilitation, wetland health and integrity and wise use of wetlands. The wetland rehabilitation was prioritised for two reasons. Firstly, it is estimated that South Africa has lost approximately 50% of its wetlands, and wetlands are increasingly being recognised as providing valuable services. And secondly, there has been substantial Government expenditure on wetland rehabilitation through the Working for Wetlands project, which is linked to the Expanded Public Works Programme. This project was co-funded by Working for Wetlands to 50% of the budget.

The main objectives were: The project leader must help to make these objectives meaningful.

- Prioritisation of wetland areas for conservation and rehabilitation
- System rehabilitation
- Methodologies for rehabilitation
- Synergy with other programmes
- Institutional arrangements
- Performance auditing

WET-Management Review

Donovan Kotze, Charles Breen, Innocent Nxele, John Kareko

1. TT 321/09 WET-RoadMap: A Guide to the Wetland Management Series
2. TT 334/09 WET-Origins: Controls on the Distribution and Dynamics of Wetlands in South Africa
3. TT 335/09 WET-Management Review: The Impact of Natural Resource Management Programmes on Wetlands in South Africa

4. TT 336/09 WET-RehabPlan: Guidelines for planning Wetland Rehabilitation in South Africa
5. TT 337/09 WET-Prioritise: Guidelines for prioritizing Wetlands at National, Regional and Local Scales
6. TT 338/09 WET-Legal: Wetland Rehabilitation and the Law in South Africa
7. TT 339/09 WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by Wetlands
8. TT 340/09 WET-Health: A Technique for Rapidly Assessing WET-Health
9. TT 341/09 WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation
10. TT 342/09 WET-RehabEvaluate: A Manual for the Performance Evaluation of Wetland Rehabilitation Projects

This series of documents provides all the information that is needed for the rehabilitation of wetlands, consultants or for private land.

Owners who wish to monitor the state of, and/or rehabilitate, wetlands on their property, or for use by programmes such as Working for Wetlands.

TT 335/09

ISBN: 978177005 6343

Overseas price: \$30 00 (excl. postage)

WET-RehabPlan

Donovan Kotze, William Ellery, Mark Rountree, Michael Grenfell, Gary Marneweck, Innocent Nxele, Charles Breen, John Dini, Allan Bachelor, Erwing Sieben

This project was co-funded by Working for Wetlands to 50% of the budget.

1. TT 321/07 WET-RoadMap: A Guide to the Wetland Management Series
2. TT 334/09 WET-Origins: Controls on the Distribution and Dynamics of Wetlands

3. TT 335/09 WET-Management Review: The Impact of Natural Resource Management Programmes on Wetlands in South Africa
4. TT 336/09 WET-RehabPlan: Guidelines for planning Wetland Rehabilitation in South Africa
5. TT 337/09 WET-Prioritise: Guidelines for prioritising Wetlands at National, Regional and Local Scales
6. TT 338/09 WET-Legal: Wetland Rehabilitation and the Law in South Africa
7. TT 339/09 WET-EcoServices: A Technique for Rapidly Assessing Ecosystem Services Supplied by wetlands
8. TT 340/09 WET-Health: A Technique for Rapidly Assessing WET-Health
9. TT 341/09 WET-RehabMethods: National Guidelines and Methods for Wetland Rehabilitation
10. TT 342/09 WET-RehabEvaluate: A Manual for the Performance Evaluation of Wetland Rehabilitation projects

TT 336/09

ISBN: 978 1 77005 6350

Overseas price: \$25.00 (excl. postage)

River ecoclassification manual for ecostatus determination (version 2): Module G: Index of habitat integrity section 1: Technical manual

Kleynhans CJ, MD Louw, M Graham

The habitat integrity of a river refers to the maintenance of a balance of a balanced composition of Physico-chemical and habitat characteristics on a temporal and spatial scale that there are comparable.

Protocol for the Assessment of the Status of Sustainable Utilisation and Management of Groundwater Resources with special reference to Southern Africa.

E Braune, B Hollingworth, Y Xu, M Nel, G Mahed, H Solomon

The development role for groundwater in Africa and Southern Africa is still poorly understood, resulting in under utilisation and poor management of the important resource. The international experience is that turning around this situation will require strategic action across sector and international boundaries. The study confirmed that SADC has made excellent progress to address groundwater in its comprehensive regional water resources policies and strategies. Groundwater is explicitly referred to in the SADC Protocol on Shared Watercourses. It is also featuring in the SADC Regional Strategic Action Plan for Integrated Water Resource Management and the Regional Water Policy and it has its own Groundwater Management Programme for the roll-out of this plan. When it comes to implementation in individual countries, the performance in groundwater resources management in SADC must still be generally rated as “below expectation”, compared to relevant international best practice. The importance of groundwater in this region, the cooperative regional IWRM structures and institutions that already exist and the understanding there is already for groundwater at the highest decision-making levels, offers a major opportunity to initiate a systematic, region-wide, and ultimately continent-wide, programme and approach, as foreseen by AMCOW, for building the capacity required to ensure that groundwater resources are utilised and managed sustainably in the SADC region. It is felt that the South African capacity for IWRM and, in particular for groundwater resources management, can make a much greater contribution than at present to developments in southern Africa and that the Water Research Commission should strategically position itself for such a role.

Report No: TT318/08
ISBN: 978 1 77005 712 8
Overseas price: \$20 00 (excl. postage)

An introduction to dense NON-AQUEOUS phase liquids (DNAPLs) in South Africa: A community guide

Usher BH, Pretorius JA, Gebrekristos RA

This document is aimed specifically at the lay person, to make them aware of DNAPLs and its occurrences, sources and behavior. This document forms part of a series of documents, produced by Water Research Commission project K5/1501 "Field investigations to study the fate and transport of dense non-aqueous phase liquids (DNAPLs) in groundwater". The documents in this series include:

- Executive Summary of the Project (only available on CD accompanying all reports listed below)
- Manual for Site Assessment at DNAPL Contaminated Sites in South Africa (WRC Report 1501/2/08)
- Groundwater monitoring guidelines for DNAPLs in South African Aquifers (WRC Report 1501/3/08)
- Guidelines for the acceptance of Monitored Natural Attenuation processes in South Africa (WRC Report 1501/4/08)
- Handbook for DNAPL Contaminated Sites in South Africa (TT 326/08)
- An Introduction to DNAPLs in South Africa: A Community Guide (WRC Report TT 326/08)
- Field and laboratory investigations to study the fate and transport of DNAPLs in groundwater (1501/5/08)

Report No: TT 325/08
ISBN: 978 1 77005 658 9
Overseas price: \$25.00 (excl. postage)

Handbook for DNAPL contaminated sites in South Africa

Usher BH, Pretorius JA, Gebrekristos RA

Report No: TT 326/08
ISBN: 978 1 77005 659 6
Overseas price: \$30.00 (excl. postage)

A guide to catchment-scale eutrophication assessments for rivers, reservoirs and lacustrine wetlands

JN Rossouw, WR Harding, OS Fatoki

A study commissioned in 2000 by the WRC found that South Africa's policy and approach to eutrophication control has been inadequate over the previous 20 years. A strong need was identified to remobilise and redevelop our capacity to manage eutrophication. A workshop followed in 2001 to discuss research and capacity building within the field of eutrophication where assessment of the eutrophication problem was identified as the highest priority research area. This project produced a Guide to assess eutrophication related water quality using the same protocol as the DWAF Guide to catchment scale water quality assessment studies. The Guide is structured around six management questions that are designed to establish the eutrophication status and management options at catchment scale. The best eutrophication assessment practice was, furthermore, captured in a web-based nutrient enrichment assessment protocol (NEAP). Course material making use of these two products was developed to fast track capacity building concerning eutrophication assessment. The primary target audience of the short course material is water resource practitioners, water resource managers and freshwater scientists.

Report No: TT 352/08
ISBN: 978 1 77005 715 9
Overseas price: \$30.00 (excl. postage)

Technical instruments to support water quality use allocation

JN Rossouw, W Kamish and AHM Gorgens

The National Water Act prescribes the minimum components of a catchment management strategy. Prime amongst these are the formulation of water allocation principles and a Water Allocation Plan for each Water Management Area. This project focused on a very particular part of the allocation challenge, namely the allocation of "Water Quality Use". It aimed to develop a conceptual framework for water quality use allocation procedures, and to develop and disseminate Technical Guidelines for water quality use allocation procedures. The project employed a process of "learning-by-doing" by applying the framework in a stressed catchment with water quality concerns. The ACRU Salinity model was applied to the Berg River catchment because it also offered a ready-made water quality information system (WQIS) previously developed under WRC Project No 951.

Report No: TT 363/08
ISBN: 978 1 77005 653 4
Overseas price: \$20.00 (excl. postage)

Towards a socio-ecological systems view of the Sand River catchment, South Africa: An exploratory resilience analysis

SR Pollard, HC Biggs, D Robert

South Africa is in the process of implementing IWRM, which by definition is a process based on managing the behavior of people and their response to a finite resource. In addition, wetland systems are under increasing pressure to support subsistence livelihoods, and their sustainability is being compromised. New thinking and understanding on the functioning of complex socio-ecological systems (SES) and how

these contribute to the resilience of these systems could give managers a tool for improved management of these systems. This consultancy investigated how this new thinking may be employed in this situation.

Report No: TT 364/08
ISBN: 978 1 77005 747 0
Overseas price: \$20.00 (excl. postage)

Fire management in the Cape Peninsula: lessons for catchment management agencies from the Ukuvuka Campaign

Fowkes SM

The Ukuvuka initiative was a short-term collaborative campaign designed to inject finance, skills, innovation and passion to address a core issue of common concern to the partners – changing fire-related behaviour. Ukuvuka ran from 2000 to 2004 and was supported by the three spheres of Government, business (a short-term insurance company, a bank, an oil company and a daily newspaper) and NGOs. The trigger for the initiative was the immediate crisis of fires in the mountains of Cape Town's Cape Peninsula.

The purpose of this report is to make a contribution to the policy implementation challenge by sharing some practical insights and experiences from that crisis initiative. The report focuses particularly on applying the lessons to the water sector, specifically the formation of Catchment Management Agencies (CMAs.)

Report No: TT 324/07
ISBN: 978 1 77005 656 5
Overseas price: \$10.00 (excl. postage)

High-yielding groundwater areas around the Nelson Mandela Bay Municipality

Murray R, Goedhart M, Baron J

Prime groundwater development areas were identified and grouped into five hydrogeological domains. Within each of the domains specific groundwater exploration target areas were identified and prioritised. No ground-truthing was done to verify the target areas. It is likely that some of the areas may be unsuitable for groundwater development for a variety of reasons, and it is equally likely that there are a number of other areas that could be developed for large-scale groundwater supply.

The total groundwater potential for each domain was estimated using the GRA II data sets and by assuming the number of high-yielding boreholes that could be obtained in each domain.

This latter approach is based largely on estimates of the number of prime drilling targets that can be located. It was not based on a remote sensing analysis and the identification and weighting of individual drilling targets. Thus in some areas there may be fewer prime drilling targets, and in other areas, more. The purpose of this exercise was to provide a first-order estimate of the groundwater potential, and thus it will not be correct, but it should serve as a good starting point. A summary of the groundwater potential of all five domains is presented:

Groundwater Exploitation Potential (normal years) = 48 Mm³/a

Groundwater Exploitation Potential (dry years) = 32 Mm³/a

Borehole yield without artificial recharge and continuous abstraction = 28 Mm³/a

Borehole yield with artificial recharge and 6-month/a abstraction = 41 Mm³/a

Existing use = 9 Mm³/a

Report No: TT 327/08

ISBN: 978 1 77005 671 8

Overseas price: \$20.00 (excl. postage)

National Microbial Monitoring Programme for Groundwater: Implementation Manual

Murray K, du Preez M, Meyer R, van Wyk E, Parsons R, Flanagan L, Taylor M

The general purpose of this manual is to describe how the national microbial monitoring programme (NMMP) for groundwater should be implemented on a national scale. This national monitoring programme for groundwater supplements the National Microbial Monitoring Programme for surface waters. However, it should not be regarded as an extension of it. Monitoring groundwater is fundamentally different from monitoring surface water and accordingly has a completely different design.

This manual gives guidelines, procedures and methods for microbial monitoring of groundwater as well as how and when such data can be reported.

Accordingly, this manual is aimed at a variety of people and organisations. It is initially aimed primarily at DWAF officials who will have the primary responsibility to implement national water-related monitoring programmes. However, it is also aimed at Catchment Management Agencies (CMAs) and water management institutions to which monitoring responsibilities may be delegated.

Report No: TT 312/07

ISBN: 978 1 77005 594 0

Overseas price: \$20.00 (excl. postage)

Integrated water resource management plan guidelines for local authorities: (IWRMP)

Burke J

The principle of integrated water resource management is endorsed by the National Water Act, Act 36 of 1998 and the National Water Resource Strategy (2004). Simply put, integrated water resource management in Local Authorities is about striking the right balance between a Local Authority's developmental role and the need to maintain environmental integrity in fulfilling the Constitutional obligations of sustainable development, socioeconomic development and a safe and healthy environment. Striking this balance is a challenge and requires cooperation between all tiers of Government as well as between Government and the private sector, but there are no hard and fast rules as the environment is a dynamic system, continually adapting itself to a new balance, following the effects of both human and natural influences on it. Implementation of the Local Authority Integrated Water Resource Management Plan will be a positive step forward in ensuring that Local Authorities achieve sustainable integrated water resource management in line with the catchment vision set by the Catchment Management Agency.

Report No: TT 304/07
ISBN: 978 1 77005 548 3
Overseas price: \$30.00 (excl. postage)

A task oriented approach to participation: Please download from <http://www.wrc.org.za/>

Burt JC, du Toit DR, Neves DT

The NWA puts emphasis on the decentralization of water resource management to the catchment level. This necessitates an adoption of participatory management approaches that can support a multi-stakeholder dialogue of diverse interest groups such as water user associations (WUAs), community-based

organisations, NGOs, water resource managers, policy-makers and planners.

Therefore, there is a need for appropriate tools that can be used to support meaningful participation of the public at different levels of decision making. This project answers the following questions:

- What is the appropriate CMA level of organisation that will be effective in ensuring that voices of 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 sub catchment level?

Report No: TT 289/06
ISBN: 1 77005 502 9
Overseas price: \$15.00 (excl. postage)

Water as a human right, made easy! Workbook 1: Please download from <http://www.wrc.org.za/>

Dericj du Toit, Teresa Sguazzin

Report No: TT 269/07
ISBN: 978 1 77005 435 6
Overseas price: \$15.00 (excl. postage)

Human Rights project workbook 2: please download from <http://www.wrc.org.za/>

Dericj du Toit, Teresa Sguazzin

A key concept evident in the South African Constitution is that National Government is committed to providing adequate food and water '... to meet basic human needs'. Arguably the most crucial resource, in terms of human need, is water. This commitment in providing water for basic human needs is captured by the National Water Act (1998) in the concept of the 'Basic Human Needs Reserve' (BHNR). The notion of

the BHNHR 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 BHNHR 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 BHNHR.

Report No: TT 296/07
ISBN: 978 1 77005 513 1
Overseas price: \$15.00 (excl. postage)

Guide for local Government cooperation with catchment management agencies

Mazibuko G, Pegram GC

The recent demarcation process and the 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 research will amongst others provide recommendations on the requirements for cooperative governance and the most appropriate approaches and mechanisms to foster cooperative governance between CMAs and local Government, to achieve a range of objectives under differing circumstances.

Report No: TT 270/06
ISBN: 1 77005 460 X
Overseas price: \$15.00 (excl. postage)

Artificial Groundwater Recharge: Wise water management for towns and cities

Rickey Murray

Report No: TT 219/03
ISBN: 1 77005 092 2
Overseas price: \$15.00 (excl. postage)

Surface water: Groundwater interaction in a South African context: A Geohydrological Perspective

Parsons Roger

In response to a greater awareness of the role of groundwater in sustaining the environment and recognition of a unitary and interdependent hydrological system, surface-groundwater interaction has emerged as an issue requiring greater attention. This publication aims to establish the correct and consistent use of hydrological terms which is key for developing a better understanding of surface water-groundwater interaction.

Report No: TT 218/03
ISBN: 1 77005 084
Overseas price: \$25.00 (excl. postage)

An explanation of a set of national groundwater, plus 2 Hydrogeological maps (SA Price: R114.00)

Vegter JR

Advances in hydrogeology over the past years, and the increasing demand on groundwater resources, have given rise to the need to portray hydrogeological information in such a manner that planners and various groundwater users can make decisions by means of a quick and accurate overview of the most up-to-date information. Hydrogeological maps are seen as a powerful tool to meet this objective.

Report No: TT 74/95
ISBN: 1 86845 183 6
Overseas price: \$70.00 (excl. postage)

Explanation of the 1:500 000 hydrogeological map 2326 Pietersburg (SA Price: R50.00)

Water Systems Management, DWAF

This is a high-quality hydrogeological map of the Pietersburg map sheet at a scale of 1:500 000 and a set of explanatory notes which provide guidelines as to the need for detailed groundwater investigations and what hydrogeological conditions are expected to occur.

Report No: TT 75/95
ISBN: 1 86845 188 7
Overseas price: \$35.00 (excl. postage)

Dealing with reservoir sedimentation (SA Price: R171.00)

Basson GR, Rooseboom A

Dam siltation has always been and still is a serious problem in South Africa. This report presents different techniques for controlling and managing dam siltation in South Africa.

Report No: TT 91/97
ISBN: 1 86845 255 7D
Overseas price: \$70.00 (excl. postage)

Sluicing flumes: A new structure for discharge measurement in sediment laden rivers

Rossouw J, Loubser C, Rooseboom A, Bester A

This report confirms the flumes' good characteristics with respect to handling heavy sediment loads.

Report No: TT 103/98
ISBN: 1 86845 368 5
Overseas price: \$35.00 (excl. postage)

Dealing with reservoir sedimentation Dredging (SA Price R200.00)

G R Basson A, Rooseboom

In this report the reservoir sedimentation theory and dam dredging techniques from around the world are evaluated. A criterion for selecting dredging techniques which emphasise on cost-cutting measures is presented.

Report No: TT 110/99
ISBN: 1 86845 493 2
Overseas price: \$60.00 (excl. postage)

A Global Overview of Inter Basin Water Transfer Schemes, Socio Economic and Socio Political Implications, and Recommendations for their Management

Snaddon CD, Davies BR, Wishart MJ

This report combines two source documents. The first is the report on the research done during the project and the second is a worldwide synthesis of information on inter-basin transfer (IBTs) with contributions from scientists in the USA and Australia.

Report No: TT 120/00
ISBN: 1 8645 583 1
Overseas price: \$20.00 (excl. postage)

Groundwater Development in South Africa and an introduction to the Hydrogeology of Groundwater Regions

Vegter 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: TT 134/00
ISBN: 1 86845 642 0
Overseas price: \$25.00 (excl. postage)

Hydrogeology of Groundwater: Region 1 Makoppa Dome

JR Vegter

Report No: TT 135/00
ISBN: 1 86845 643 9
Overseas price: \$20.00 (excl. postage)

Hydrogeology of Groundwater: Region 3 – Limpopo Granulite-Gneiss belt

JR Vegter

Report No: TT 136/00
ISBN: 1 86845 644 7
Overseas price: \$20.00 (excl. postage)

Hydrological information and techniques to support the determination of the water quality component of the ecological reserve for rivers

Hughes DA, Munster F

Report No: TT 137/00
ISBN: 1 86845 646 3
Overseas price: \$20.00 (excl. postage)

Hydrogeology of Groundwater: Region 7 – Polokwane/Pietersburg Plateau

JR Vegter

Report No: TT 209/03
ISBN: 1 86845 027 2
Overseas price: \$20.00 (excl. postage)

Hydrogeology of Groundwater: Region 19 – Lowveld

JR Vegter

Report No: TT 208/03
ISBN: 1 86845 026 4
Overseas price: \$20.00 (excl. postage)

Hydrogeology of the main Karoo basin: Current knowledge and future research needs

AC Woodford and L Chevallier

This document is aimed primarily at the groundwater practitioners working in Karoo fractured-rock aquifers, especially those involved on rural water supply projects and WRC-funded research projects. The level of information presented is also useful to other professionals with only limited groundwater knowledge.

Report No: TT 179/02
ISBN: 1 86845 851 2
Overseas price: \$40.00 (excl. postage)

Evaluation of the role of water user associations in water management in South

Pegram G, Mazibuko G

The new institutional reforms in water resource management prescribed in the National Water Act of 1998, delegate many water resource management functions (particularly resource protection and allocation) to organisations within Water Management Areas (WMA), namely Catchment Management Agencies (CMAs) and Water User Associations (WUAs). WUAs are statutory bodies intended to operate at a restricted localised level aimed at facilitating cooperative associations of individual water users, who wish to undertake water-related activities for their mutual benefit. This study is aimed at clarifying the roles of WUAs, evaluating the functioning of a number of established WUAs against this framework and the particular needs of the local conditions, and formulating guidelines for the institutional and management arrangements.

Report No: TT 204/03
ISBN: 1 8645 982 9
Overseas price: \$25.00 (excl. postage)

Guidelines for integrating the protection, conservation and management of wetlands into catchment management planning

Dickens C, Kotze D, Mashigo S, MacKay H, Graham M

The South African legal environment provides for the sustainable use of the country's water resources. Yet, all is not well with the wetland resources of this country. Already suffering from years of abuse and over-utilisation, wetlands remain under threat as part

of the water resource. These guidelines provide management agencies with much needed information for the management of wetlands. The impact of these guidelines is expected to be significant, especially for professional staff and interested members of society working at ground level.

Report No: TT 220/03
ISBN: 1 77005 096 5
Overseas price: \$30.00 (excl. postage)

An assessment of the water policy process in South Africa (1994 to 2003)

de Coning C, Sherwill T

The political changes which have taken place in South Africa during the last decade have had profound impacts on the development of new water policy, and have opened the way for significant shifts in policy and legislation generally, in relation to sustainable management of natural resources. The implementation context will strongly influence the future development and strategic direction of water policy in South Africa, but there is still limited understanding of the inter-relationships between policy development and implementation, with the added shaping forces of politics, economics and social factors.

This project aims to provide, through critical review and analysis, an understanding of where we have come from and where we are going to in terms of water policy, in order to support ongoing development and implementation throughout this and future policy cycles.

Report No: TT 232/04
ISBN: 1 77005 180 5
Overseas price: \$15.00 (excl. postage)

Sediment control at river abstraction works in South Africa: Vol 1

Brink CJ, Basson GR, Denys F

This report presents a review of the international and South African state of the technologies available for controlling sediments at river abstraction works. Optimum abstraction locations, flushing channel designs and suitable pumping designs. Guidance for planning and design of river abstraction works is one of the main highlights of this report.

Report No: TT 259/06
ISBN: 1 77005 410 3
Overseas price: \$85.00 (excl. postage)

Considerations for the design of river abstraction works in South Africa: Vol 11

Basson GR

Report No: TT 260/06
ISBN: 1 77005 411 1
Overseas price: \$40.00 (excl. postage)

Guide for local Government cooperation with catchment management agencies

Mazibuko G, Pegram GC

The recent demarcation process and the 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 cooperative governance and the most appropriate approaches

and mechanisms to foster cooperative governance between CMAs and local Government, to achieve a range of objectives under differing circumstances. The guide is a userfriendly 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 synthesise 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 realise the potential, of this groundwater supply, many uncertainties and barriers need to be overcome, including: deficient understanding of the occurrence, attributes and dynamics of TMG aquifer systems; lack of understanding of environmental impacts of exploitation; and uncertainties about how best to manage the resource within a multi-objective

environment. Research of a multi-disciplinary nature is thus needed to find appropriate answers to questions concerning the water resource potential and optimal management of TMG aquifers, in the interest of furthering integrated water resource management in the region.

Report No: TT 158/01
ISBN: 1 86845 804 0
Overseas price: \$40.00 (excl. postage)

Learning about participation in IWRM: A SA review: Book 1 and 2 (also available in Venda, Sotho and Zulu)

Burt J, du Toit D, Pollard S

Report No: TT 293/06
ISBN: 1 77005 506 1
Overseas price: \$20.00 (excl. postage)

Research on Berg river water management: Summary of water quality information system and soil quality studies: (Integrated Catchment Management: ICM)

Gorgens AHM, de Clercq WP

This report describes the development of an integrated information system specifically for water quality (WQIS) for the Berg River that is both integrated and interactive. The WQIS has been developed in close cooperation with its intended technical users to provide water resource operational and planning decision-support. The WQIS has a user-friendly GIS-based Graphical User Interface and incorporates interfaces with DUFLOW and CE-QUAL-W2. It was applied to the proposed Skuifraam Dam in the Upper-Berg to illustrate its utilisation to support decision making for various in-dam water quality management scenarios.

Also reported are field-scale process studies and large-scale soils data interpretation, with a strong focus on salinisation processes. The main products are a soils map and a salinity hazard map that were compiled for the Berg River catchment.

Report No: TT 252/07
ISBN: 1 77005 367 0
Overseas price: \$30.00 (excl. postage)

Developing and trailing guidelines for participatory water resources management

Rowntree K; Motteux N

South Africa's National Water Act of 1998 makes the management of any water resource a partnership between local water users, regional catchment managers, and DWAF. The Act encourages communities to become actively involved in developing and managing their water resources. The three sets of guidelines - Participatory Guidelines, Environmental Guidelines, Planning and Economic Guidelines - are aimed at IWRM practitioners who work with stakeholder communities. The guidelines help practitioners make participatory water resource management a reality.

Report No: TT 258/07
ISBN: 1 77005 064 7
Overseas price: \$20.00 (excl. postage)

A study of Roman water law, with specific reference to water allocations and prior appropriation

Burger A

In view of the common law of South Africa being Roman-Dutch and Roman law, the question was asked: Can the Roman law provide some guidance for water law and water allocations in South Africa in as much as the Roman law represents principles

developed and successfully applied for almost a thousand years. The principles of Roman law were developed over a very long period in the vast Roman Empire, which covered a number of different countries with widely different climates. The final version of the Roman law is contained in the Corpus Juris Civilis compiled under the direction of the Emperor Justinian around 534 AD. The law of all European, and many other countries grew out of Roman law. It is, with Roman-Dutch, the common law of South Africa. That part of the Roman law constituting the principles of the water law is set out in this article. Before a law has withstood the test of years of practice, one cannot say whether it is a successful law or not. The Roman interdicts offer practical, tested guidance for resolving conflicts arising in water-stressed situations typical of arid and semi-arid areas. This makes the body of Roman water law worthy of attention and further study for application in South Africa, particularly as we approach full-scale implementation of the National Water Act.

Report No: TT 279/06
ISBN: 1 77005 469 3
Overseas price: \$20.00 (excl. postage)

Hydrogeology of groundwater region 26 Bushmanland

Vegter JR

This report forms part of a series on the hydrogeology of the various groundwater regions in South Africa. Region 26 (Bushmanland) is the fifth region that will be published; there are 64 Groundwater Regions. The Regions previously published are: 1 (Makoppa dome), 3 (Limpopo Granulite-Gneiss belt), 7 (Polokwane/Pietersburg Plateau) and 19 (Lowveld). The hydrogeology of the Bushmanland Region is described using available data and gives a good overview of the groundwater conditions in this region.

The main findings indicate that with decreasing rainfall and an increase in thickness of the superficial deposits there is a

corresponding though not uniform deterioration in groundwater conditions from east to west. The report lists the conditions at which potential water strikes can be encountered. The data revealed that weathering enhances secondary porosity only where the water levels are less than about 30 metres deep. Water is generally struck in fractured fresh rock below the weathered zone and not in the transition between weathered and fresh rock as is the case in the higher rainfall areas. Seventy-four percent of groundwater samples, out of 968 samples, tested were unsuitable for domestic use. The constituents of concern in the groundwater are, in order of frequency of occurrence: fluoride, nitrate, chloride, sodium and sulphate. In most instances if a borehole produces significant water then the poor quality of the water becomes a limiting factor for development.

Report No: TT 285/06
ISBN: 1 77005 495 2
Overseas price: \$40.00 (excl. postage)

Groundwater Research needs in the Eastern Karoo Basin of South Africa

Murray EC, Cobbing JE

The main aim of the report is to outline the current groundwater research needs in the densely populated, impoverished eastern regions of the Eastern Cape Province. Groundwater is the main source for community water supply in the rural areas. Little groundwater research has been done to date in the eastern regions of the Eastern Cape Province – an area that comprises the Eastern Karoo Basin (the geological term for this region). The focus area of this document is Water Management Area 12, incorporating most of the former Transkei and Ciskei 'homelands'. This document describes how new research will coincide with national and provincial development priorities. It takes into account past research, proposes broad research areas, and finally, it lists what are considered to be the most important geohydrological research projects completed to date. It was

developed after widespread consultation that included officials from the Department of Water Affairs and Forestry (DWAF) in the Eastern Cape Province, and a number of locally-based groundwater and engineering consultants.

Report No: TT 286/06

ISBN: 1 77005 497 0

Overseas price: \$25.00 (excl. postage)

Integrated water resource management plan guidelines for local authorities (IWRMP)

Burke J

From a groundwater perspective, Groundwater Resource Directed Measures (GRDM) is more important than the Reserve on its own. While the Reserve only addresses the role groundwater plays in meeting basic human needs and sustaining aquatic ecosystems such as rivers and wetlands, GRDM allows the use and protection of the entire groundwater resource to be addressed holistically. Four levels of GRDM assessments are recognised – desktop, rapid, intermediate and comprehensive – each providing an increased level of confidence.

The objectives of this project were:

- To review and implement methods developed to set RDM for groundwater through an appropriate case study;
- To refine and adapt methods as a result of lessons learnt during the pilot study; and
- Align methods with other components of RDM (e.g. estuaries, rivers and wetlands).

The E10 catchment containing the Olifants River was selected as the pilot study area. A Groundwater Resource Directed Measures assessment was undertaken. Additional data and information was collected, through a hydro census, for the study area where

data was lacking. The research resulted in the development of the GRDM manual that can be used as a guide by both experienced and inexperienced geohydrologists to undertake and review GRDM assessments. Accompanying software was developed to assist with the assessments.

Report No: TT 299/07

ISBN: 978 1 77005 510 0

Overseas price: \$30.00 (excl. postage)

Groundwater Sampling: a comprehensive guide for sampling methods: Second edition

Weaver JMC, Cave L, Talma AS

This revised edition incorporates a number of additional sections, such as sampling for isotopes, down-hole logging, etc. Some chapters have been substantially revised to include advances in field instrumentation, such as pH meter technology and increased attention to organic compounds. A short chapter on the sampling of wetlands, springs and groundwater seeps has also been included. Other chapters have undergone only minor changes, since what was relevant in 1992 is today still relevant.

Groundwater quality data collected according to these described techniques can then reliably be used to evaluate hydro geochemical conditions.

Report No: TT 303/07

ISBN: 978 1 7005 545 2

Overseas price: \$20.00 (excl. postage)

KSA 2:

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module A: Ecoclassification And Ecostatus Determination

CJ Kleynhans, MD Louw

Report No: TT 329/08
ISBN: 978 1 77005 677 0
Overseas price: \$20.00 (excl. postage)

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module D: Volume 1: Fish Response Assessment Index (FRAI)

CJ Kleynhans

Report No: TT 330/08
ISBN: 978 1 77005 678 7
Overseas price: \$30.00 (excl. postage)

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module D Vol 2: Reference frequency of occurrence of fish species in SA

CJ Kleynhans, MD Louw, J Moolman

Report No: TT 331/08
ISBN: 978 1 77005 681 7
Overseas price: \$25.00 (excl. postage)

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module E: Volume 1: Macroinvertebrate Response Assessment Index (MIRAI)

Thirion C

Report No: TT 332/08
ISBN: 978 1 77005 679 4
Overseas price: \$25.00 (excl. postage)

River Ecoclassification Manual For Ecostatus Determination (Version 2) Module F: Riparian Vegetation Response Assessment Index (VEGRAI)

Kleynhans CJ, MacKenzie JA, Louw MD

Report No: TT 333/08
ISBN: 978 1 77005 680 0
Overseas price: \$30.00 (excl. postage)

Module G: EcoClassification and EcoStatus determination in River EcoClassification: Index of Habitat Integrity (Section 1, Technical manual)

Kleynhans CJ

Report No: TT 377/09
ISBN: 978 1 77005 800 2
Overseas price: \$25.00 (excl. postage)

Module G: EcoClassification and EcoStatus Determination in River EcoClassification: Manual for Index of Habitat Integrity (Section 2, Model Photo Guide)

M Graham, MD Louw

Report No: TT 378/09

ISBN: 978 1 77005 801 9

Overseas price: \$20.00 (excl. postage)

Environmental flow assessments for rivers: Manual for the building block methodology – Updated version

JM King, RE Tharme and MS De Villiers

Environmental (or instream) flows are flows that are left in, or released into, a river system with the specific purpose of managing some aspect of its condition. As the condition of river systems deteriorates globally, environmental flows are increasingly appearing in legislation. The science of advising on environmental flows is relatively young (about 50 years), but more than 100 methodologies in existence.

South Africa formally addressed the topic in the 1980s, and during the 1990s made considerable progress at a national level. Recognising that international approaches to environmental flow assessments did not meet South Africa's needs entirely, development of a local approach was initiated. Through a decade of extraordinary cooperation and willingness to contribute, the national body of aquatic scientists, water managers and engineers developed the BBM to the point where it is now one of only a few advanced environmental flow methodologies in the world with a formal manual. In addition, the BBM (Building Block Methodology) has advanced the field of environmental flow assessment in an entirely new direction, being a holistic methodology that addresses the health (structure and

functioning) of all components of the riverine ecosystem. The BBM is essentially a prescriptive approach, designed to construct a flow regime for maintaining a river in a predetermined condition. This manual describes its basic nature and main activities, and provides guidelines for its application.

Report No: TT 354/08

ISBN: 978 1 77005 721 0

Overseas price: \$40.00 (excl. postage)

Assessing the Impact of Research Funded by the Water Research Commission in Support of the River Health Programme

DJ Roux, L Hill and W Strydom

The River Health Programme is a multi-institutional national programme which has 3 custodians, the DWAF, the DEAT and the WRC. The WRC, with its mandate for research, was very closely involved during the developmental stages, and published the first few State of the Rivers reports (SoR). Once the programme was running the WRC withdrew support from the publication of the SoR, but has remained involved at the levels of national coordination and research as required.

The report covers the history and development of the River Health Programme (RHP) from the concept of using biological systems for monitoring environmental quality, which was new when the programme was first conceived, through the early growth phase to its becoming established as a national programme.

Report No: TT 360/08

ISBN: 978 1 77005 742 5

Overseas price: \$20.00 (excl. postage)

Local institutions for water governance: the development of a water users association and catchment forum in the Kat River Valley, Eastern Cape

J Burt, A McMaster, K Rowntree, R Berold

This report describes the development of water resource management organisations (institutions) in the Kat River Valley from 1997 to 2006. The two organisations described here - the Kat River Valley Water User Association and the Kat River Catchment Forum - are given separate narratives for the sake of clarity, although they developed in close association. The developments described here were taking place at a time of great change in South Africa's political and institutional structures, both locally and nationally. The Kat River Valley was one of the first catchments in the country to set up water management structures. At the time there was no clear direction from the Department of Water Affairs and Forestry about requirements for the water users association process, nor was there a clear policy in relation to catchment forums. Researchers, practitioners and the members of the various institutions had to learn as they went along.

This report offers a reflection on what worked and what did not. The authors hope that the story will be useful to others who are grappling with how to implement the National Water Act in a way that honours the Act's principles of equity, sustainability and efficiency.

Report No: TT 295/07
ISBN: 978 1 7005 586 5
Overseas price: \$20.00 (excl. postage)

Estuaries and Integrated Development Planning: A Managers' Guide

Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active cooperative management. While local Government has a key leadership role to play in their management, their Integrated Development Plans (in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local Government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local Government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07
ISBN: 978 1 77005 541 4
Overseas price: \$15.00 (excl. postage)

An introduction to Aquifer dependent Ecosystem in South Africa

Colvin C, Le Maitre D, Saayman, Hughes S

Aquifer Dependent Ecosystems (ADE) occurs throughout the South African landscape, but their identification is often difficult although this is relevant for water management and allocation. ADEs have been categorised by 8 principal aquifer types (based on lithology) and 7 habitat types. At a coarse national scale it is possible to identify areas with a high probability of supporting terrestrial and aquatic ADEs and to assess their vulnerability to disturbance. High areas of risk are linked to shallow discharge

zones where over abstraction is taking place and mining and irrigated agriculture dominate land-use. South Africa is moving towards IWRM and ADEs need to be considered in this context. The successful protection of ADEs requires cooperative governance of land, water and the environment.

Report No TT 301/07
ISBN: 978 1 77005 532 2
Overseas price: \$25.00 (excl. postage)

Learning and teaching about water in our classrooms: A series of lesson plans for grades 8-12

Peddie C, Hibbert D, Conway-Physick C

In support of learning and teaching about water-related issues, the Water Research Commission of South Africa and Share-Net (a project of the Wildlife and Environment Society of South Africa) have developed a series of lesson plans on water. These lesson plan packs, from Grade 8 to 10, are linked to the South African National Curriculum.

All the lesson plan packs (Grade R-8) are available on www.envirolearn.org.za
Other useful websites are the Water Research Commission: www.wrc.org.za and the Wildlife and Environment Society of SA www.wessa.org.za

Report No: TT 346/08
ISBN: 978 1 77005 693 0
Overseas price: \$30.00 (excl. postage)

Learning and teaching about water in our classrooms: A series of lesson plans for grades R-7

Clare P, Hibbert D, Conway-Physick C

Report No: TT 345/08
ISBN: 978 1 77005 650 3
Overseas price: \$30.00 (excl. postage)

WET-Roadmap: A guide to the wetland management series

Dada R, Kotze D, Ellery W, Uys M

This programme, co-funded by Working for Wetlands, aims to establish national wetland rehabilitation procedures by establishing a framework within which wetlands requiring rehabilitation may be prioritised and continually assessed. It will develop a diagnostic framework for assessing the underlying causes of degradation and develop national guidelines for rehabilitation including a review of the methods available. It will also develop synergy with other research being done on wetlands, examine the institutional arrangements around wetland management, and develop a long-term monitoring system that will allow strategic adaptive management of wetlands.

Report No: TT 321/07
ISBN: 978 1 77005 632 9
Overseas price: \$10.00 (excl. postage)

Guidelines for the planning, design and operation of fishways in South Africa

Ralph Heath, Anton Bok, Pieter Kotze, Paul Fouche, Hylton Lewis, Jan Rossouw, Mathew Ross

The need to manage water has led to the construction of barriers in rivers, effectively fragmenting the habitat and curtailing the passage of migratory biota.

This project will develop protocols for assessing the extent of blockage to free passage, and so 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.

Report No: TT 287/07
ISBN: 978 1 77005 577 3
Overseas price: \$30.00 (excl. postage)

Hydrology and water quality of the Mgeni catchment

Kienzle SW, Lorentz SA, Schulze RE

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub-catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 87/97
ISBN: 1 86845 297 2
Overseas price: \$30.00 (excl. postage)

The biological and chemical database. User manual (SA Price: R28.50)

Dallas H, Janssens P

A Biological/Chemical Database was developed as part of this project, incorporating virtually all the ecological studies done on South African rivers which include both taxonomic and chemical

data. Using SASS4 (South African Scoring System, version 4), several of the water quality variables in the DWAF guidelines for environmental water quality were tested for each of the four regions (mountain, foothills, transitional and low land rivers).

Report No: TT 100/98
ISBN: 1 86845 421 5
Overseas price: \$50.00 (excl. postage)

Guides to the freshwater Invertebrates of Southern Africa

The principle aim of the series of ten books is to synthesise much of the existing knowledge on the identification of freshwater invertebrates into a standard format that is accessible to users who wish to identify taxa beyond their field of expertise. This series will include an introductory volume containing general information and a key to the families of invertebrates.

Volume 1: In preparation

Volume 2: Guides to the freshwater Invertebrates of Southern Africa: Crustacea I (SA price: R50.00)

Day JA, Stewart BA, De Moor IJ, Louw AE

Report No: TT 121/00
ISBN: 1 86845 581 5
Overseas price : \$25 00 (incl postage)

Volume 3: Guides to the freshwater Invertebrates of Southern Africa: Crustacea II (SA price: R50 00)

Day JA, Stewart BA, De Moor IJ, Louw AE

Report No: TT 148/01
ISBN: 1 86845 703 6
Overseas price: \$25.00 (incl postage)

Volume 4: Guides to the freshwater Invertebrates of Southern Africa: Crustacea III (SA price: R50 00)

Day JA, Stewart BA, De Moor IJ and Louw AE

Report No: TT 141/01
ISBN: 1 86845 676 5
Overseas price: \$25.00 (incl postage)

Volume 5: Guides to the freshwater invertebrates of Southern Africa: Non Arthropods (SA Price: R114.00)

Day JA and IJ de Moor

Report No: TT 167/02
ISBN: 1 86845 827 X
Overseas price: \$50.00 (incl postage)

Volume 6: Guides to the freshwater invertebrates of Southern Africa: Arachnida & Mollusca: Araneae, Water Mites & Mollusca (SA Price: R50-00)

Day JA and IJ de Moor

Report No: TT 182/02
ISBN: 1 86845 875 X
Overseas price: \$50 00 (incl postage)

Volume 7: Guides to the freshwater invertebrates of Southern Africa: Insecta; Ephemeroptera, Odonata & Plecoptera (SA Price: R114.00)

IJ de Moor, JA Day, FC de Moor

Report No: TT 207/03
ISBN: 1 86845 875 X
Overseas price: \$50.00 (incl postage)

Volume 8: Guides to the freshwater invertebrates of Southern Africa (SA Price: R100.00)

de Moor IJ, Day JA, de Moor FC

Report No: TT 214/03
ISBN: 1 77005 055 8
Overseas price: \$50.00 (incl postage)

Volume 9: Guides to the freshwater invertebrates of Southern Africa: Diptera (SA Price: R100.00)

JA de Moor, AD Harrison and IJ de Moor

Report No: TT 201/02
ISBN: 1 86845 900 4
Overseas price: \$50.00 (incl postage)

Volume 10: Guides to the freshwater invertebrates of Southern Africa (SA Price: R100.00)

Stals R, De Moor IJ

Report No: TT 320/07
ISBN: 978 1 77005 629 9
Overseas price: \$50.00 (incl postage)

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 and F Venter

The Kruger National Rivers research programme is a cooperative 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 and Dept of Environmental Affairs

Between 1996 and 1999, the River Health Programme (RHP) conducted surveys on the three major river systems of Mpumalanga, the Crocodile, Sabie Sand and Olifants Rivers, including some of their tributaries.

The RHP collected and assessed a substantial body of data on the ecological health of these rivers during the surveys.

The following reports are available:

- 1) State of the Rivers Report: Letaba and Luvuvhu River Systems 2001 (TT 165/01)
- 2) State of the Rivers Report (TT 147/00)
- 3) State of the rivers report: Umngeni River and neighbouring rivers and streams (TT 200 /02)

Report No: TT 147/00
ISBN: 1 86845 689 7
Overseas price: \$20.00 (excl. postage)

Ecological risk assessment guidelines (SA price: R50.00)

Claassen M, Strydom WF, Murray K, Jooste

Ecological risk assessment is a structured approach that describes, explains and organises scientific facts, laws and relationships and provides a sound basis to determine sufficient protection measures and to develop utilisation 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 and Bate GC

Botanical importance refers to the contribution of the plants to the conservation status of an estuary. In this study botanical importance is the sum of functional importance, species richness, community richness and community type rarity.

Report No: TT 160/01
ISBN: 1 86845 790 7
Overseas price: \$20.00 (excl. postage)

Guidelines for Legionella levels in water: A code of practice

Pauline Coubrough

The guidelines are intended for use in South Africa, taking in account South African environmental conditions. International guideline documentation, results from outbreaks that have occurred throughout the world, and the National Legionella Action Group's research findings were used in the formulation of the guidelines.

Report No: TT 174/02
ISBN: 1 86845 846 6
Overseas price: \$15.00 (excl. postage)

Predicting water quality and biotic response in ecological reserve determinations

Malan H, Day JA

The management of water quality in the environmental Reserve is more complex than that of water quantity. The principal aim of this project is to examine the relationship between water quality and water quantity with particular reference to instream flow requirement assessments, and to produce a framework for the assessment of water quality in IFR studies. Secondary aims are to investigate how the Biobase database may be used in the assessment of water quality guidelines.

Report No: TT 202/02

ISBN: 1 86845 923 3

Overseas price: \$30.00 (excl. postage)

Prioritisation of South African estuaries based on their potential importance to estuarine-associated fish species

Maree RC, Whitfield AK, Quinn NW

This report presents a ranking of South African estuarine systems based on their importance to estuarine-associated fish species, and aims to facilitate the identification of South African estuaries with a high conservation priority, by placing all South African systems in a regional and national context.

Report No: TT 203/03

ISBN: 1 86845 979 9

Overseas price: \$10.00 (excl. postage)

Freshwater fish and human health: Overview guide

Heath R, du Preez H, Genthe B, Avenant-Oldewage A

This programme focuses on the development of a series of guidelines and protocols to promote and advocate the safe use of water with the aim to build awareness and to transfer technology to the public to minimise water-related health risks. This programme is intended to meet the needs of practitioners and will consider aspects of water use and health, hygiene, hazards and risks as well as epidemiological studies, communication protocols and education guidelines.

These projects are concerned with translating scientific data into accessible formats.

Report No: TT 212/04

ISBN: 1 77005 046 9

Overseas price: \$20.00 (excl. postage)

Freshwater fish and human health: Reference guide.

Heath R, du Preez H, Genthe B, Avenant-Oldewage A

Report No: TT 213/04

ISBN: 1 77005 047 7

Overseas price: \$25.00 (excl. postage)

Environmental water quality in water resources management

Palmer T, Berold R, Muller N

The release of harmful and potentially harmful substances into the environment has caused water quality problems worldwide. Toxicology offers a cost-effective way of measuring the likely impact of an effluent on the environment, in that it will identify whether the effluent is toxic, including any synergistic and

antagonistic effects. This will allow for both the determination of the suitability of the effluent for discharge to be determined for licensing purposes, and for specific industries to monitor their compliance with license conditions.

Most toxicity tests measure acute effects and the chronic values are calculated empirically. The measurement of sub-lethal methods will, thus, provide accurate values on which to base decisions, so enhancing the capacity of managers to protect the water resource.

During this project new methods will be developed for quantifying the chronic effects of toxic effluents at sub-lethal concentrations.

Report No: TT 217/04
ISBN: 1 77005 083 3
Overseas price: \$10.00 (excl. postage)

The effect of water quality variables on aquatic ecosystems review

Dallas HF, Day JA

Water is a scarce resource in South Africa, and increasing population pressure has meant that the resource is heavily exploited and carries an increasing pollution load. Aquatic ecosystems are able to remediate a certain amount of pollution, but once this level has been exceeded then the ecosystem, together with its ability to remediate pollution declines. Chapters 2 and 3 of the review provide a general introduction to the issue of water quality in relation to aquatic ecosystems. Chapters 4 to 12 synthesise what is known about the effects on aquatic ecosystems of specific physical attributes and chemical constituents. Specifically, these include temperature, turbidity, pH, total dissolved solids and dissolved oxygen. Organic enrichment, including bacterial contamination, as well as the effects of enrichment by specific nutrients are covered, as are

biocides and trace metals. The last eight chapters examine the effect of different types of whole effluents or other specific disruptions resulting from human activities, including agriculture, aquaculture, engineering and construction with specific reference to river regulation, forestry, industrial effluents, mining and urban runoff.

Report No: TT 224/04
ISBN: 1 77005 131 7
Overseas price: \$30.00 (excl. postage)

Towards the conservation and sustainable use of Eastern Cape estuaries

Breen C, et al

The ACRU hydrological model was configured for the Umgeni catchment upstream of Inanda Dam to simulate daily streamflow for 137 sub-catchments for a 34-year period from 1 January 1960 to 31 January 1993. Simulated streamflows were verified against observed data for a limited number of sub-catchments. All verifications gave a coefficient of determination above 78%. In all cases simulated streamflow was within 6% of the observed values. It was found that the simulated impact of present land uses compared with pristine conditions can be highly significant.

Report No: TT 237/04
ISBN: 1 77005 235 6
Overseas price: \$20.00 (excl. postage)

Spatsim, an integrated framework for ecological reserve determination and implementation

Hughes DA, Palmer CG

Water quality is currently trailing water quantity in the ecological Reserve methodology. Further development of the methods used is necessary to enable the water quality component to be

considered adequately. The aims of this project are to develop acceptable time-series data for selected water quality variables, encapsulate the expert water quality knowledge in an organised way and encode these for inclusion into the DSS currently being developed as part of a parallel project, and coordinate this with other water quality projects working on the Reserve. This will ensure that decisions taken on water quality in the Reserve determination process are done in a standard way and in parallel with those on water quantity.

Report No: TT 245/04
ISBN: 1 77005 296 8
Overseas price: \$25.00 (excl. postage)

Managing sedimentary processes in SA Estuaries: A guide

Hay D, Huizinga P, Mitchell S

Ingress of marine sediments into estuaries was the single most important issue in estuary management identified in the western part of the Eastern Cape during the early stages of the EC Management Programme. The local authority for the Port Alfred/Boesmans River area has committed funds to develop the predictions of the effect of interventions on the problem. If the predictions indicate that an intervention may be successful, then the EIA around the planned intervention will be undertaken within this project. Thereafter, the implementation of any technology will be for the expense of the local authority.

Report No: TT 241/05
ISBN: 1 77005 272 0
Overseas price: \$20.00 (excl. postage)

The SA diatom collection:

1. An appraisal and overview of needs and opportunities

Harding WR, Archibald CGM, Taylor JC, Mundree S

The South African Diatom Collection (which extends beyond South Africa's borders) was established over the period 1950 to 1995 by a number of collectors and is amongst the larger collections worldwide. A number of case studies were carried out which showed the relevance of the OMNIDIA software package (use of diatom-based water quality indices) for South African conditions. The general conclusion is that the data and information contained in this collection will add value to, and have a place in, the current suite of assessment tools currently being used for the management of the surface water resource in South and Southern Africa.

Report No: TT 242/04
ISBN: 1 77005 275 5
Overseas price: \$25.00 (excl. postage)

2. Benthic diatoms in the rivers and estuaries of South Africa

Bate GC, Smailes PA, Adams JB

This follow-on project (from the project entitled identification of diatoms and their use in the assessment of water quality) will address 3 aspects of the use of diatoms in monitoring for water quality. The determination of the relationship between dominant diatom assemblages and freshwater quality will continue. The same will be done for estuarine diatoms, where the relationship between water quality and dominant assemblages will be defined. Thirdly, a manual of South African diatoms will be produced. The product of this project will enable the use of diatoms, long recognised as being sensitive indicators, in

water quality management at the technician level, not achieved elsewhere before.

Report No: TT 234/04
ISBN: 1 77005 182
Overseas price: \$35.00 (excl. postage)

3. A methods manual for the collection, preparation and analysis of diatom samples

Taylor JC, Harding WR, Archibald CGM

Report No: TT 281/07
ISBN: 1 77005 483 9
Overseas price: \$20.00 (excl. postage)

4. An illustrated guide to some common diatom species from South Africa

Taylor JC, Harding WR, Archibald CGM

Report No: TT 282/07
ISBN: 1 77005 484 7
Overseas price: \$30.00 (excl. postage)

The state of Yellowfish report in South Africa: (SA price R50.00)

Wolhuter LE; Impson ND

Report No: TT 302/07
ISBN: 978 1 77005 543 8
Overseas price: \$30.00 (excl. postage)

Cross-sector policy objectives for conserving South Africa's inland water biodiversity

Roux D, Nel JL, MacKay HM, Ashton PJ

Report No: TT 276/06
ISBN: 1 77005 459 6
Overseas price: \$25.00 (excl. postage)

Conservation planning for river and estuarine biodiversity in the Fish to Tsitsikamma water management area

Lindsay NJ, Smith-Adao L, Roux DJ, Adams J, Cambray JA, de Moor FC, 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 prioritisation and selection was tested, refined and demonstrated in the Fish to Tsitsikamma Water Management Area, and provides a process for implementing biodiversity conservation in practice.

Report No: TT 280/06
ISBN: 1 77005 473 1
Overseas price: \$30.00 (excl. postage)

Estuaries and Integrated Development Planning: A Managers' Guide

Hay D

Estuaries are valuable economic, social and ecological resources supplying a range of goods and services to society. As public resources their management requires active co-operative management. While local Government has a key leadership role to play in their management, their Integrated Development Plans

(in the Eastern Cape) indicate that in most instances they are not taken into account.

A social and political process of engaging local Government on estuary management is proposed. The approach focuses on the economic value of estuaries and how local Government can optimise the benefits that accrue from estuaries for itself and for its residents. As part of this engagement an estuary management training course has been developed for municipalities and tested in three areas.

Report No: TT 294/07

ISBN: 978 1 77005 541 4

Overseas price: \$15.00 (excl. postage)

KSA 3:

Integrated algal ponding systems and the treatment of domestic and industrial wastewaters: part 4: Report 7

Rose PD, Hart OO, Dekker LG, Clark SJ

Inadequate sanitation is a leading cause of water pollution and consequently illness in many underdeveloped countries, including South Africa, for example the Eastern Cape Province, where cholera has reportedly become endemic. As modern wastewater treatment processes are often energy-intensive and expensive, they are not suitable for use in these areas. There is thus a need to develop more sustainable wastewater treatment technologies for application in smaller communities. The integrated algal ponding system (IAPS) was identified as a possible solution to this wastewater management problem and was investigated for adaptation to local conditions at the Rhodes University Environmental Experimental Field Station in Grahamstown.

The system was monitored over a period of nine years, with various configuration adjustments of the high rate algal pond

(HRAP) unit operation investigated. Under standard operating conditions, the system was able to achieve levels of nutrient and organic removal comparable with conventional wastewater treatment works.

The mean nitrate level achieved in the effluent was below the 15mg.l⁻¹ South African discharge standard, but nitrate removal in the IAPS was found to be inconsistent. Although the system was unable to sustain chemical oxygen demand (COD) removal to below the 75mg.l⁻¹ South African discharge standard, an average COD removal rate of 87% was recorded, with the residual COD remaining largely in the form of suspended algal biomass.

Previous studies in the Eastern Cape Province have shown that few small wastewater treatment works produce effluent that meets the microbial count specification. Therefore, in addition to the collation of IAPS data from the entire nine-year monitoring period, this study also investigated the use of the HRAP as an independent unit operation for disinfection of effluent from small sewage plants. It was demonstrated that the independent high rate algal pond (IHRAP) as a free standing unit operation could consistently produce water with *Escherichia coli* counts of 0cfu.100ml⁻¹. The observed effect was related to a number of possible conditions prevailing in the system, including elevated pH, sunlight and dissolved oxygen.

It was also found that the IHRAP greatly enhanced the nutrient removal capabilities of the conventional IAPS, making it possible to reliably and consistently maintain phosphate and ammonium levels in the final effluent to below 5mg.l⁻¹ and 2mg.l⁻¹ respectively (corresponding South African discharge standards are respectively 10mg.l⁻¹ and 3mg.l⁻¹).

The quality of the final effluent produced by the optimisation of the IAPS would allow it to be used for irrigation, thereby providing an alternative water source in water-stressed areas. The system also proved to be exceptionally robust and data collected during periods of both high-intensity and low-intensity management regimes were broadly comparable.

In summary, the results of the nine-year study have demonstrated reliable performance of the IAPS and its use as an appropriate, sustainable wastewater treatment option for small communities. For producing a treated water suitable for irrigation, some significant strengths of IAPS compared to other wastewater treatment technologies are the relatively low capital and operating (e.g. energy) costs, stable performance and low management demands. The system should find ready application in the RSA.

Report No: TT 193/07

ISBN: 978 1 77005 890 5

Overseas price:\$35.00 (excl. postage)

Part 4: Process Scale-up in the Treatment of Mine Drainage Wastewaters and the Disposal of Sewage Sludge

Neba A, Whittington-Jones KJ, Rose PD

Acidic wastewaters from mining operations (acid mine drainage, AMD) and various industrial and metal-refining processes often contain high levels of sulphates and heavy metals. WRC studies have shown that AMD volume flows may reach hundreds of megalitres per day for decades, with acute and long-term impacts on the public water resource system, the environment, and community health, and consequences thus for the economic and social development of the water-scarce Gauteng region.

The development of suitable biological treatment processes has to date been constrained by reactor design appropriate to the large volume flows and the availability of cost effective carbon sources. Recent WRC projects have researched algal ponding technologies and applied these low-cost processes to the treatment of mining and tannery wastewaters. This has led to the development of the biological sulphate-reducing (biodesalination) BioSURE® process using sewage solids as the carbon source

for sulphate reduction and algal activity for precipitating heavy metals and neutralising of acidic drainage streams. In early 1998 a pilot plant was constructed and commissioned at Grootvlei Mine in a collaborative research venture involving the WRC (Project No. 869), ERWAT and Grootvlei Mine. Detailed study of the basic process mechanisms was undertaken in WRC Project No.972. In project 1078 the outstanding components of the pilot plant were constructed to enable evaluation of the complete integrated process over an appropriate time period. In this one-year project 1291, the specific aim was to provide managerial inputs into operationalisation and optimisation of the BioSURE® plant constructed at Ancor Sewage Works by ERWAT and Grootvlei Mine, and thus to assist in process decision-making relating to the full-scale engineering of the process and to provide specialist support to WRC research partners in their implementation of process scale-up for technology transfer.

The above aims were in general achieved and reported on during the course of the project. The operationalisation of the BioSURE® process in this project has contributed significantly to the development of the current situation, where a full-scale plant is being constructed at Ancor Sewage Works to treat AMD from Grootvlei Mine.

The final report on this project 1291, along with the final report on project 1169, is to be published as Report 12 in the series "Salinity, Sanitation and Sustainability" (ISBN series 1-86845-853-9, Volume 4, Part 4 "Treatment and Disposal of Sewage Sludges"). The report will include early results (to December 2004) from the full-scale plant currently being built and commissioned at ERWAT'S Ancor Sewage Works.

Report No: TT 198/07

ISBN: 978 1 77005 895 0

Overseas price: \$30.00 (excl. postage)

Management of water-related microbial diseases: Volume 2: What causes the problem? – A what to do for water suppliers following diarrhoea incidents?

M Steynberg, B Genthe, A van Middelkoop

Internationally there is growing concern about the general failure of authorities to understand the public health impact of waterborne and related infectious diseases. The water supplier is responsible for protecting the health of the public by providing water that is considered to be safe. When cases of diarrhoea occur in the community, the public is also very quick to blame the water. Confidence in the quality of the water can then only be restored if the allegation has been investigated to the satisfaction of the public.

This handbook provides practical guidelines on how to conduct such an investigation. The methods and materials are not original, and can be found in many books and publications that abound in the fields of water management and epidemiology. No attempt is made in this handbook to discuss all the issues surrounding the recommended procedures – the relevant literature will provide far greater insight. What sets this book apart is the fact that it pulls together the relevant methodology from traditionally remote disciplines, the methodology that is required to find out whether cases of diarrhoea could be due to water consumption.

The water quality and water treatment data routinely collected by the water supplier form an important starting point in finding out whether the water could be responsible for cases of diarrhoea. This handbook shows how to record and interpreted such routine data appropriately so that they facilitate the investigation.

The target audience for this handbook includes both the water supplier and the district health services, for example the water quality officer and the environmental health practitioner. The successful implementation of the recommended procedures depends on the involvement of both sectors. All water suppliers, however large or small, should take note of the guidelines provided in this handbook.

Report No: TT 297/07
ISBN: 978 1 77005 520 9
Overseas price: \$30.00 (excl. postage)

Management of water-related microbial diseases: Volume 4: How dangerous is the problem? – Communicating the risk

B Genthe, M Knoetze

Water-related microbial disease such as cholera causes untold misery in communities across South Africa every year. As part of the effort to promote awareness and understanding of the conditions promoting infectious disease transmission, water service providers are increasingly required to have a risk communication programme in place.

Health risk communication is the exchange of information and opinions concerning risk and risk-related factors among risk assessors, risk managers, consumers and other interested parties.

It is not merely the dissemination of information. If well managed, it will ensure that the message is constructively formulated, transmitted and received and will result in meaningful actions.

This guideline document presents the fourth in a five-volume series aimed at addressing the question of how best South Africans can protect themselves from water-related microbial disease. It provides a framework of principles and guidelines for the communication of health risks, specifically for water service providers.

Communicating with the public is an essential element of health risk communication. Ineffective communication often results in conflict, which in turn leads to the erosion of public confidence, and inefficient use of water service providers' resources. The

recognition that people are entitled to make decisions about issues that affect their lives can assist water service providers in forming a better understanding of, and formulating more appropriate reactions to, a particular risk. Appropriate risk communication not only promotes consistency and transparency in arriving at and implementing risk management decisions, it also fosters public trust and confidence in the safety of the water supply.

The document will provide guidelines and examples that will assist water service providers in communicating with the public when a water quality issue arises that has a potential impact on health.

It is hoped that this document will assist water service providers, Government departments, water boards, municipalities and district councils in communicating with the public when a water quality issue arises that could have a potential impact on health. In this way, the guide will hopefully make a significant contribution to protecting our most vulnerable communities against water-related microbial disease.

Report No: TT 298/07

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Overseas price: \$25.00 (excl. postage)

Guidebook for the selection of small water treatment systems for potable water supply to small communities

C D Swart, I Goldie, G Mwiing, LM Daries, BA Delcarne, JD Seconna, JC Geldenhuys

Small water treatment plants are defined as water treatment systems that have to be installed in areas which are not adequately serviced and do not normally fall within the confines of urban areas. They are therefore mostly used in rural and peri-urban areas and include chlorination plants for water supplies

from boreholes and springs, small treatment systems for rural communities, treatment plants of small municipalities and treatment plants for establishments such as rural hospitals, schools, clinics, forestry stations, etc. Most of these applications require small plants of less than 2.5 ML/d (although plants of up to 25 ML/d may sometimes also fall into this category).

The decision-maker selecting one of these small water treatment plants has a great number of local and international system designs to choose from. Especially in the case of novel and emerging systems, very little may be known of these systems in terms of cost, efficiency and the applicability to the intended application. Supplier information may be sketchy, or promising new technologies have not yet been fully evaluated under South African conditions. Socio-economic factors are also very important and should be taken into account in the selection of small water treatment systems in order to ensure sustainability.

Although some evaluation of a selected number of small water treatment plants has taken place under previous WRC projects (WRC Report No 450/1/97: Package water treatment plant selection, and WRC Report No 828/1/01: Field evaluation of alternative disinfection technologies for small water supply), a number of other small water treatment plants, available on the international market, have not yet been assessed in any way for possible (beneficial) application in South Africa. This guidebook is therefore seen as complementing existing guidelines in providing assistance in the selection and operation of specific small water treatment systems being marketed for the treatment of potable water for small communities.

A number of local and international studies have shown that the selection of the correct water treatment system is but a first step in ensuring a sustainable supply of potable water to small communities. Following of the correct operational and maintenance procedures is of even greater importance for ensuring sustainability of water supply. Although most suppliers of small water treatment systems provide their clients with

some operational and maintenance guidelines, these may not be exhaustive, or certain important generic aspects may not be covered. Information on operation and maintenance aspects will be of significant value to the owners and operators of such small water treatment systems.

The guidebook aims to provide guidelines for the identification and optimal selection of available and emerging new water treatment systems, which are currently being marketed for the supply of potable water to small communities in South Africa.

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Overseas price: \$30.00 (excl. postage)

Enabling water fluoridation on small drinking water treatment plants Part A: Guidelines for the implementation of fluoride dosing in small systems Part B

R Rajagopaul, PThompson, A Hariram

Regulations for the fluoridation of South African potable water supplies to an optimum concentration of (and not more than) 0.7mg/l in order to limit the development of dental caries were published in the Government Gazette of 8 September, 2000. Water Services Providers (WSP's) had to register with the Department of Health (DOH) by 8 September 2001 for fluoridation of their water supplies to consumers – or apply for exemption. However, because of the larger safety risk foreseen for both plant operators and water users in smaller and rural water treatment plants, such plants supplying water to less than 60 000 people, currently receive, on application, temporary exemption from the Director-General: Health. This unfortunately excludes a large part of the population from receiving the benefits of fluoridation. By far the majority of water treatment plants fall within the category of supplying less than 60 000 people with potable water. In addition, most of the operators on these smaller plants are not

at a skills level required by the regulations for the safe operation of a fluoride dosing facility. A need therefore existed to enable these smaller plants to administer fluoride safely through the correct choice and operation of instrumentation and equipment, as well as by innovative ways in which to make a plant fail-safe in terms of both technology and human shortcomings. The project aimed to enable fluoridation to be done safely on small water treatment plants by means of the evaluation, selection and implementation of safe handling and dosing equipment and monitoring instrumentation.

Potentially suitable handling and dosing equipment and monitoring instrumentation were evaluated at an Umgeni Water treatment plant and the following products emanated from the study and evaluation: i) A full report was produced on the various fluoridation handling, dosing and monitoring equipment evaluated, including cost implications to the water treatment plant. ii) A comprehensive guideline document was compiled, outlining suitable fluoridation techniques, equipment available, correct installation and use of the equipment and general safety measures that (especially) small plant personnel need to adhere to. In the light of the fact that fluoridation will go ahead in the near future, this guideline is a very timely document, which will assist especially the small water treatment facilities – but also larger plants – in ensuring that their fluoridation requirements are met in an efficient and safe way.

Report No: TT 347/08
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Overseas price: \$30.00 (excl. postage)

On-site mobile training of water treatment operators in small rural water supplies

MNB Momba, N Makala, M Dugeni

Many small rural water treatment plants in South Africa do not produce the quality or quantity of water that they were meant to.

Both technical and human factors have been reported to be the major causes of the failure of small rural water treatment plants to provide potable water to their consumers. Inadequate water treatment systems are therefore placing rural communities at risk of diseases. It has been found that most of the operators who operate rural small water treatments lack the knowledge of plant operational processes. Even when an attempt has been made to offer training, the level of the material used is well beyond the educational level of the operators. Consequently there is a need for the training to be adapted to their capability as well as to be done on-site. This guide was meant to complement the cartoon guide "An illustrated Guide to Basic Water Purification Operations" by providing a practical, mobile course oriented training manual.

Report No: TT 348/08

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Overseas price: \$20.00 (excl. postage)

Water Services Barometer Study

SM Martin

Community consultation in the provision of water services is both a legislative obligation and a critical success factor. Legislation and policy require Government to engage with communities in the provision of Water Services. In order to inform/consult the public and obtain their participation and support, national departments such as DWAF and DPLG embarked on awareness campaigns and/or solicited public participation through meetings, leaflets and the mass media.

No single comprehensive study has been done which provides a barometer of the general public's knowledge and understanding of the water services messages as communicated, and their involvement in, and preferences for, consultative processes. To this end, this study into the level and status of community consultation on a range of water services issues was undertaken.

The study gives a 'reading' of the current state of knowledge and awareness amongst the South African public regarding five key water services knowledge areas. The analysis of the data furthermore identifies areas of strength and weakness with the view to developing recommendations for improvement.

For the purpose of this study, the term 'community consultation' was broadly defined to include all types of communication aimed at the general public, ranging from information dissemination to community participation. The study limited itself to water services messages and it focuses on two major communication campaigns of the Department of Water Affairs and Forestry that have dealt specifically with Water Services, Free Basic Water and Water and Sanitation Hygiene (WASH).

In order to assess the results/outcomes of these water services campaigns, a barometer instrument was constructed. The barometer quantifies, with a composite score out of a possible 10, the knowledge/awareness/desired behaviour of adult South Africans regarding key messages of the campaigns.

Five key water services knowledge areas were identified from the literature review and the analysis of the National Spatial Biodiversity Assessment (NSBA) established that 30% of grasslands in South Africa are irreversibly transformed and only 2.8% are formally conserved. The National Grasslands Biodiversity Programme (NGBP) aims to mainstream biodiversity in production landscapes involving the coal mining and agricultural sectors, and is investigating both regulatory and market-based approaches to achieve this. Off-site mitigation and mitigation banking for wetlands have been identified as concepts with the potential to achieve the desired conservation of aquatic biodiversity within the priority areas of the grassland biome. The concept of wetland mitigation banking developed in the United States to meet the country's policy of 'no-net loss' of wetlands. It is, however, a controversial concept, with the overriding argument against adopting the mechanism being that "it encourages a commodity approach to conservation wherein wetlands are traded for cash."

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Overseas price: \$20.00 (excl. postage)

Guidelines for the improved disinfection of small water treatment plants

MNB Momba, CL Obi and PThompson

The efficacy of drinking water treatment by small water treatment plants – and particularly the disinfection aspects thereof, is fraught with several technical and management problems. This is corroborated by the extensive documentations on the supply of water of poor microbiological quality which is unsafe for human consumption in different provinces of South Africa. In order to unravel the intricacies around the operational and management parameters impinging upon the disinfection efficiency of small water treatment plants and to ensure sustainability of potable water supply to rural communities, this study was executed, involving 181 small water treatment plants across seven provinces of South Africa. The goal was to determine the nature and full extent of the disinfection problems experienced and to provide practical and user-friendly guidelines for intervention.

From extensive surveys at these plants and their disinfection systems, it was established that equipment, maintenance, operator education, operator training, operator working conditions and Management-operator interaction were normally inadequate. These aspects were quantified and graphically portrayed on the report. A detailed and user-friendly guide document was further drawn up to assist in improving disinfection of final water at small water treatment plants and distribution systems. It includes practical steps and also installation and operating costs for the different disinfection systems and chemicals. This guide document is intended for use at operational and management levels by plant managers, supervisors, plant operators and plants owners, consultants and Municipal Water Local Authorities. The report and guide document will fulfill a long-standing need for

more complete information on (both technical and social) aspects regarding improved final water quality produced from small water treatment systems in South Africa.

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Research into UD/VIDP (Urine diversion ventilated improved double pit) toilets: Prevalence and die-off of ascaris ova in urine diversion waste

CA Buckley, KM Foxon, DJ Hawksworth, C Archer, S Pillay, C Appleton

Urine Diversion (UD) systems have recently received a great deal of international attention in the context of “Ecological Sanitation” or “EcoSan”. EcoSan refers to a cycle, or closed-loop system, which treats human excreta as a resource. In this system, excreta are processed on site until they are free of pathogenic (disease-causing) organisms. Thereafter the sanitised excreta are recycled by using them for agricultural purposes.

Despite the obvious benefits of the design, there are a number of unresolved scientific, technological, social and health-related questions about how the design works from a biological and mass transfer perspective, and what the real health and environmental risks are to the householder, community and any outsiders involved in the pit emptying process. The processes of drying and biological degradation which take place in UD vaults were investigated, with a view to understanding the characteristics of the UD waste at the time that the vault is to be emptied. The process of degradation in a UD vault was thought to be anaerobic biodegradation, with some aerobic degradation occurring at the air interface at the top surface of the waste; however it was found that the conditions in the heaps are not conducive to anaerobic digestion. Because of the way in which the faeces and sand are added to the vault, the mixture is very

non-homogeneous. Further the analysis has also highlighted the importance of the air circulation rate for achieving good drying. The fact that the Durban system is to close off the vault during the standing phase is therefore an unsatisfactory feature of the system, since it means that very little drying will occur during the standing phase. The risk assessment showed that there was a 31% reduced risk of diarrhoea in the areas where the on-site sanitation program had been implemented to areas where it had not been implemented.

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Scientific support for the design and operation of ventilated improved pit latrines (VIPS) and the efficacy of pit latrine additives

Buckley CA, Foxon KM, Brouckaert CJ, Rodda N, Nwaneri C, Balboni E, Couderc A, Magagna D

This project proposed to undertake field and laboratory investigations of VIPs and their contents in and around the eThekweni Municipal area in order to understand the conditions found in the pits and to propose design and operating practice that will extend the life of pits. The standard VIP design was found to be effective for the accumulation and degradation of faecal sludge. However, it was observed that the ability of a VIP latrine to function as an improved sanitation system i.e. to provide hygienic separation of human waste from human contact, to limit the transport of pathogens from human waste by vectors such as rodents and insects, to reduce nuisance associated with flies and odour and to preserve the dignity of the user, was compromised in a number of respects due to poor construction, bad user habits, and during pit emptying operations. It was observed that poor construction or lack of maintenance

often resulted in essential features of the VIP latrine design being missing or damaged, including vent-pipes, flyscreens, pedestal lids, doors and back plates. Under these conditions, there were usually problems with odours and flies. Bad user habits resulted in rapid accumulation of pit contents, particularly when poorly degradable anal cleansing material such as magazines, plastic bags or stones were used. In many cases pit latrines appeared to double as waste disposal sites, resulting rapid filling of the latrines.

During pit emptying operations, significant risk of infection of workers and community members with human pathogens originating from the pit contents is expected due to difficulties in removing pit latrine contents and separating faecal sludge from solid waste. Examination of face masks worn by workers engaged in emptying pit latrines and screening the exhumed contents indicated that viable ova of a number of helminth species including *Ascaris*, *Trichuris* and *Taenia* spp (roundworm, whipworm and tape worm) may be present in pit latrine contents and that these constitute a significant health risk to workers involved in handling pit latrine contents, and community members who have access to the area around the pit latrine during and after pit emptying operations.

Finally, commercial pit latrine additives were found to contain large concentrations of active microorganisms with the ability to utilise organic substrates. However, neither the field trials, nor the laboratory trials provided evidence that the use of these products could result in a significant reduction in either mass or volume of pit latrine contents.

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Overseas price: \$30.00 (excl. postage)

The status and use of drinking water conservation and savings devices in the domestic and commercial environments in South Africa

D Still, S Erskine, N Walker and D Hazelton

This study included four different surveys in order to gauge the status and use of water efficient devices in South Africa. Firstly, commercial and institutional settings such as hotels and hostels were investigated; secondly the suppliers of plumbing fittings were studied; thirdly the architectural profession was surveyed; and finally the knowledge and attitude of 1 428 home owners in 10 towns and cities in South Africa were tested. The findings indicate that in commercial and institutional settings, there is clear evidence that water efficient devices are becoming more common. The plumbing industry demonstrates an increasing market share of water efficient devices and this is apparent on the showroom floors of the major plumbing suppliers. This is almost in spite of the suppliers, who as a rule do not push water efficiency (as one said, it is not their job to preach to their customers, who buy mainly on functionality, style and cost). Of the 1 428 homeowners surveyed, 29% indicated that they had at least one water efficient device in the home. Typically only about 20% of the respondents in the average town believed they might possibly use too much water, but significantly more, 40% to 50%, have considered reducing their water consumption.

Report No: TT 358/08

ISBN: 978 1 77005 730 2

Overseas price: \$35.00 (excl. postage)

The view from below: Citizen Voice and regulation in water services to the poor

D Hemson, R Shirley, C Munthree

Regulation in a democratic society cannot work independently of participation by citizens. Public agencies acting as regulators

have to have the views of citizens to hand as it is their interests which are being protected. As the regulatory strategy in South Africa acknowledges, without this knowledge, regulation will have a limited impact. Internationally there is increasing interest in engaging poor communities and capturing citizen voice in scorecards as a step towards improving accountability between citizen and provider. Such participation should assist developing the regulatory framework in South Africa as communities understand the operation and standards of water services, voice their needs, and, as necessary, seek redress. The expression of voice is an integral aspect of a developed reflexive delivery system in which community voice operates as an important prod to municipalities acting as Water Service Authorities to respond to expressed need. Although greater attention to citizen voice is advocated, the challenge remains as to what method can be adopted to involve poor communities on the widest basis actively in people's regulation of water services?

The project has succeeded in providing a set of tools for community appraisal and engagement with the evolving regulatory system. New tools appropriate to the situation have been developed and existing community tools reshaped. These tools and community materials on water services are supported by an established training programme and strategy for spreading their use and techniques. The methods and materials have been developed in deprived and remote communities with the greatest challenges in water services and the tools have been shown to add data and value to community advocacy for better services.

Report No: TT 359/08

ISBN: 978 1 77005 733 3

Overseas price: \$25.00 (excl. postage)

Guidelines for the implementation of sanitation and hygiene education programmes in informal settlements

N Naidoo and C Chidley

The need for this research study was largely informed by the outcomes of the Naidoo et al (2007) research study, 'The Effectiveness of Sanitation Education and Awareness Programmes in Informal Areas'. Rapid urbanisation in South Africa has resulted in the mushrooming of numerous informal settlements, however the provision of services especially sanitation services has not kept pace. According to the National Sanitation Task Team most water and sanitation projects carried out by local authorities have lacked significantly in the aspect of health and hygiene awareness. National and international experience has shown that the most successful sanitation initiatives have been those in which emphasis was placed on generating a high level of health and hygiene awareness rather than producing a large number of latrines. In addition, hygiene education programmes lay the foundation for an integrated approach to the provision of a wider set of environmental services. The benefits of effective and sustainable hygiene education programmes in informal settlements are numerous and include reduced infant mortality from diarrhoea, reduced environmental pollution, reduced health care costs, improved conditions of living, reduced operations and maintenance etc. Hygiene education programmes are among the most cost effective ways of lowering health costs especially in high-density settlements where residents are at greater risks to poor sanitation related diseases. The study has determined that hygiene education programmes should be seen as an integral component of the functions provided by the Water Service Authority (WSA). As such, hygiene education can no longer be linked to only new sanitation infrastructure programmes. Instead, hygiene education should be a continuous function, like operations and maintenance, which is an ongoing function of local

Government. This approach will ensure that the message of good hygiene practice is continuously re-enforced and the approach is supported by existing policy and legislation.

Report No: TT 365/08

ISBN: 978 1 77005 765 4

Overseas price: \$15.00 (excl. postage)

Membrane-related Water Research Impact Assessment

Frost & Sullivan

This study was commissioned as one of the impact studies contemplated to showcase research funded by the WRC in specific water research areas. The WRC has been instrumental in building the membrane industry in South Africa. The WRC has already funded a few projects on membrane research since its inception in 1971. However, most projects were funded after the establishment of a dedicated membrane programme in the early 90's. 66 membrane projects were funded since 1993. Research on membranes have resulted in significant economic, social, environmental and health benefits. The projects in this category have further helped to develop guidelines for best practices and are expected to be important within the water industry in South Africa for some time to come. Projects in this category have often led to the commercialisation of new products. They have further resulted in guidelines that have significantly impacted membrane project operational improvement, helped to decrease fouling and created methods to extend the life of membranes. Therefore, membrane research funded by the WRC was selected as a theme to perform an impact assessment on as showcase of the research funded by WRC and its impact on the South African and international society.

Report No: TT 366/08

ISBN: 978 1 77005 766 1

Overseas price: \$20.00 (excl. postage)

Guidelines for the Utilisation and Disposal of Wastewater Sludge, Volume 1 – 5: Impact Assessment

Cornelis van der Waal

The release of the 2006 Sludge Guideline series aims to rectify previous sludge guideline shortcomings and provide an easy to use management tool for the handling of wastewater sludge. The aim of this project was to quantify the potential impact of the 2006 Sludge Guidelines on South African society by analysing current examples of wastewater sludge best practice that are aligned with the 2006 Sludge Guidelines.

Numerous examples of wastewater sludge handling best practice were reviewed. A variety of organisations benefit economically from the re-use of wastewater sludge and distinct social impacts that stem from these economic benefits were also identified. Environmental impacts have resulted largely from unsustainable sludge handling and mismanagement practices.

The examples identified during the completion of this project clearly reflect that wastewater sludge management practices that are aligned with the 2006 Sludge Guidelines are having a significant impact across economic, social and environmental areas of South African society.

Report No: TT 370/08
ISBN: 978 1 77005 786 9
Overseas price: \$20.00 (excl. postage)

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

Kim Lesley Walsh

The purpose of this research was to assess whether being a

member of a large consumer unit, defined as more than eight people sharing a stand, results in inhibited access to water and sanitation services, and whether large consumer units find water and sanitation services to be unaffordable. This research suggests that large consumer units cannot be viewed simply as a homogenous group. Different types of consumer units, and different households making up those consumer units, face different challenges with respect to water and sanitation. Nuanced policy approaches will be necessary to help to alleviate these differing challenges. Such policy approaches might include considering programmes to upgrade backyard accommodation, and meter such accommodation separately; increases in the amount of Free Basic Water allocated to large consumer units; revisions to the rising block tariff structures, or consideration of alternative tariff approaches; and education programmes around the wise use of water. Indigent policies should also be reviewed to take large consumer unit size into consideration.

Report No: TT 371/08
ISBN: 978 1 77005 788 3
Overseas price: \$20.00 (excl. postage)

Development of a knowledge management system for operation of the algal integrated ponding system (AIPS) – A training and operations tool for small wastewater treatment plants

KJ Whittington-Jones, PD Rose, W Leukes, G Lok, Si Naidoo and D Lok

TSI had been approached by the Environmental Biotechnology Research Unit (Rhodes University) in 2001, with respect to providing a solution to the loss of valuable tacit knowledge at Sewage Processing Plants around the country due to high staff turnover. A knowledge management technique, developed by Gerrit Lok, was proposed as a possible solution and a demonstration site was recommended by the Water Research Commission and Rhodes University to evaluate the applicability

of this tool. The Integrated Algal Ponding System (IAPS) project, co-ordinated by the University at the Grahamstown Sewage Works was used for the demonstration of this tool. As part of its contribution towards the country's RDP, in terms of provision of low-cost sanitation for low-income consumers, the Water Research Commission (WRC) had embarked upon the IAPS project in Grahamstown. IAPS had been designed as both a demonstration plant and a research facility with the objective of promoting acceptance and advancing knowledge in the operation of low-cost photosynthetic water treatment systems.

The primary objective of this initiative was to capture the expertise, skills and knowledge developed by an individual or a team of individuals, who have performed demanding tasks at the IAPS. A secondary objective was to develop the decision-support system to allow for the simulation of fault conditions with appropriate remedial actions and reference to background support material. One of the main requirements of the diagnostic system was that it should not be another so-called "expert system" but would be a "non-robotic" system. In other words, when used for problem solving, it would actually enhance the learning of the user. A "hands-on" approach was used in this study to develop a totally comprehensive tool for the layman-operator.

A decision-support system was developed on an MS Access database using web page support for the decision tree and reasoning path. The final product was presented in the form of a CD to the client with installation and operational instructions.

Report No: TT 372/08
ISBN: 978 1 77005 791 3
Overseas price: \$20.00 (excl. postage)

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

G Mackintosh and U Jack

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

Report No: TT 373/08
ISBN: 978 1 77005 736 4
Overseas price: \$30.00 (excl. postage)

Technical and social acceptance evaluation of microfiltration and ultrafiltration membrane systems for potable water supply to rural communities

CD Swartz, MJ Philips, J Setlolela, B R Delcarme, JD Seconna

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

Report No: TT374/08
ISBN: 978 1 77005 781 4
Overseas price: \$30.00 (excl. postage)

Guideline for the inspection of wastewater treatment works

Lee Ann Boyd and AM Mbelu

The Department of Water Affairs and Forestry (DWAF) monitors Waste Water Treatment Works (WWTW) as mandated through

the National Water Act, 1998 (Act 36 of 1998). This is done through regular inspections of the WWTW. For an inspector to undertake inspections thoroughly and give proper guidance on any problems encountered, it is important that he/she fully understands the complex nature of the various unit processes involved in the treatment of wastewater. Equally, Process Controllers must have insight with regards to the aspects that are monitored during the inspection. This Field Guide provides Inspectors and Process Controllers with a tool to conduct inspections on a WWTW. It provides guidance on how to identify possible problem areas and makes recommendations on how to solve common problems. The guideline and electronic checklists will assist the Inspector undertaking the inspection providing guidance where a problem is identified as well as assist Process Controllers to prepare for an inspection at their WWTW and take corrective action where problems are identified.

Report No: TT375/08
ISBN: 978 1 77005 795 1
Overseas price: \$40.00 (excl. postage)

Community-based governance of freshwater resources in Southern Africa

S Pollard, T Cousins

One result of the process of democratisation is legal pluralism in areas of communal tenure, in that the traditional locally-derived rules and norms for natural resource management run in parallel to statutory systems. In addition, South Africa is about to implement reforms in the statutory systems aimed at brining about equity and sustainability. Within this complex social system, this project aimed to examine governance options for community based natural resource management in communal areas.

This project contributed to the growing discourse on legal pluralism in water management through examining local

or customary, laws in practice, focusing on water resource management. The research reviewed the status of community governance of water resources in four SADC countries (South Africa, Mozambique, Zimbabwe and Zambia), and documented the complementarities and tensions between statutory and customary systems in these countries. One lesson from these countries is that where the implementation of national legislation is weak, people revert to the traditional governance structures.

The reality is that legal pluralism will be part of the South African Water governance landscape for some time to come, and internationally-based research has warned that the 'neglect of customary laws may cause IWRM implementation to fail, or will have negative consequences for individuals and groups who were better served by customary-based systems – especially the poor'. The report concludes that we should not be constrained by a few idealised models of centrally managed water. Preferably let us seek innovative ways to integrate, or embed, common-property regimes with the formal, statutory system.

Report No: TT 328/08
ISBN: 978 1 77005 674 9
Overseas price: \$20.00 (excl. postage)

Standard methods for the recovery and enumeration of Helminth Ova in wastewater, sludge, compost and urine-diversion waste in South Africa

Priya Moodley, Colleen Archer, David Hawksworth and Lizette Leibach

These Guidelines detail a new classification system according to the microbiological class, stability class and pollutant class and total viable Helminth Ova have been added in the microbiology class. The Guidelines do not specify the analytical methods and as a result, different laboratories adopted different methods in South Africa. This project aims to validate a new EPA method for

measuring Helminth Ova in wastewater and wastewater sludge. The method and related literature with sufficient visual material will be documented and used to build capacity in South African water and wastewater laboratories to measure all Helminth Ova in wastewater sludge and wastewater samples.

Report No: TT 322/08
ISBN: 978 1 77005 648 0
Overseas price: \$25.00 (excl. postage)

Condensed laboratory methods for monitoring phytoplankton, including cyanobacteria, in South African freshwaters

Swanepoel A, du Preez HH, Schoeman C, J van Vuuren S, Sundram A

The project will compile a comprehensive methods manual for the analysis of phytoplankton, cyanobacterial toxins, Geosmin and MIB for South African freshwaters. Current methods used for phytoplankton identification and enumeration, cyanobacterial toxin analysis, as well as for Geosmin and MIB analysis will be synthesised and a summarised reference document compiled.

Report No: TT 323/07
ISBN: 978 1 77005 684 8
Overseas price: \$25.00 (excl. postage)

AquaLite Water Balance Software – User Guide

Roland Scott McKenzie

The methodologies used in AquaLite draw strongly on recent recommendations of Task Forces of the International Water Association (IWA). It should be noted that the methodologies for quantifying water losses contained in the AquaLite model are not the only methods used worldwide. They are, however, well-accepted and used extensively in many parts of the world and are

rapidly being recognised as the most appropriate and pragmatic techniques for assessing the water balance components for potable water distribution systems. AquaLite also includes the calculation of the Unavoidable Annual Real Losses (UARL) as well as the use of the Infrastructure Leakage Index (ILI) as a key performance indicator. These two parameters are currently the subject of considerable attention and debate throughout the world and are being used in many countries. When used properly they can provide very useful information on the performance of a water distribution system but must be used with care to ensure that the results are meaningful since there are situations where the estimates can be misleading.

Report No: TT 315/07
ISBN: 978 1 77005 599 5
Overseas price: \$10.00 (excl. postage)

Water Services and HIV/AIDS; Integrating health and hygiene education in the water and sanitation sector in the context of HIV/AIDS

(PLEASE DOWNLOAD FROM WEB: www.wrc.org.za)

Clacherty A, Potter A

This Water Research Commission study (Project K5/1634) arose from a growing realisation that, in relation to water and sanitation infrastructure development projects, there is little consistency or coherence of approach to health and hygiene education (H&HE). As a result, many interventions are ineffectual. Further, the linkages between HIV/AIDS and the improvement of water and sanitation facilities and related H&HE are poorly addressed in this country. The response involved considerable research over a period of time. It has identified factors which constrain and enable effective implementation of project-based H&HE in the context of HIV/AIDS. Based on that research and understandings of the context, it has developed and tested various institutional and financial arrangements and developed implementation

models based on this work. The study places considerable emphasis on the linkages between water and sanitation, health and hygiene education and HIV/AIDS. The impact of HIV/AIDS on the lives of many South Africans is severe; it is imperative that the water services sector formulates and implements an appropriate response as a matter of urgency. It is critical that issues around HIV/AIDS are mainstreamed, both in terms of prevention as well as in reducing the impact on people living with AIDS. Caregivers, in particular, require not only knowledge of water and sanitation and related health and hygiene issues, but also access to adequate quantities of water of good quality.

Report No: TT 316/07
ISBN: 978 1 77005 602 2
Overseas price: \$20.00 (excl. postage)

Report No: TT 317/07
ISBN: 978 1 77005 603 9
Overseas price: \$20.00 (excl. postage)

The assessment of training programmes and capacity needs for the water sector: Executive summary

Mjoli N, Schoeman G

The South African Government has committed itself to an ambitious target of eliminating the water and sanitation services backlog by 2008 and 2010, respectively. However, the current skills shortage at the local Government level poses a threat to the achievement of the water and sanitation delivery targets. The slow rate of delivery is largely due to inadequate technical skills in most municipalities. The problem is particularly acute within rural municipalities which have the lowest resource base and, at the same time, have the highest sanitation backlog figures.

The shortage of skills is not limited to the water services sector; the water resources management sector faces a similar problem.

There is a growing concern among sector stakeholders that the current approaches to skills development are not producing the numbers of skilled people that are needed to improve the performance of municipalities. This situation calls for a review of the current practices in skills development and training provided by public and private providers in order to identify factors that are hampering accelerated skills development, despite the availability of large budgets from the skills development fund.

Report No: TT 306/07

ISBN: 978 1 77005 554 4

Overseas price: \$10.00 (excl. postage)

Standardisation of the use of particle counting for potable water treatment in SA

Ceronio AD, Haarhoff J, Pryor M

Turbidity is a gross measure of the quality of potable water. Particle counting and size analysis is fundamental to a deeper understanding of flocculation, settling and filtration processes. The primary objective of water treatment is the removal of particles. This project investigated the use of particle size analysis as a control parameter for the optimisation of water quality, and compared this to the control using zeta potential and streaming current. It studied the effects of pretreatment processes such as ozonation and coagulation on the clarity of the filtered water by measuring particle size; and considered the use of particle size analysis together with CFD for the optimisation of water treatment equipment. The report stresses the importance of standardisation of this technology and also includes a substantial amount of fundamental principles and practices useful to potential users considering the implementation of this technology.

Report No: TT 166/01

ISBN: 1 86845 801 6

Overseas price: \$20.00 (excl. postage)

An illustrated guide to basic water purification operations.

Bouwer JL, Haylett

Lack of skills because of lack of training was identified as one of the most important hindrances to the supply of good quality potable water, especially in rural areas. Suitable training material is not available and current training material is inadequately targeted for rural operator training. A cartoon based operator manual for sewage plant operator training had previously been completed and proved to be a big success. Therefore, it was seen as appropriate to complete a similar guide for operator training on, especially, small- to medium-sized water treatment plants

Report No: TT 247/05

ISBN: 1 77005 323 9

Overseas price: \$30.00 (excl. postage)

Corporatisation of municipal services providers

Development Group, University of Western Cape

The restructuring of municipal water departments into stand-alone companies has been a long-standing subject of debate within the industry. This study aimed to further explore the concepts of corporatisation and its relevance to the South African water sector by, combining an international literature review with local case studies and policy reviews. The research concludes that corporatisation in itself does not guarantee performance. Whilst a shift in legal form from a municipal department to a stand-alone legal entity can make a difference, this is not the only or major determinant of performance. Various objective factors and broader governance factors are likely to have a greater impact than simply the legal form of the utility. Further corporatisation may be a suitable option for some municipalities. For capacity reasons corporatisation is only likely to be feasible within the large metro poles at this stage. As the experience

base grows within South Africa, and transaction costs diminish, corporatisation may become feasible for smaller local authorities. This study highlights that before embarking on a corporatisation process municipalities should assess whether they have sufficient financial, managerial and political capacity to see the process through.

Report No: TT 199/02
ISBN: 1 86845 897 0
Overseas price: \$25.00 (excl. postage)

Management of water-related microbial diseases.

DWAF, WRC

The purpose of this guideline series is to provide awareness building and management information on the nature and prevention of important water-related microbial diseases. The purpose of volume one in the series, "Disease characteristics", is to introduce and describe the basic facts of some important water-related diseases. This guide is primarily an awareness building guide to educate the upcoming generation in the need for: (1) disinfected drinking water, (2) safe waste disposal, (3) good personal and kitchen hygiene, and (4) protection of water resources from faecal pollution.

Report No: TT 175/03
ISBN: 1 86845 849 0
Overseas price: \$25.00 (excl. postage)

1. Guidelines for the appropriate management of urban runoff in SA

Ashton PJ, Bhagwan JN

As the aim of this study was to establish general guidelines for the management of urban runoff water quality, especially focusing on dense settlements, urban runoff quality is a country-

wide problem, the causes of which must be addressed. Past attempts to intercept urban storm water and channel it through a single storm water system to receiving water have failed. As storm water quality may be worse than treated sewage effluent and sometimes even raw sewage, treatment of storm water at some stage before discharge to the receiving waters has to be considered. Present engineering storm water management options do not cater for improving storm water quality. The impact of low-cost, high-density urban land use on the catchment warrants serious attention. Appropriate sanitation and waste disposal for peri-urban areas requires fundamentally new approaches. It is imperative therefore that applied research into these areas be conducted for the protection of South Africa's limited water resources.

Report No: TT 155/01
ISBN: 1 86845 764 8
Overseas price: \$15.00 (excl. postage)

2. Expert system for design of storm water management systems for urban runoff quality

Coleman TJ

Report No: TT 156/01
ISBN: 1 86845 768 0
Overseas price: \$15.00 (excl. postage)

PRESMAC: Development of a pragmatic approach to evaluate the potential savings from pressure management in potable water distribution systems in South Africa. (Presmac User Guide Version 1.1)

McKenzie R, Lambert A

This document incorporates the user guide to the South African Pressure Management and Control (PRESMAC) model which has been developed through the Water Research Commission (WRC)

funded project titled “The Water Leakage: Pressure Management Model”.

The PRESMAC model represents one of several models that are being developed through the WRC in order to assist water suppliers to manage and reduce their levels of unaccounted-for water. The models are supplied free-of-charge through the WRC for use within South Africa and further details can be obtained from the WRC web site on: <http://www.wrc.org.za>.

Report No: TT 152/01
ISBN: 1 86845 722 2
Overseas price: \$20.00 (excl. postage)

Financial planning for infrastructure services at district level: A user guide to the district services model. Version 1.1

Palmer Development Group

This manual outlines the philosophy behind the model, its aims, limitations and key assumptions. The structure and operation of the model is described in detail, covering the required data inputs and the meaning and presentation of the various outputs.

The District Services Model (DSM) has been designed to assist district municipalities to undertake financial analysis of infrastructure investment plans. The model performs this analysis at two levels:

Level 1: District-wide infrastructure planning, and
Level 2: Medium-term Council budgeting.

Report No: TT 143/01
ISBN: 1 86845 680 3
Overseas price: \$15.00 (excl. postage)

A guide to non-point source assessment to support water quality management quality of surface water resources in SA

Pegram GC, Gorgens AHM

The primary focus of this guide is to support water quality management of surface water resources, and particularly non-point sources management, through the provision of appropriate and cost-effective information for decision making.

Report No: TT 142/01
ISBN: 1 86845 677 3
Overseas price: \$20.00 (excl. postage)

The Development of Effective Community Water Supply Systems using Deep- and Shallow-Well Hand pumps

Hazelton DG

Deep- and shallow-well hand pumps are used extensively for rural community water supplies over large parts of South Africa. Very often, however, these installations fail to meet the requirements even though they are considered to be one of the simplest community water supply technologies.

It has, however, been demonstrated in other parts of the world that high failure rates are not inevitable and that these schemes can be transformed into reliable low-cost solutions through the adoption of the so-called village level operation and maintenance (VLOM)-concept, where appropriate design technologies and implementation policies are systematically included. The study indicated that 10% of the South African populations (2 million people) are dependent on the estimated 10 000 hand pumps which exist in this country. This can be equated to an investment of about R400 million, and the study estimates that between 40% and 50% of the hand pumps are not working at any one time.

Report No: TT 132/00
ISBN: 1 86845 629 3
Overseas price: \$25.00 (excl. postage)

Applicability of waste minimisation clubs in South Africa: Results from pilot studies

Barclay S; Buckley C

Industrial small-, medium- and micro-enterprises (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, renders ITEMS an extremely versatile information tool. The total computer file size of the databases is 87 Mbytes. ITEMS is available on CD-ROM.

Report No: TT 94/98
ISBN: 1 86845 378 2
Overseas price: \$70.00 (excl. postage)

Solids-free sewer systems in South Africa: A community leader's guide

Du Pisani JE

This study evaluated the STED systems in South Africa. It showed that STED systems were used on over 16 000 erven in South Africa. The study showed that problems experienced with these systems were mainly due to poor operation and maintenance and some incidents of blockages were due to incorrect design and construction of the STED systems. The study concludes that with proper design, operation and maintenance, STED systems offer a cheaper alternative of meeting the sanitation needs of. The output of this research includes two guidelines, namely Operation and Maintenance of Solids-free Sewer Systems in South Africa: Guidelines for Engineers; and Solids-free Sewer Systems in South Africa: A Community Leader's Guide.

Report No: TT 96/98
ISBN: 1 86845 401 0
Overseas price: \$20.00
excl. postage

Handbook to guide communities in the choice of sanitation systems

Bernhardt Dunstan and 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

Ramotlholo JS, Ringas C

The brochure highlights cost-effective ways in which external corrosion can be minimised. The brochure can also be useful to repair teams working in the field. The brochure contains colour photographs showing the different forms of corrosion in order to assist field teams to correctly identify the cause of the failure. Appropriate repairs can then be carried out. The brochure also describes how each local authority can build up its own database, thereby assisting in the long-term strategy of each local authority by ensuring that correct corrosion prevention strategies are used.

Report No: TT 112/99
ISBN: 1 86845 510 6
Overseas price: \$15.00 (excl. postage)

Domestic water supply: Guides

The provision of an adequate and safe water supply to all people is one of the goals of the South African Government. To ensure the safety of water supplies, a need for a user-friendly Guide to facilitate evaluation of the health-related quality of water supplies was identified as a priority by both the Departments of Health and Water Affairs and Forestry. This resulted in the production of a series of guides.

This Guide forms part of a series which is intended to provide water supply agencies, water resource managers, workers in health-related fields, as well as communities throughout South Africa, with the information they need to sample, analyse, assess and interpret the quality of domestic water supplies.

The following documents from the series:

Quality of domestic water supplies –
Vol: I: Assessment Guide TT 101/98

Report No: TT 101/98
ISBN: 1 86845 416 9
Overseas price: \$25.00 (excl. postage)

Quality of domestic water supplies –
Vol II: Sampling Guide1 TT 117/99

Report No: TT 117/99
ISBN: 1 86845 543 2
Overseas price: \$15.00 (excl. postage)

Quality of domestic water supplies –
Vol III: Analysis Guide1 TT 129/00

Report No: TT 129/99
ISBN: 1 86845 620 X
Overseas price: \$20.00 (excl. postage)

Quality of domestic water supplies –
Vol 4: Treatment guide TT 181/02

Report No: TT 181/99
ISBN: 1 86845 873 3
Overseas price: \$30.00 (excl. postage)

Quality of domestic water supplies –
Volume 5: Management Guide TT 162/01

Report No: TT 162/99
ISBN: 1 86845 809 1
Overseas price: \$30.00 (excl. postage)

The management of urban impoundments in South Africa volume 2: Guideline manual

Freeman MJ, Howard MR, Wiechers HNS

This Urban Impoundment Management Guideline Manual is the product of a research project carried out for the Water Research Commission to investigate the water-quality problems most commonly experienced in South African urban impoundments, as well as the management techniques which can be used to address them.

The purpose of the Guideline Manual is to assist those responsible for, or with an interest in, the management of the water quality of urban impoundments. It is thus aimed predominantly at those persons in local authorities who must manage the water bodies in their areas.

Report No: TT 119/00
ISBN: 1 86845 553 X
Overseas price: \$25.00 (excl. postage)

The economic cost effects of salinity – integrated report

Urban-Econ Development Economists

As the salt content of water increases, the water becomes less suitable for most users, and additional costs are incurred. The study was undertaken because of uncertainties about some of the methodology and assumptions that were used in the desk study and the need for a versatile economic model that can be used to quantify the effect of salinity in monetary terms and to compare the cost-benefit ratios of alternative options. A generic methodology to determine the financial, economic and social impacts associated with an increase in salt concentration were first developed, and then applied by conducting a survey to determine the impacts of increased salt concentrations in the middle Vaal River.

Report No: TT 123/00
ISBN: 1 86845 590 4
Overseas price: \$20.00 (excl. postage)

Defluoridation, denitrification and desalination of water using ion-exchange and reverse osmosis

Schoeman JJ, Steyn A

This project concentrated on demonstrating the feasibility of using advanced adsorption, ion-exchange and membrane technologies to remove fluorides, nitrates and dissolved suspended solids from groundwater in order to produce potable water for rural communities which are remote from first-world infrastructure. Activated alumina, ion-exchange and reverse-osmosis systems were evaluated at a number of rural sites

in terms of both technical and social acceptance factors. The results achieved in these demonstration studies show that activated alumina and ion-exchange processes and advanced water treatment processes such as membrane filtration can be employed successfully for the purification of adverse-quality groundwater to potable standards in the rural areas.

Report No: TT 124/00

ISBN: 1 86845 597 1

Overseas price: \$20.00 (excl. postage)

Land-based effluent disposal and use: Development guidelines and expert systems-based decision-support

Murphy K O'H

Effluents and soils were identified as factors which help in the process of making decisions on the applicability of a specific effluent on a specific land. The identification of the effluent takes into account health-related aspects, the risk of pollution to the water source and the effects of it on plants. The identification of the soil relates to the ability of soils to attenuate the contaminants in the effluents.

The user guide takes one through the process in order to be able to determine whether the combination is acceptable or not and whether it conforms to health guidelines. If this is acceptable, it is indicative of restrictions or protective measures. ELADS Effluents to land-application decision-support software is the expert systems-based decision-support software developed. It could be used not only for sewage effluents, but also for organic effluents, to some extent for nitrogenous effluents and effluents containing potentially toxic trace elements. It could be modified to accommodate any site, soil or effluent-related limits specified by new regulations. (WRC Report No TT 125/00).

Report No: TT 125/00

ISBN: 1 86845 551 3

Overseas price: \$20.00 (excl. postage)

The level of communication between communities and engineers in the provision of engineering services

Pybus P, Schoeman G, Hart T

The purpose of this research was to test the hypothesis above and to establish how engineering information, for example, concerning the level of service, can best be given so that the community leaders can make a decision based on sound knowledge of the technicalities of the situation. In an analysis of the major factors that negatively affect communication between consultants (specifically engineering) and communities, it was found that the majority of factors stemmed from a lack of integrated and comprehensive project planning.

The findings from this study are supported by an excellent set of guidelines, aimed at improving communication processes between practitioners and communities in water and sanitation development projects.

Report No: TT 133/00

ISBN: 1 86845 630 7

Overseas price: \$20.00 (excl. postage)

Waste minimisation guide for the textile industry: A step towards cleaner production: Vol I

Barclay S, Buckley C

The Waste Minimisation Guide for the Textile Industry has been found to be a useful tool for assisting the RSA textile industry to improve its environmental performance in the following areas of application:

- The textile industry can use the Guide to self-assess and improve its implementation of waste minimisation practices and, hence, its aquatic environmental performance.
- Similarly, use of the Guide will assist factories in achieving compliance with environmental management standards e.g. ISO 14000, and, thereby, improving their international competitiveness.
- Local regulatory authorities can use the Guide both as a training tool and as a management tool for monitoring and assessing the performance of textile manufacturers in their area of jurisdiction.

Report No: TT 139/00
 ISBN: 1 86845 659 5
 Overseas price: \$20.00 (excl. postage)

Waste minimisation guide for the textile industry: A step towards cleaner production. Vol II

Report No: TT 140/00
 ISBN: 1 86845 659 5
 Overseas price: \$20.00 (excl. postage)

Human resources planning and management system (HRPMS) user manual

Stewart Scott

The study has developed a management tool to help managers to implement integrated human-resource planning of water service institutions. The report focuses on the human resources that are required in order to support the infrastructure, as well as the organisational structure requirements of various sizes of water service institutions. The computerised human resources planning and management system (HRPMS), which was developed for water service institutions through this study, includes facets of both a management information system (MIS) as well as a

decision-support system (DSS). The management component of the HRPMS includes portions of the job analysis and employee profile modules. The reporting facilities provided by the HRPMS facilitate management, planning and decision making.

Report No: TT 146/01
 ISBN: 1 86845 686 2
 Overseas price: \$15.00 (excl. postage)

Assessment of the attended coupon-operated access-point cost recovery system for community water supply schemes

Lima Rural Development Foundation

The study highlights parameters in which attended coupon operated access point cost recovery system operates efficiently by analysing seven existing schemes. The research to identify the operational constraints that community water supply schemes are currently facing by conducting sample surveys in the schemes.

Report No: TT 150/01
 ISBN: 1 86845 716 8
 Overseas price: \$15.00 (excl. postage)

Development of a simple and pragmatic approach to benchmark real losses in potable water distribution systems in South Africa: BENCHLEAK

Ronnie McKenzie, Allan Lambert

The BENCHLEAK software and this User Manual are part of the ongoing process of refining and improving the methodologies for calculating and presenting performance data associated with management of public water supply systems in South Africa.

Report No: TT 159/01
ISBN: 1 86845 773 7
Overseas price: \$20.00 (excl. postage)

The BENCHLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: <http://www.wrc.org.za>

Development of a Windows-based package for assessing appropriate levels of active leakage control in potable water distribution systems: ECONOLEAK

Ronnie McKenzie

The ECONOLEAK model is aimed specifically at determining when a water supplier should invest in active leakage control for a specific zone metered area.

Report No: TT 169/02
ISBN: 1 86845 832 6
Overseas price: \$20.00 (excl. postage)

The ECONOLEAK software is available from the Water Research Commission and further details can be obtained from the web site at: <http://www.wrc.org.za>

Guidelines for the implementation of benchmarking practices in the provision of water services in South Africa

Pybus P

The guidelines are intended to encourage the local authorities to benchmark their activities with their peers with a view to delivering water and sanitation services in a more effective and efficient manner.

Benchmarking offers a route to more effective and efficient service delivery.

Report No: TT 168/02
ISBN: 1 86845 842 3
Overseas price: \$20.00 (excl. postage)

Environmentally responsible mining: Water management guidelines for small-scale mining

Clacherty A, Moodie P

This report identifies and characterises the critical water-related impacts of small-scale mining and is developing appropriate tools to assist their environmental management. The study focused primarily on the water-related issues of peat extraction, clay-mining for brick making, alluvial diamond-mining and other small-scale mining activities associated with gravels, alluvial sands and sediments.

Report No: TT 170/04
ISBN: 1 86845 833 4
Overseas price: \$20.00 (excl. postage)

Guidelines for the application of natural stone trickling filters with some reference to synthetic media trickling filters

Wates, Meiring, Barnard (Pty) Ltd

Trickling filters are applied in many domestic and industrial wastewater treatment plants in Southern Africa. Trickling filtration technology is still evolving and this document provides current information on the design, operation and maintenance of filters.

Report No: TT 178/02
ISBN: 1 86845 852 0
Overseas price: \$15.00 (excl. postage)

Water and wastewater management in the oil refining and re-refining industry: NATSURV 15

CSIR

In this study the water intake, water use and pollutant loads of the crude oil refinery, synthetic fuel refinery and refining sectors of the industry were surveyed and characterised. Crude oil refineries in the RSA were found to have a relatively narrow range of specific water intake (SWI 0.51 to 0.67 m³/t) and re-refining SWIs were found to vary widely (0.06 to 7.2 m³/t), depending on the type of process used. The results obtained present a snapshot of the water and wastewater characteristics of the industry in which crude oil refining (at four refineries) is around 20 million t/a, syn-fuel refining (at two refineries) is around 9 million t/a and oil re-refining is around 120 000 t/a. In addition to the water and effluent survey data, the Guide produced contains a number of specific recommendations for reducing water use and effluent generation in the industry.

Report No: TT 180/05
ISBN: 1 86845 508 4
Overseas price: \$15.00 (excl. postage)

Elementary handbook of water disinfection

Carlsson FHH

The salient features of the handbook covers:

- Description of water disinfection processes, principally chlorination and chloramination but including ozonation, peroxone, chlorine dioxide and ultraviolet treatments
- Written such that it is understandable by non-specialists in water treatment plants and informed lay-persons
- To be used as an aid in effective education and training of plant personnel while avoiding detailed chemistry
- To be used as a ready reference for daily use on water purification plants where disinfection is implemented.

Report No: TT 205/03
ISBN: 1 86845 983 7
Overseas price: \$20.00 (excl. postage)

Watrex expert system for water treatment plant design (SA 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

Lenehan AM, Abelitis L

This study investigated the cost-recovery efficiency of the trickle feed system. In this system a known quantity of water is delivered each day to a storage tank at each customer's house. This allows the implementation of a monthly prepaid cost-recovery system with relatively low administration. There are potential benefits of implementing the trickle feed system in rural areas and it is currently implemented in pilot projects in Northern KwaZulu-Natal.

Report No: TT 210/03
ISBN: 1 77005 031 0
Overseas price: \$10.00 (excl. postage)

The measurement and reduction of urban litter entering storm water drainage systems

Marais M Armitage N

This project addresses the following aims:

- The improvement in the knowledge of the source type and amount of urban litter coming from different types of urban catchments; and
- Provision of scientific data on the efficacy of various management techniques in reducing the amount of urban litter reaching drainage systems. This information, together with the knowledge, would enable the development of Litter Management Plans (LMPs) resulting in reduced litter loadings and realising considerable cost savings.

Report No: TT 211/03

ISBN: 1 77005 041 8

Overseas price: \$30.00 (excl. postage)

A guidebook on household water supply for rural areas with saline groundwater

Goldie I, Sanderson RD

This report captures and presents options of small-scale water purification technologies for potable water supply to farms, schools, clinics and small communities from brackish surface water sources. The report produced in the form of a guide will assist decision-makers in the selection of these technologies. Both membrane- and distillation-based technologies have been assessed, mostly in terms of a desk study. Recently developed local innovations are also included into this guide.

Report No: TT 221/04

ISBN: 1 77005 107 4

Overseas price: \$30.00 (excl. postage)

Feasibility of water fluoridation for South Africa

Genthe B, Herold CE Haarhoff J, Hosking S, Syke G

A team, consisting of five experts in their fields, was requested to perform a desk study to identify both the positive and negative consequences which could be expected to arise following the fluoridation of potable water supplies in South Africa.. Results from the study for the first time summarise and bring together a whole spectrum of aspects to take into consideration when potable water supplies are fluoridated. The results show that further actions, including further research, are required before fluoridation can be effected with full safety and confidence in a developing country such as South Africa.

Report No: TT 222/04

ISBN: 1 177005 108 2

Overseas price: \$25.00 (excl. postage)

A summary of lessons and experiences from the 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 Pit latrines (VIPs) and conventional sewerage. With this as a stimulus, the Durban Metro Water was the first local authority to indicate interest in taking the recommendations further. This study captures the lessons and experiences from the pilot implementation of the shallow sewers.

Report No: TT 225/04

ISBN: 1 77005 135 X

Overseas price: \$20.00 (excl. postage)

An introduction to the concepts of customer relations management for water services institutions

Naidoo J, Mosdell T

The fact that the concept of customer service has received little attention in South Africa is perhaps related to the historic situation where water supply and sanitation services were provided on a monopolistic take it or leave it basis, particularly in the case of poorer customers. It is now recognised increasingly that successful water services provision is strongly associated with the application of good business principles. This implies a service orientation, with a primary focus on the customer. This report provides an overview of customer management, principles and methodology.

Report No: TT 227/04

ISBN: 1 77005 147 3

Overseas price: \$20.00 (excl. postage)

Community identified performance indicators for measuring water services

Schoeman G, Magongoa

This work implements the major recommendation arising from the comprehensive multi-stakeholder WISA Sludge Management Group in the consultative process coordinated by the WRC to review and update the current published sludge management guidelines.

Report No: TT 228/04

ISBN: 1 77005 158 9

Overseas price: \$15.00 (excl. postage)

Guidelines for economic regulation of water services in South Africa

Palmer Development Group

For the regulation of water services to become effective in South Africa, considerable work needs to be undertaken. In particular the methodology to be used in undertaking economic regulation is one of the key components. This report has investigated the subject of economic regulation and its relevance to South Africa and has defined the manner in which water services authorities should regulate water services providers, within the current legislative framework. It highlights the importance of the methodology for economic regulation and in particular regulating tariffs and associated financial parameters. This report is aimed to stimulate discussion on the subject matter, towards effective economic regulation.

Report No: TT 229/04

ISBN: 1 77005 164 3

Overseas price: \$20.00 (excl. postage)

Guidelines on reduction of the impact of water infiltration into sewers

Stephenson D, Barta B

The effects of urban developments on storm water quality and quantity as well as groundwater infiltration into the sewer facilities cannot be left anymore to ad hoc solutions and there is an urgency for a strategic approach to these problems. This report based on identifying and quantifying the problem of ingress, provides the necessary strategy and answers to these problems.

Report No: TT 239/05

ISBN: 1 77005 264 X

Overseas price: \$20.00 (excl. postage)

Benchmarking of leakage from water reticulation systems in South Africa

McKenzie RS, Seago C

In the attempt to get a better handle on the level of leakage at a municipal and national level, this study was undertaken in order to assess the levels of leakage in various water utilities throughout South Africa. The standard water auditing model BENCHLEAK, previously developed through a WRC study was used for the analyses since it is relatively simple to use and follows the standard IWA and BABE leakage benchmarking methodology. Benchleak introduces the concept of Infrastructure Leakage Index (ILI) as a standard method for the purpose of leakage evaluation, as it has been found to be the most reliable and meaningful indicator.

Report No: TT 244/05
ISBN: 1 77005 282 8
Overseas price: \$25.00 (excl. postage)

Water and waste-water management in the power generating industry (NATSURV 16)

Van Zyl HD, Premllal K

The power-generating industry in the RSA is a substantial water user and effluent producer and impacts nationally both on water use allocations and the maintenance of resource water quality. The report provides the volumes and breakdown of water taken in and discharged by major and minor power generating plants, to determine pollutant loads and identify suitable wastewater management processes and strategies, and to a guideline document assisting both the industry and regulators in effective water and wastewater management of this sector.

Report No: TT 240/05
ISBN: 1 77005 270 4
Overseas price: \$15.00 (excl. postage)

Ecological sanitation – Literature review

Austin LM, Duncker LC, Marsebe, Phasha MC, Cloete TE

Urine-diversion sanitation systems have been successfully implemented in many countries; including South Africa where about 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. This report captures the state of knowledge on urine diversion toilets.

Report No: TT 246/05
ISBN: 1 77005 322 0
Overseas price: \$25.00 (excl. postage)

Guidelines for ensuring sustainable effective disinfection in small water supply systems

Momba MNB, Brouckaert BM

This is a follow-up to a previous project that evaluated a combined chlorine-monochloramine disinfection process for the inhibition of bacterial and bio-film 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.

Report No: TT 265/06
ISBN: 1 77005 428 6
Overseas price: \$25.00 (excl. postage)

The development of a successful unaccounted-for water management programme in the rural water supply context

Ross-Jordan J

The challenge to develop simple and effective systems that are easily understood by water committees has resulted in this report which can be used by the community as well as their local authority to manage water losses in distribution systems.

Report No: TT 256/06
ISBN: 1 77005 392 1
Overseas price: \$20.00 (excl. postage)

The use of key performance indicators in the benchmarking of rural water supply schemes: An aid to development of meaningful local Government capacity

Still D, Balfour F

New local authorities have limited knowledge on the nature of inspection needed to promote good management at community level. Therefore, the challenge was to develop simple and effective systems that are easily understood by water committees. These can be used to report to the community as well as to their local authority. This report provides a set of key performance indicators (KPIs) which have been tested on a number of RDP projects that are presently being transferred from Umgeni Water to relevant district councils in KwaZulu-Natal.

Report No: TT 255/06
ISBN: 1 77005 391 3
Overseas price: \$25.00 (excl. postage)

The WRC community based health and hygiene model and implementation kit

Bolu O, Maliti N

This research seeks to support the acceleration of sanitation service delivery without improving developmental principles such as demonstration of ownership and community-based participation. The study will investigate methods of improving communities so that they can earn an income which will enable them to make a partial contribution to the costs of building toilets. The study will be undertaken in selected villages in the Eastern Cape.

Report No: TT 264/06

ISBN: 1 77005 427 8

Overseas price: \$20.00 (excl. postage)

A strategic framework for water-related human health research

Venter SN, Mjoli NP

The report is a compilation of a framework and strategy plan to guide the future funding of priority research on the improvement of water-related human health in Southern Africa. The plan had to include health related aspects of all human-water interactions. The plan further identifies research gaps for future, local, research on water-related human health and a list of institutions and researchers active in health research, both nationally and internationally.

Report No: TT 257/06

ISBN: 1 77005 404 9

Overseas price: \$20.00 (excl. postage)

1. Waste Minimisation Clubs in SA (Facilitator's Manual)

2. Waste Minimisation Clubs in SA (Training Manual)

Barclay S, Buckley C

Previous WRC Project No. 973 detailed the feasibility of waste minimisation (WasteMin) clubs as a model for achieving significant improvements in environmental performance by local industry. The aim of this follow-up project No. 1171 was to develop a methodology for promoting, managing and sustaining waste minimisation clubs, by producing inter alia guides for effectively establishing and managing WasteMin clubs, specific sectoral self-assessment guides, and training material for WasteMin consultants in a franchised operation.

The project's two technology transfer products are a Facilitator's Manual and a Training Manual. The Facilitator's Manual is aimed at a person or organisation that wishes to initiate a waste minimisation club and requires guidelines for undertaking such a project. It addresses aspects such as how to form a club, call meetings, determine the level of contributions from companies, identify some of the problems that can occur, and explains the various roles of the people involved. It also provides sample letters and presentations, and provides sources of information. The Facilitator's Manual draws on the experiences gained in the previous WRC project no. 973 and also that gained from facilitators of other waste minimisation clubs in South Africa, facilitated by various organisations such as consultants, university researchers and, in at least one case, by the company itself as an in-house club.

Report No: TT 283/07

ISBN: 978 1 77005 493 6

Overseas price: \$30.00 (excl. postage)

Report No: TT 284/07
ISBN: 978 1 77005 494 3
Overseas price: \$20.00 (excl. postage)

Life cycle costing analyses for pipeline design and supporting software

van Vuuren SJ, van Dijk M

There are various factors that influence the hydraulic capacity and pipeline designers need to take all of these into consideration during the design. For instance the estimation of roughness parameter for a pipeline has a significant effect on the hydraulic capacity and operational costs. An underestimation of this parameter can be catastrophic when the required demand cannot be met. Findings identified that the two main contributing factors of energy losses are:

- Inherent resistance against flow exerted by the fluid (i.e. viscosity).
- The friction losses resulting from the interface between the fluid and the conduit boundary (i.e. shear), as well as secondary losses resulting from abrupt local changes in the system.
- The roughness parameters that are normally quoted by manufacturers tend to be too low.

Report No: TT 278/07
ISBN: 1 77005 449 9
Overseas price: \$20.00 (excl. postage)

A research strategy for the detection and management of algal toxins in water sources

Harding WR

This analysis undertaken in support of the development of a cyanobacterial and cyanobacterial toxin research strategy in South African water sources has identified two vital planning elements:

- The need to create a management and support infrastructure
- 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 organisations not be implemented. To South Africa's advantage is its current involvement in both the Global Water Research Coalition (GWRC) and CYANONET initiatives, plus willingness expressed by international specialists formerly associated with cyanobacterial work in South Africa to continue their association. Allied to this is the cosmopolitan nature of the cyanobacterial problems as experienced worldwide. This analysis was fortunate to have been commissioned during the year (2004) that saw the launch of the GWRC and CYANONET initiatives, as well as two key international conferences that allowed for the identification of globally-relevant research initiatives and emerging issues. The strategy proposed here is based on comparing and contrasting the current directions and emerging issues in international cyanobacterial research with identified South African needs. From this analysis a suite of key research issues have been formulated.

Report No: TT 277/06
ISBN: 1 77005 461 8
Overseas price: \$20.00 (excl. postage)

Guidelines for the design, operation and maintenance of urine-diversion sanitation systems

Austen LM

If a dry toilet (i.e. not requiring water for its operation) is designed and constructed in such a way that the faeces vault can be quickly, easily and safely emptied, then one of the biggest maintenance problems will be obviated. If the processed excreta can also be productively and safely used for agriculture, the technology will become even more attractive. In South Africa,

where many rural communities rely on subsistence agriculture, often in poor soils, and with urban agriculture becoming more common, this is an important aspect. Urine-diversion sanitation systems address the above opportunities. They have been successfully implemented in many countries, including South Africa where more than 3 000 of these toilets are already in existence. However, despite much research having been carried out internationally and locally, various questions still remain, particularly on the health aspects of operation, maintenance, and excreta reuse or disposal. A need has thus been identified to create further competence in this area of sanitation in South Africa, and to increase knowledge concerning the technology. The technology is increasingly being introduced in a manner which consists of faulty design, poor implementation and improper use. This study developed strategies and guidelines, through monitoring and evaluating existing schemes, which would provide fundamental answers in the sustainable management of this technology.

Report No: TT 275/06

ISBN: 1 77005 456 1

Overseas price: \$15.00 (excl. postage)

A desalination guide for South African municipal engineers

du Plessis JA, Burger AJ, Swartz CD, Musee N

Municipalities have to develop Water Service Development Plans (WSDP's) as part of Integrated Development Plans (IDP's) as a first requirement in their budgetary process, and have to be aware of what options are available to provide adequate water services. While 25l/person/day has been set as the minimum basic water supply and while many consumers receive far in excess of this amount, there are areas of the country where enough fresh water of acceptable quality is not available for household use. However, in many areas adequate quantities of saline water may be or are readily available. This is especially

the case for coastal cities and towns. The cost of treating water is a fraction of the total cost of making water available to the consumer. This, together with the fact that membrane desalination technology is becoming more affordable, makes the overall water tariff less dependent on the cost of desalination. In other words, desalination may in many cases become a viable option to supply fresh water for domestic purposes. Therefore, DWAF identified a need to provide guidelines and procedures to select and evaluate suitable treatment options for desalinating sea water from both the Indian and Atlantic oceans, or brackish water from boreholes.

The specific objectives of the project were to identify the technologies which may currently be commercially implemented in South Africa to treat saline water to drinking water standards, to identify typical pre-treatment requirements, and to identify the most common technical, operating and environmental problems experienced in the selection and use of these technologies. An important aspect was also to provide estimates for capital and operating costs, as would be required to successfully bring the water to the accepted standards for potable and domestic use. Of particular importance for the South African application was to identify the level of skills required for daily operation of the desalination plants, the level of skills required to provide technical back-up and advice, and to identify and advise on the competencies, training needs and capacity building required at operator and management levels. Lastly, the relevant local environmental legislations governing desalination were also identified.

Report No: TT 266/06

ISBN: 1 77005 431 6

Overseas price: \$30.00 (excl. postage)

Generic incident management framework for toxic blue-green algal blooms, for application by potable water suppliers

Du Preez H, van Baalen

An increase in the eutrophication of surface water resources is leading to increased incidence of toxic blue-green algae growth – thereby increasing health risks when drinking water from a treatment plant which does not use activated carbon adsorption in its process train. No structured framework yet exists in South Africa to manage the supply of safe drinking water during a persistent blue-green algae bloom in the source water. The project aims to establish such a pro-active approach by means of a generic algal bloom incident management framework to effectively manage potable water supply when toxic algal blooms are present. Such a system will be widely applicable to water services providers and will reduce the risk of human incidents related to blue green algae toxins by providing this framework for informed and appropriate pro-active management measures.

Report No: TT 263/06

ISBN: 1 77005 472 3

Overseas price: \$25.00 (excl. postage)

An assessment of non-revenue water in South Africa

Seago CJ, McKenzie RS

Municipal water use in South Africa has been under investigation for many years and the Department of Water Affairs and Forestry has been trying to establish the levels of wastage from all water supply systems countrywide. This has proved a very difficult task due to the absence of reliable data in many Municipalities as well as confusion regarding how such wastage should be estimated. Until the wastage can be quantified accurately, it is impossible to develop and prioritise the actions that must be taken to ensure

that water is used effectively and efficiently in this water scarce country. Despite many problems associated with the gathering of data from the various water utilities, the study was able to obtain information from 62 of the largest water reticulation systems throughout South Africa. It was found that the average bulk system input volume per property served for the 19 low-income areas analysed as part of the study was approximately 37kl per property per month. The losses (real and apparent) for the 62 systems analysed was estimated to be 623 million m³/annum or 29% of the total water supplied.

Report No: TT 300/07

ISBN: 978 1 77005 529 2

Overseas price: \$20.00 (excl. postage)

KSA 4:

1. On-farm application of in-field rainwater harvesting techniques on small plots in the central region of South Africa : Vol 1 – Main Report

JJ Botha, JJ Anderson, DC Groenewald, NN Nhlabatsi, TBZere, N Mdibe and MN Baiphethi

Report No: TT 313/07

ISBN: 978 1 77005 595 7

Overseas price: \$20.00 (excl. postage)

2. On-farm application of in-field rainwater, harvesting techniques on small plots in the central region of South Africa – Vol 2: Extension manual

Botha JJ, Anderson JJ, Nhlabatsi NN

Water harvesting is the process of concentrating rainfall as runoff from a larger area for its productive use on a smaller

area. A number of Water Research Commission projects on the In-field rainwater harvesting (IRWH) technique have demonstrated that rural communities can greatly benefit from this production practice. Intensive field experiments on clay and duplex soils, conducted over a period of six seasons, indicated that IRWH increased maize and sunflower yields by as much as 50%, compared to conventional production techniques (CON). Research results over a number of years have indicated that the IRWH technique is sustainable in terms of increased agronomic productivity, reduction of risk, conservation of the natural resources base, social acceptability and economic feasibility. This technology transfer project was initially planned for implementation in six rural communities around the towns of Thaba Nchu and Botshabelo in the Free State Province.

The technology exchange process expanded rapidly resulting in many more households and communities than initially anticipated implementing the IRWH technique that the need arose to employ a proper exit strategy that ensured continued implementation of the technique by interested communities. As the number of farmers and communities using IRWH techniques increased, a decision was taken by representatives from each group and community to form a municipal-based water harvesting interest group (MB:WHIG). This body was later named the Tswelopele Small Farmers Cooperative (TSFC). Amongst the organisations that were co-opted into the structure were the municipality, the tribal authority and the local agriculture office.

Report No: TT 314/07

ISBN: 978 1 77005 596 4

Overseas price: \$20.00 (excl. postage)

Technology transfer and integrated implementation of water management models in commercial farming

AJ Pott, N Benadé, P van Heerden, B Grové, JG Annadale and M Steyn

This integrated transfer of technology project targeted the commercial irrigation sector in particular since, according to the National Water Resources Strategy (NWRS, first edition, 2004), this sector is responsible for over 62% of South Africa's total water use. The terms of reference required the research team to (i) identify, (ii) negotiate with and (iii) select 5 to 7 Water User Associations or Irrigation Boards to participate in the technology transfer (TT) project. A key objective of the project was for the decision-support models to be used sustainably after the completion of the project to increase efficiency of water use. As such, the potential participant WUAs/IBs were evaluated in terms of (i) their user needs for the respective models, (ii) the level of commitment shown and (iii) the level of infrastructure of the respective schemes. The participants were ranked in terms of these criteria, and short-listed. It is expected that the WUAs/IBs which were selected will act as centres of excellence, from which other WUAs/IBs can learn over time.

The models which were included in the TT exercise were ACRU, WAS, SAPWAT, SWB and RISKMAN. All models are driven by some form of input data, which is then transformed into information via computational processes through the models. A central approach of this integrated technology transfer project was to capture high-quality data of the targeted participant Water User Associations and Irrigation Boards in a Geographical Information System (GIS). In the course of the implementation of the models, further developments were undertaken to improve the user friendliness. It was clear from earlier WRC projects that stakeholders showed a strong interest in GIS packages, largely due to the understanding that the use of GIS promotes for spatial and temporal information. This is due to the graphical (visual)

nature of GIS which enables features to be viewed in a spatial context. In order to promote the buy-in from potential WUA and IB participants, a key feature of the project was the collection of data pertinent to the WUAs and IBs which would then be captured in a GIS. The data incorporated in the GIS could then be used (with other input data) to drive the models associated with the TT project.

The WUAs/IBs have shown a very high interest in the use of GIS, which is very encouraging, as the GIS data, if kept current over time, will provide valuable input data for the various models forming part of the TT project. The current user needs for some of the models is very high, resulting in the models either being used now, or the intention to use the model in the near future (e.g. WAS & SAPWAT). For some of the other models the user need is growing, and is anticipated to grow significantly once the compulsory licensing process has been completed in many of the over-allocated catchments in the country. Models like SWB and RISKMAN will be very useful to test the hydro-economic impact of various water-use and land-use scenarios. Like-wise, the ACRU-MIKE BASIN model combination is well-placed to assist water resource managers and stakeholders evaluate water management scenarios.

It is recommended that the WRC and/or DWAF provide funding to support a technical user support unit, which continues supporting the use of the models associated in the TT project. Although the technology transfer project was successful, it targeted only 7 WUAs/IBs, which is a very small percentage of the total number of WUAs and IBs in the country. At some stage all water users will require assistance in the management of their water, be it a catchment scale, scheme scale, or field scale. An organisation such as the former Computer Centre for Water Research (CCWR), would be a suitable organisation to provide support and assistance for this purpose.

Report No: TT 267/08

ISBN: 978 1 77005 703 6

Overseas price: \$30.00 (excl. postage)

Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research in Limpopo Province

Wim van Averbek

The project was conducted as a case study of the Dzindi Irrigation Scheme. Dzindi is a canal Irrigation scheme that was constructed shortly after World War II and is found about 6km south west of the town of Thohoyandou, in the Vhembe district of Limpopo province. Dzindi has a total command area of 135.6ha, which is subdivided into 106 plots of 1.28ha each, held by a total of 102 plot holders. Fieldwork was also conducted at Khumbe Irrigation Scheme and Rabali Irrigation Scheme to determine the extent to which the situation at Dzindi was unique. Both Khumbe and Rabali are canal irrigation schemes and their characteristics are fairly similar to Dzindi. All three schemes can be described as maize (summer) and vegetables (winter) schemes, but there were differences among the schemes in the types of vegetables that featured most prominently.

The overall objective of the project was to develop and implement technologies and knowledge useful for farmers in order to improve rural livelihoods. Two types of research and development activities were conducted, namely initiatives aimed at understanding management practices and initiatives aimed at improving management activities. Methods used in data collection at Dzindi included; the use of Rapid Rural Appraisal (RRA) techniques; surveys involving probability sampling and structured interview schedules; experiments in the green house, on-station and on-farm and qualitative methods. Methods of data collection at Khumbe and Rabali were largely limited to the use of RRA techniques.

The analysis of livelihood and farming of plot holder households revealed that for the purposes of developing best management practices, the 'one size fits all' perspective is not valid. At individual farm level best management practices need to be tailored to the objective of the farmer and the role of farming in the overall livelihood strategy of the household. The longitudinal study of the livelihood and farming of a selection of households at Dzindi showed that both were dynamic and subject to interaction. The development of livelihood types, farming styles and the relationship between farming and overall livelihood were shown to be useful approaches to make sense of the diversity that was observed. The study of the social and institutional domains of Dzindi showed that there was considerable room to improve the management of shared resources. On smallholder canal irrigation schemes, the sharing of water and the maintenance of the irrigation infrastructure influence the availability of water for irrigation at the plots. Collaboration among farmers, or the lack thereof, also affects access to markets. However, the study found that state intervention (through the compulsory introduction of the cooperative model) in areas where smallholders successfully operate their own organisations should either be avoided completely or be done in ways that allow smallholders sufficient time to internalise the new concepts and adapt them to suit their own circumstances. Land tenure and farmers' interpretation of the prevailing tenure system influence land exchange among farmers, which is important for farmers seeking to expand their operations. Collaboration among farmers is also important in terms of access to land preparation services. Research and development activities aimed at improving management practices focused on production aspects and included the integration of crop and animal production systems, improvement of the production of selected indigenous crops (African leafy vegetables) and the improvement of green maize production.

The findings of this study revealed that the development of best management practices for farmers on smallholder irrigation schemes needs to consider three important domains, namely the individual farm enterprises, the irrigation scheme as a whole

and the scheme and its surrounds, because these domains interact. The development of best management practices at the level of the individual farm enterprises, within the Terms of Reference for this project, is mostly technical in nature. This suits the biological and technical disciplines in the agricultural expert system. However, social and institutional issues are of cardinal importance in the domain of the irrigation scheme as a whole and its surrounds. This raises questions about the appropriateness of the composition of the South African expert system, which has long been dominated by specialists in agricultural production and agricultural engineering.

Report No: TT 344/08
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Overseas price: \$45.00 (excl. postage)

Water-use in relation to biomass of indigenous tree species in woodland, forest and/or plantation conditions

Dye PJ, Gush MB, Everson CS, Jarman C, Clulow A, Mengistu M

Report No: TT 361/08
ISBN: 978 1 77005 744 9
Overseas price: \$30.00 (excl. postage)

Nutritional status of South Africans with specific reference to malnutrition

Wenhold F, Faber M

Report No: TT 362/P/08
ISBN: 978 1 77005 756 2
Overseas price: \$25.00 (excl. postage)

Developing a land register and a set of rules for application of infield rainwater harvesting in three villages in Thaba Nchu: A pilot project

Manona S, Baipethi M

The Water Research Commission (WRC) is funding a 5-year research project in rural villages around Thaba Nchu, titled Social and economic factors affecting the adoption of rainwater harvesting and conservation practices. The solicited project commenced in April 2006 and is being undertaken by the University of the Free State. The project follows on other WRC funded projects in the same area that aimed at the improvement of crop production, thus poverty alleviation, through the use of infield rainwater harvesting (IRWH) techniques developed by the Agricultural Research Council's Institute for Soil Climate and Water (ARC-ISCW). There is a need for up-scaling IRWH from the household food gardens to the communal croplands. This requires the development of a land register and clear rules to gain access to land. Umhlaba Consulting have specialist capabilities in this regard to make a contribution and thereby support ongoing research efforts.

The study revealed the complex nature of land tenure and the total collapse of land administration in the three villages. The underlying drivers of the collapse of land administration can be attributed to lack of a coherent policy and legislative framework since 1994. On the one hand Government discontinued the implementation of permission to occupy (PTO) legislation and did not replace it with new legislation, while other organisations that were historically key role players in land administration were removed from the functions they played in the past.

A survey conducted among the three villages showed a widespread support for extension and/or revitalisation of cultivation to arable fields, albeit with conventional technologies in mind, as shown by the appeal for the provision of machinery commonly used in conventional tillage methods. The observation

was not surprising since the farmers had not been exposed to the use of the IRWH techniques beyond the household food plots. Furthermore, land rights holders expressed sufficient support for an improved local land administration system that would support land exchange agreements. While fencing of the fields does not necessarily fall within the realm of land administration, it was seen to be a major constraint towards the cultivation of arable fields. This is largely because of the threat of damage to crops by livestock from within and the neighbouring villages.

Following from support to developing and/or strengthening local land administration, an initial framework of rules that would govern local land administration was agreed to by the three villages. This process was undertaken mindful of the lack of a supportive legislative framework and therefore lack of enforcement mechanisms. Nonetheless, the communities were willing to devise and revitalise some of the traditional and collective initiatives to ensure the launching of the local land administration system. There was consensus across all three villages on how a local land administration structure should be set up. The process of setting up of rules was seen as a dynamic and continuous process which should be facilitated by the local land administration structures over time.

Report No: TT 367/08

ISBN: 978 1 77005 785 2

Overseas price: \$25.00 (excl. postage)

Training manual for small-scale rainbow trout farmers in net cages on irrigation dams water quality, production and fish health

K Salie, D Resoort, D du Plessis and Ma Maleri

This project investigated the suitability of on-farm irrigation dams for aquaculture fish production and the effect this would have on the quality of the water for irrigation purposes. A study of irrigation dams in the Western Cape and the Makhathini flats

canal system in KwaZulu-Natal, indicated that water exchange rate and inflow water quality are main factors in determining the suitability of water bodies for fish production. While the water chemistry did not show effects of aquaculture or differences between production and control sites, the phytoplankton composition and biomass did. Especially during the winter dam turnover, overall biomass of phytoplankton was higher at all production sites. The additional clogging of filters as a result of changes in phytoplankton biomass was the most significant impact of aquaculture on the quality of water for irrigation. It was further found that a significant portion of the fertiliser requirements of the crops irrigated from the dams would become available because of aquaculture activities.

Report No: TT 369/08
ISBN: 978 1 77005 784 5
Overseas price: \$20.00 (excl. postage)

The social/cultural acceptability of using human excreta (Faeces and Urine) for food production in rural settlements in South Africa

Duncker LC, Matsebe GM, Moliwa N

Introducing and operating sanitation systems that promote the use of human excreta in rural areas require a combination of technical and managerial aspects that fit the prevailing socio-cultural context in the specific area. An in-depth understanding of the social and mental fabric concerning people's views towards recirculation of nutrients is necessary in order to understand the motivational factors behind people's acceptance or rejection of using human excreta for food production. No research has been conducted so far in this field of study in South Africa, and therefore the scoping study is required to investigate the status quo, determine the views and attitudes of people towards the use of human excreta in food production, and to guide relevant future interventions and actions regarding use of human excreta. Use of human excreta for agricultural purposes may not only have

direct benefits of protecting and improving natural resources such as water and soils and enable households to increase food crops, but also indirect benefits of improved food security resulting in improved health of the individual, greater productivity, increased economic output and opportunities, and a decreasing burden on social services.

Report No: TT 310/07
ISBN: 978 1 77005 592 6
Overseas price: \$25.00 (excl. postage)

A procedure for an improved soil survey technique for delineating land suitable for rainwater harvesting

Hensley M, Roux PAL, Gutter J, Zerizghy MG

Subsistence farmers in rural semi-arid areas with low cropping potential are a category of poor people in South Africa that the Government urgently wants to assist. Their well-being is jeopardised by a low income and inadequate food security. To address this problem a number of research projects, managed and funded by the Water Research Commission (WRC), have been launched during the last ten years by the ARC-Institute for Soil Climate and Water (ISCW) located at Glen. Success in this regard was achieved, shown by the fact that large numbers of households in the region now successfully use IRWH to grow maize and vegetables in their backyards. The time is now ripe for expanding the application of IRWH to the relatively large unused cropland areas available to these subsistence farmers. The need then arises to identify and delineate the portion of each village area that is suitable for IRWH. Because of the relatively small area of cropland allocated to each household it is essential that the soil survey be conducted on an intensive basis, at a scale of at least 1:10 000, but preferably larger. Intensive soil surveys at this scale, carried out using the traditional grid technique, are costly. It was hypothesised that it should be possible to develop a more effective survey procedure to select suitable land for IRWH

by maximising the application of tacit knowledge and employing modern and innovative technology. Aware of this need the WRC has wisely created this research project to test this hypothesis.

Report No: TT 311/07

ISBN: 978 1 77005 591 9

Overseas price: \$20.00 (excl. postage)

A manual for cost benefit analysis in SA with specific reference to water resource development: Second Edition (Updated and Revised)

Mullins D, Mosaka DD, Green AB, Downing R, Mapekula PG

This guideline is in the format of a manual for conducting Cost-Benefit Analysis (CBA) in South Africa with specific reference to evaluating the development and management of water resources. This evaluation of projects is often a difficult task since costs and benefits do not occur only once but appear over time. The CBA method, provides a logical framework by means of which projects can be evaluated, serving as an aid in the decision-making process. This manual is specifically aimed at the decision-maker in the public sector, but can also be used outside the public sector.

It is interesting to note a few highlights of the CBA Manual. A broader approach is followed to incorporate the relationships between CBA and other aspects of the economy. In this regard the following aspects have been included:

- The relationship between the principles of CBA and welfare economics;
- CBA as one component of the range of decision-making support instruments; and
- The equity and efficiency principles.

Thus it deals specifically with the uses, limitations and basic principles of CBA in order to explain the underlying conceptual framework to the reader. This manual advocates that the CBA

concept needs to be widened to include the broader social costs and benefits derived from a project. Furthermore it is also accepted that CBA is only one of several instruments for evaluating proposed projects. One of the main objectives therefore was to incorporate an income weighting system. This system provides for the recognition of some of the macroeconomic policies of the Government e.g. combating poverty and promoting regional development.

Report No: TT 305/07

ISBN: 978 1 77005 598 8

Overseas price: \$30.00 (excl. postage)

Technology transfer for implementation of the FARMS system

Botha PW, Oosthuizen LK, Meiring JA

Over the last 10 years, three WRC-funded research projects were undertaken to develop user-friendly models to provide decision-support for farmers. The aims of this technology transfer project were firstly, to train agribusinesses, bureau services and advisors in the main irrigation areas of South Africa to implement the Risk Man (Risk Management), IrriCost (Irrigation Cost Estimator) and FARMS (Firm Level Agricultural Management Simulator) computer software for decision-taking support in the field of risk management, irrigation cost estimation and whole farm planning respectively; and secondly, to give these organisations and individuals the necessary support in order for them to apply the abovementioned computer software on a continuous basis.

New technology must pass through several stages before it is accepted. The five stages of adoption are awareness, interest, evaluation, trial and adoption. The implementation strategy with this technology transfer project consisted of a combination of methods, messages and approaches followed by the research team. The first step was to identify target groups to whom the three programs were demonstrated. The demonstrations

were attended by the contact person of that area together with potential adopters of the technology. These demonstrations were used to create awareness and interest in the use of the models. The next step was to arrange workshops for interested persons for specific models to make further progress with the technology adoption process. The website was used to provide additional information about forthcoming courses and continuous support on larger scale adoption and application.

Report No: TT 274/05

ISBN: 1 77005 450 2

Overseas price: \$20.00 (excl. postage)

Building capacity in irrigation management with wetting front detectors

R Stirzaker, CSIRO, Stevens J, Annandale J, Maeko T, Steyn M, Mpandeli S, Maurobane W, Nkgapele J, Jovanovic N

Scheduling of irrigation does not only ensure that adequate volumes of water are applied. It also ensures that many people who rely on the limited water resource can share. Much as irrigators are aware of the importance of scheduling, very few practice it. A wide range of reasons for not scheduling exists, the common ones being the high level of management required and the costs involved. With simple and cheap scheduling tools, water savings will be achieved and farmers will soon realise the importance of irrigation scheduling and its benefits. The project is aimed at improving adoption of irrigation scheduling through the introduction of a cheap and simple technique. It also evaluates factors affecting the acceptability of this irrigation scheduling technology by resource-poor and commercial farmers.

Report No: TT 230/04

ISBN: 1 77005 138 4

Overseas price \$25.00 (excl. postage)

Using Sapwat to estimate water requirements of crops in selected irrigation areas managed by the Orange Vaal and Orange – Riet water users association

Van Heerden PS, Crosby CT, Crosby CP

This report serves as a user manual for the application of SAPWAT. Furthermore, it demonstrates that the estimation of irrigation requirements can be credible and that the requirements that the National Water Act (36 of 1998) sets for future water management can be met.

Report No: TT 163/01

ISBN: 1 86845 812 1

Overseas price: \$30.00 (excl. postage)

Micro-irrigation for smallholders: Guidelines for funders, planners, designers and support staff in SA

Du Plessis FJ, Van Averbek W, Van der Stoep I

The objective of this project was to assess how small-scale farmers experience the concept of micro-irrigation systems and how they cope with problems. The aim was to identify those aspects that eventually determine the success or failure of small-scale crop production, utilising these systems. During the course of the project it became apparent that external factors, generic to any small-scale farming system and seemingly unrelated to micro-irrigation, had a significant influence, and that it would, therefore, be almost impossible to evaluate the former without taking the latter into account. The aim of the guideline report is to help prevent mistakes of the past and, hopefully, it will contribute to policy-making on a small scale regarding the utilisation of micro-irrigation. Thus, the successful use of the systems is ensured.

Report No: TT 164/01
ISBN: 1 86845 824 5
Overseas price: \$15.00 (excl. postage)

Contribution of aquaculture to rural livelihoods in South Africa: A baseline study

Rouhani QA, Britz PJ

At present there is a lack of information on the importance of fish production systems in agricultural activities, the contribution it makes to household food security and constraints or opportunities which exist for expansion. This study should highlight specific topics for research projects that need attention. Particular emphasis will be placed on research of water-related issues that will lead to an improvement of rural livelihoods.

Report No: TT 235/05
ISBN: 1 77005 186 4
Overseas price: \$25.00 (excl. postage)

Guidelines for irrigation water measurement in practice

Vd Stoep I, Benade N, Smal HS, Reinders FB

Effective management of water resources can be vastly improved if water use is measured accurately. This applies in particular to efforts to influence the quantity of water demanded by levying tariffs on the volume of water actually consumed. However, on most irrigation schemes water flow is not measured and water tariffs are presently still levied on an area and not a volumetric basis. This report is as a result of a comprehensive study of water measurement in irrigation.

Report No: TT 248/05
ISBN: 1 77005 324 7
Overseas price: \$25.00 (excl. postage)

Irrigation scheduling using the Soil Water Balance (SWB) model as a user-friendly irrigation scheduling tool

Annandale JG, Steyn JM, Benade N, Jovanovic NZ, Soundy P

Most commercial farmers recognise that effective irrigation scheduling is a prerequisite to save on irrigation water and to improve on water-use efficiency. However, only a small percentage of irrigation farmers currently uses any scientific irrigation scheduling aid. One important reason may have been the lack of quick, simple and reliable irrigation scheduling techniques. This aspect has been addressed to a large extent by the development of the SWB model. Although the model follows a scientifically based mechanistic approach, a user-friendly interface makes it accessible to any person with basic computer training.

Report No: TT 251/05
ISBN: 1 77005 339 5
Overseas price: \$20.00 (excl. postage)

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: A rough guide for irrigation development practitioners: Vol 1

Denison J, Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.

The 'Rough Guide' (Volume 1) is a quick reference guide that covers policy implications and revitalisation objectives, as well as recommended principles, approaches and methodologies for scheme diagnosis, participative planning,

feasibility evaluation and formulation of farmer support programmes.

Report No: TT 308/07

ISBN:978 1 77005 568 1

Overseas price: \$25.00 (excl. postage)

Principles, approaches and guidelines for the participatory revitalisation of smallholder irrigation schemes: Concepts and cases: Vol 2

Denison J, Manona S

The guidelines document best South African and international practice and are intended for Government decision-makers, technical and extension staff, consultants, development practitioners and scheme leadership.

'Concepts and Cases' (Volume 2) contains the theoretical rationale for the guidelines. Four major South African revitalisation initiatives are compared with international initiatives and success factors are identified. Eight farmer support approaches are documented, providing lessons of best practice as well as alternatives for programme design, and new approaches are presented. These are a tailored consultative planning approach, a land-leasing strategy for irrigation schemes and the formulation of four basic farming styles to guide planning.

Report No: TT 309/07

ISBN: 978 1 77005 569 8

Overseas price: \$35.00 (excl. postage)