WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW **2014/15**

CONTENTS

INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2014/15, 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 research portfolio for 2014/15 was set on the basis of the WRC's Strategic Plan. The WRC continued to invest in the creation of knowledge via its four main key strategic areas (KSAs): **Water Resource Management**, **Water-Linked Ecosystems**, **Water Use and Waste Management**, and **Water Utilisation in Agriculture**. **KSA 5: Business Development, Marketing and Communications** provides strategic direction to the business development, communication, marketing and branding goals of the WRC, with an emphasis on research uptake and knowledge dissemination.

Dhesigen Naidoo:
Chief Executive Officer, Water Research Commission

Figure 1 WRC Research Key Strategic Areas

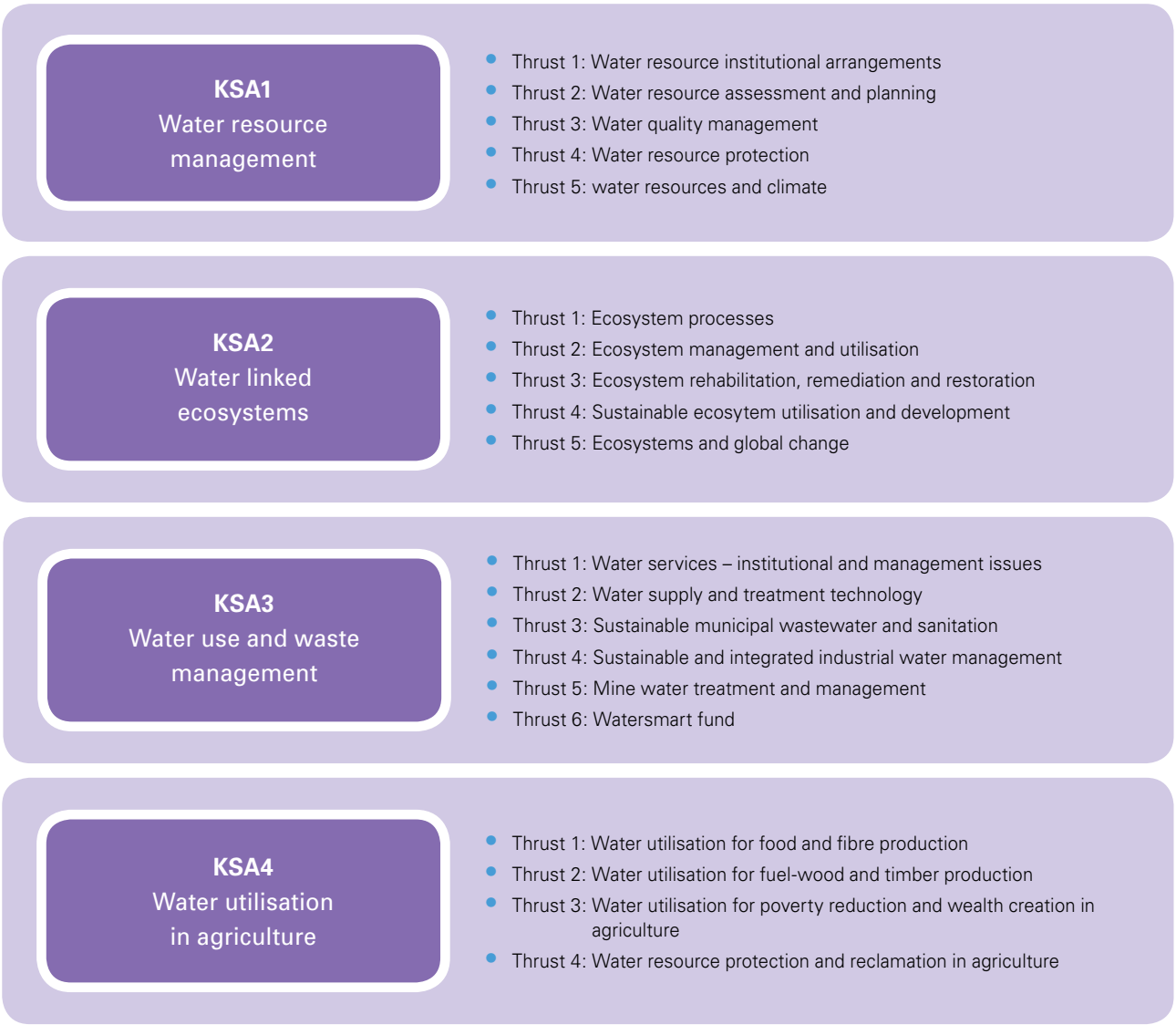


Figure 2 The WRC Knowledge Tree

ACHIEVING THE GOALS OF THE 'WRC KNOWLEDGE TREE'

In addition to contributing to several Government Outcomes, the WRC's strategic outcome-orientated goals comprise of five impact areas based on the operationalisation of the WRC Knowledge Tree, a fundamental guiding framework and corporate planning tool used by the WRC to define, measure and evaluate research impact.

The WRC strives to achieve as many of the WRC Knowledge Tree impact areas as reasonably possible in the research that it funds. This applies within a research project, to post-project actions, and to follow-on projects. By 2014/15 the Knowledge Tree had been well entrenched in the WRC's activities, with all research proposals articulating objectives of the Knowledge Tree branches.

The WRC's actions are further driven by the concept of the water science and technology (WS&T) Transformation Bridge as a strategic planning objective. This entails moving South Africa from a resource-driven economy to a knowledge-based economy with a successful South African water and sanitation industry; science-based and evidence-driven policy, decisions and actions; and a larger, more diverse water community of practice. In addition, the Transformation Bridge also signifies the need to move from a focus on a knowledge generation axis towards an additional focus on action and impact.

The WRC, therefore, continues to focus on the development of its impact narrative that provides a pathway from research to impact. This entails a continuous review of current actions and activities as well as the identification of new actions that will ensure impact realisation.

SUPPORTING RESEARCH PROJECTS

In 2014/15, the WRC initiated 113 new projects and also completed 77 projects. This represents a cumulative increase in the amount of new and finalised research projects funded over the past five years.

Over the past 5 years the WRC has finalised 421 research projects (Figure 3) indicating a significant contribution to knowledge in the water sector. An average number of 84 projects were finalised per year over the past 5 years. Over the same 5-year period 432 new projects (Figure 4) were initiated, ensuring the continuous contribution of new knowledge to the sector. The large number of initiated projects was largely as a result of the WRC's new and existing funding partnerships.

Table 1 The WRC's strategic outcome-orientated goals

Strategic Outcome-Oriented Goal 1	**Inform policy and decision-making** The WRC aims to commission appropriate evidence-based knowledge generated to guide decision-making, influencing the development of policy, practice or service provision, shaping legislation, altering behaviour, contributing to the understanding of policy issues, and reframing debates.
Strategic Outcome-Oriented Goal 2	**Develop new products and services for economic development** The WRC capitalises on those projects that have potential to develop new intellectual property or to introduce innovations which create new or improved technologies, products and services that can be used in the real economy. Effectively, this is the WRC's contribution to job creation, and economic development through water science innovations.
Strategic Outcome-Oriented Goal 3	**Enhance human capital development (HCD) in the water and science sectors** The WRC strives to have high levels of student participation in its projects. Although the emphasis is on post-graduate degrees, inclusion of undergraduates has also been investigated. There is also a particular emphasis on previously-disadvantaged individuals (PDIs) and women. The WRC also aims to support institutional development through mentorship provided to new research leaders.
Strategic Outcome-Oriented Goal 4	**Empower communities** The WRC places an emphasis on projects that (a) include communities not only as end-users of research but as active participants in the research process from the project design phase; (b) have a direct impact on the livelihoods of communities through water-related interventions, and (c) build sufficient capacity to assist with the post-project sustainability of those interventions.
Strategic Outcome-Oriented Goal 5	**Promote transformation and redress** This goal focuses on growing PDI involvement/leadership in projects, as well as helping to promote socio-economic development through the reduction of poverty and inequality in South Africa, particularly of marginalised groups such as women and youth.
Strategic Outcome-Oriented Goal 6	**Drive sustainable development solutions** The WRC prioritises those projects that provide sustainable development solutions that have had positive effects on the environment, economy and society including: protection of water resources, optimal water use, equity between generations, equitable access, environmental integration and good governance. Additionally, this goal focuses on developing knowledge products that are fit-for-use to ensure the uptake of research.

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

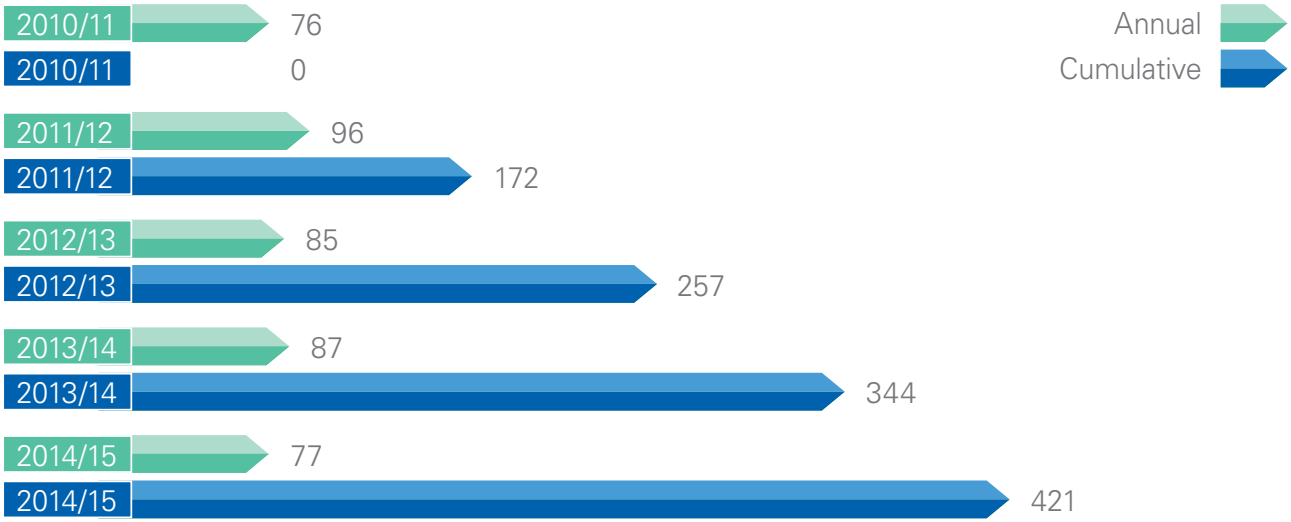
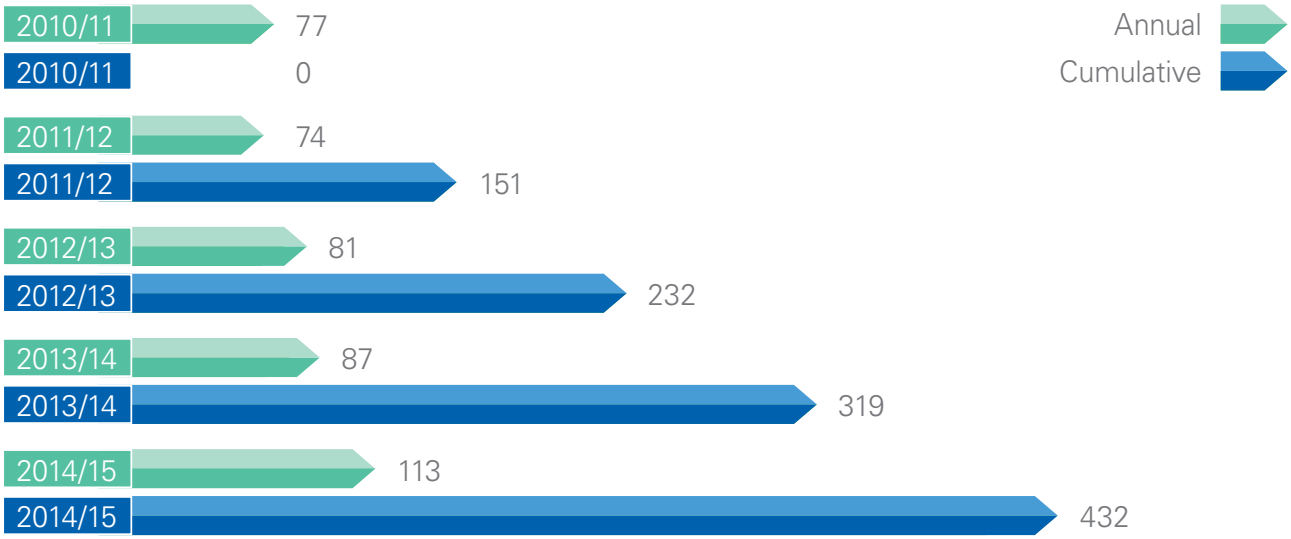


Figure 4 Annual and cumulative number of projects initiated over the past five years



BUILDING CAPACITY

The WRC aims to provide 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 Commission-funded research projects and/or serving as members of steering committees as well as representatives of new proposals.

Figure 5 Number of students supported by WRC in 2014/15

In recent years the WRC has adjusted its portfolio to train and mentor new research leaders. More than 60% of research leaders on new projects are now from designated groups and most are younger than 50 years old. This is both assisting with the national transformation project as well as building the next generation of researchers. Historically, most projects lay within universities; however, it is encouraging to note that 32 WRC projects were being led by small, medium and micro enterprises in the last financial year.

The crowning achievement in this domain is 83% representation of students in WRC projects who are previously disadvantaged individuals. The general consensus from the community of practice is that the value-add of this injection of diversity is already having a positive impact on the overall portfolio. This large number of Masters and PhD candidates provides the critical mass required for the next generation of academics and researchers in the water sector.

While stakeholder participation in research has always formed an important part of WRC research activities, this year the Commission is reporting for the first time on community participation as a KPA. The WRC is proud to report that it has 20 community-based research projects in its project portfolio.

Figure 6 Number of community-based projects

WRC RESEARCH PORTFOLIO 2014/15

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2014/15 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

SCOPE

Fundamental global challenges affect the scope of KSA 1, such as climate change, population growth and urbanisation. The results of these drivers are clear pressure manifestations, such as demand far exceeding available freshwater resources, increased competition between sectors and deteriorating water quality.

The current situation, in which there is perpetually growing water demand and competition, is leading to deepened water insecurity in certain locations. The ability and preparedness of sectors to engage on water issues has improved with the enhanced comprehension of water shortages, yet the issue of water management is not as high as it should be on the national political agenda. Water quality remains a concern, where causes and management options are well researched but the need to implement control and/or incentive measures requires additional work. Deteriorating water quality has compromised water resource integrity and its resilience in adapting to natural as well as man-induced impacts, and to be able to support national as well as regional sustainable development.

Eiman Karar:
Executive Manager

Tensions around decisions about allocations and de-allocations, water tenure, and trade-offs in satisfying demands for food security, energy and sustained environmental services will become much more heightened. In response, research focusing largely on understanding the barriers to policy implementation at the different levels is required. The democratisation of the management of water resources, through decentralised management, will need to amplify the developmental dimension, in order to ensure equitable access to water, its use and economic benefits.

The main aim of this KSA is to provide 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 unit operates in five thrusts, ranging from institutional arrangements, reform and governance to catchment assessment and planning, water quality management, water resource protection, and water resources and climate.

Apart from the problems of water resource limitations and induced scarcity, South Africa has specific challenges relating to inequities in the physical, social, administrative and institutional access to this important resource. This applies especially to the poor and disempowered majority, whose ability to pay for water is limited.

OBJECTIVES

The strategic objectives of KSA 1 are as follows:

- To establish better freshwater governance aimed at facilitating equitable, productive and sustainable use of water resources among all users
- To develop a deeper scientific understanding of the hydrological cycle (and inter-linkages) in order to promote systematic water assessment and planning
- To consolidate the vast amount of existing water quality-related research outputs in priority domains and to transfer this knowledge whilst being alert to emerging issues
- To contribute research towards a reliable supply of good quality water for the health, and environmental, social and economic wellbeing of the country
- To develop the needed understanding of global climate change and hydro-climatic variability impacts

THRUSTS AND PROGRAMMES

Thrust 1: Water resource institutional arrangements

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the

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

Programme 1: Water governance and institutional reforms	***Scope:*** The principle of subsidiarity, or, as sometimes referred to, 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.
Programme 2: Compliance and enforcement	***Scope:*** For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Benchmarking and best practice are crucial here to accelerate learning.
Programme 3: Pricing and financing WRM	***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 ground-breaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource charge exclude the poor and will it further cripple local government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.
Programme 4: Transboundary water resources	***Scope:*** This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.

Programme 5: Future scenarios	***Scope***: This activity has been 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. This is considered as one of the tools for assisting in learning and allowing for dialogue to take place around options. Other tools exist which will also be explored in due course such as Game Theory especially in support of water allocation options.

Thrust 2: 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.

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

Programme 3: Water resource planning	***Scope*:** This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps such as the absence of reliable information in 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 Water for Growth and Development 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.
Programme 4: Water resource infrastructure	***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).
Programme 5: New water and water security	***Scope:*** Secure and sustainable access to water is essential for a wide range of critical uses such as human health, economic growth, food security, etc. However, in semi-arid environments such as South Africa, conventional water sources are not sufficient to meet the ever growing demand. Therefore, the understanding and assessments of alternative sources of water such as fog water, desalination, water transfers, etc., is essential. The programme will also promote research on transboundary water issues (with respect to water quantity and quality) to ensure water security for South Africa. Other issues to be researched include cooperation on shared surface water and groundwater resources, as well as the integration of social, economic, and environmental considerations as key components of sustainable water resource development.

Thrust 3: Water quality management

Scope: This thrust acknowledges the significant water quality problems in our natural water resources. Water quality is generally reflected in concentrations of substances and microorganisms, physico-chemical attributes, radioactivity, as well as biological responses to these. Within each of the programmes in this thrust, research will focus on two broad fronts, namely, (1) consolidation and knowledge transfer and (2) alertness

to emerging issues. Consolidation is necessary of the vast amount of existing water quality-related research outputs in priority domains. The primary aim will be to distil effective decision support for management of our water quality problems. Emphasis will be more on formulating solutions than on formulating problems. By actively sharing knowledge with decision makers, and working closely with them, the decision support must explicitly address their absorptive capacity in its broadest sense. On the one hand, solutions need to be based on a thorough holistic and realistic examination of likely consequences of implementation of those solutions. This must create confidence that risks of unintended consequences will be minimised. However, on the other hand, solutions must cater for the inherent complexity (and hence uncertainty) of both the institutional and natural environment. Research will also be encouraged that heightens awareness, and/or recommends management approaches, specifically to important emerging issues, i.e., those potential or recognised concerns that are either not addressed, or are only partly addressed, in current water quality management practice and research. High priority issues include those of national concern, those for which the frequency or probability of adverse conditions occurring is high, and the consequences are severe, and so on. Water quality necessarily cuts across various KSAs as well as thrusts within this KSA. The scope of this particular thrust focuses primarily on water quality of inland surface waters and its management.

Programme 1: Water quality monitoring	***Scope:*** Sound water quality monitoring data are crucial to sustainable management because they provide information on the current status and trends. Creative yet soundly-scientific approaches to monitoring are required that optimise information and minimise costs. All phases of monitoring design need careful consideration, from data acquisition, data storage and management, information generation and dissemination, through to realistic implementation strategies.
Programme 2: Water quality modelling	***Scope:*** The programme will encourage a move to open-source modelling platforms that benefit individual model developers, while allowing effective interfacing with other modelling modules in a way that provides integrated, scientifically-defensible water quality information. Business models of such platforms must be as much in the interests of users of such information (e.g. catchment management agencies) as the service providers and modellers.
Programme 3: Impacts on and of water quality	***Scope:*** This programme will focus on identifying, characterising, and understanding (1) the changes in the state of water quality in our water resources associated with either point or non-point pollution sources, and (2) the associated impacts of such compromised water quality.

Thrust 4: 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 3 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 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.

Programme 1: Source water protection	***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).
Programme 2: Land-water linkages	***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).

Thrust 5: 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 higher resolution scale and to ensure 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. 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

Programme 1: Predictive tools (continues)	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.
Programme 2: Climate change risk, vulnerability and adaptation	***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.
Programme 3: Integrated flood and drought management	***Scope:*** Flooding and drought are major natural hazards to human society and have important influences on social and economic development. 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.

RESEARCH PORTFOLIO FOR 2014/15

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Water governance decentralization in Africa: a framework for reform process and performance analysis
Centre for Environmental Economics and Policy in Africa (CEEPA); Water Sciences and Policy Centre (WSPC); CIRAD; University of Zimbabwe; International Centre for Water Economics and Governance in Africa (IWEGA)
No. 1969

The purpose of this study was to assess the performance of the decentralisation process and the implementation of IWRM principles by in-country river basin management institutions in the three southern African countries: South Africa, Mozambique and Swaziland. Key deliverables identified in the revised terms of reference included, among others:

- A review of performance approaches and indicators, and the development of a new protocol for re-running the survey as part of the bigger Africa survey.
- A scoping review of institutional development and progress with regards to the decentralization of water resource management within the Inkomati basin. A list of current operational water management institutions (CMAs, WUAs and other platforms) in RSA, Swaziland and Mozambique was developed. Using this list as a reference point for the Inkomati basin, the intention was to survey across the water sector, at various levels, including water users and interested parties, so as to develop an understanding of the gaps and challenges of the decentralisation process. To achieve these, activity criteria for identifying and sampling respondents within each institution were developed. For reference purposes a database of institutions and representatives engaged was maintained.
- To conduct a descriptive analysis on the collected data on the three countries together and per country – the expected number of responses should allow for a statistical analysis of the collected data.

Cost: R1 000 000 Term: 2010–2013

IWRM – from theory to practice
University of the Western Cape; University of Waterloo
No. 1975

The project set out to gain an understanding of whether IWRM is implementable and, if it is, how one moves from theory to practice or from policy to outcomes. What are the factors that facilitate or constrain the implementation of IWRM? Since 1994, water resource management in South Africa has undergone a major transformation, and, tracing the evolution of IWRM in South Africa, indications are that the Department of Water Affairs has mostly got it right. Measured on the policy-outcome continuum of constitutional imperatives, policy, legislation, regulations, strategies, plans, methodologies, capabilities, ethos, implementation and outcomes, the dearth of positive outcomes seems to be mostly laid at the door of the ethos in the Department. Most of the data indicate that there is a hesitancy to implement – a fear of making a mistake. This conclusion seems to be supported by anecdotal evidence and by the views of ex-employees of the Department.

Cost: R559 700 Term: 2010–2014

Programme 4: Transboundary water resources

Water's role in driving regional economic integration in Southern Africa
Water and Development Management; Brian Hollingworth and Associates; University of Pretoria
No. 2252

This project considers whether and how different approaches to the development, management and use of water resources might contribute to regional integration in Southern Africa and concludes that water does not make an important direct contribution. Its political symbolism may have an important indirect impact and should not be under-estimated. However, 'hydro-centric' approaches, that prioritise the protection of water resources over support to the achievement of social and economic objectives may undermine even that benefit. The key conclusion of the study is that, while the development and use of the region's water resources may not make a major direct contribution to regional integration, they do have the potential to make a significant indirect contribution. Political symbolism may be more important than actual outcomes. The greatest contribution that water resources and their management can make to regional integration may be to show that cooperation for mutual benefit can, on occasion, generate greater benefits from all parties than through national action alone. The study concludes with some practical recommendations for approaches that could ensure that water resource management contributes to the SADC goal of greater regional integration.

Cost: R975 000.00 Term: 2013–2015

Programme 5: Future scenarios

Insights towards an improved governance model and practical implementation of rural development and community upliftment projects, centred around the productive use of water

Pegasys Strategy and Development (Pty) Ltd; Umhlaba Consulting Group (Pty) Ltd

No. 2166

Over the last decade there have been a wide range of projects that have supported the development of livelihoods, within both rural and peri-urban settings. Water is clearly seen as a catalyst for growth and development, and as such these projects have all too often indicated that the provision of water, technical assistance and small amounts of seed funding can indeed uplift and empower communities. There have indeed been bright spots and these include support with rainwater harvesting tanks funded by the DWS, the DWs Danida IWRM project that supported community development programmes, as well as the nodal projects supported by the Department of Rural Development and Land Reform. However, and importantly, these undertakings seem disjointed and limited in scope, space and time. There is clearly insufficient integration and coordination between various sector Departments, both at national and provincial levels, so that these projects can be guided and supported in a sustained way. All too often it seems that donor funds are required in order to catalyse some form of combined initiative in this regard. The WRC funded this project to inform that debate and provide independent insights into the topic. Understanding, therefore, that we can find ways to help communities to use water productively, it is imperative that we start to remedy this situation of uncoordinated and disjointed support. This project documented at a high level the range of projects that have supported communities to access and use water productively over the last decade. Through interviews with key actors within the various Government departments the project sought to understand why gaps exist and what can be done to establish the much needed synergies. In addition, a number of interviews were held with communities and community-based organisations to understand the perspectives of the people at grassroots level, so as to create a more complete assessment.

Cost: R580 000 Term: 2012–2014

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

The hydrogeology of Groundwater Region 17: Central Highveld

Council for Geoscience; University of the Western Cape; independent consultant

No. 2049

Groundwater Region 17 – the Central Highveld – is situated between 26°11' E and 28°48' E and between 25°51' S and 27°19' S, with a total area of 16 918 km^2 (180 km long and 80 km wide). The Region spans Gauteng, North West, Mpumalanga and Free State provinces as a wide south-easterly trending belt.

The Region consists of the western part of the Upper Vaal, north Middle Vaal and southernmost Crocodile and Marico areas, which form the headwaters of the Vaal and Crocodile Rivers, respectively. The main catchments in the Region contain: A21 Crocodile River; C21 Suikerbosrant River; C22 Klip River and Rietspruit; C23 Mooi River and Vaal River and C24, Skoonspruit. The Region covers the majority of Witwatersrand Basin Goldfields from KOSH through Far West, and then to the Western and Central Basins and part of the Eastern Basin. As a result of mining activity, the groundwater has been extracted on a daily basis. In the Far West Rand Goldfields, for instance, during the period from April to August 2005 the daily pumped volume was 59.5 ML/d, which includes 22.4 ML/d extracted from the overlaying dolomitic aquifers. The Region covers South Africa's most urbanized area – one of high population and low abundance in natural water resources. The vulnerability of the groundwater resources to contamination may increase as a result of a wide range of domestic, industrial and land-use activities. The lump size of collective irrigation which depends on both surface water and ground water is 87 km^2. The total annual use of groundwater for irrigation in the Region is 431 Mm^3.

Cost: R700 000 Term: 2011–2014

Developing a citizen-based rainfall monitoring system

Pegasys Strategy and Development (Pty) Ltd; Pegram and Associates (Pty) Ltd; Breede Overberg Catchment Management Agency; Rhodes University

No. 2057

Water managers and stakeholders realize that the management of water resources requires a stronger focus on efficiency, whilst ensuring environmental sustainability. In order to improve the management of this scarce natural resource, monitoring of climate (to determine trends) and water resources (as they come under increased pressure) must improve. Rainfall data is the most important input variable to hydrological models and the subsequent assessment of hydrological impacts. Water allocation decisions that have serious economic impacts are made based upon the understanding of hydrology. In South Africa rainfall monitoring networks have been reduced over the years and challenges exist in ensuring the adequacy of the density of rain gauges to support water planning needs. Citizen-based monitoring networks have been used increasingly across the globe with the realisation that citizen scientists can in fact play a useful role in assisting with data collection as well as the value-add that can be gained from rainfall data collected by citizens. This study explores the possible approaches to setting up a citizen-based monitoring network and explores the modalities for a national drive to obtain existing datasets from citizen scientists. There are clear institutional and governance issues that require resolution with regards to rainfall monitoring in South Africa, and the citizen rainfall monitoring approach proposed in this project should be considered carefully with that perspective in mind. Importantly, this citizen rainfall-monitoring approach could provide invaluable data and contribute to developing an engaged citizenry.

Cost: R400 000 Term: 2011–2014

WRF rainfall parameterisation and verification

EScience Associates (Pty) Ltd; ARC, South African Weather Service; University of Cape Town

No. 2162

Rainfall and temperature are the main measures of numerical weather prediction (NWP) models. As computer processing capacity increases mesoscale models are being used more frequently for forecasting purposes and downscaling global and regional NWP models. This study used the Weather Research and Forecast Model (WRF) to simulate and verify rainfall, the PyTopkapi model for hydrological modelling, and the WRFChem to simulate the emission and assess its impact on rainfall. The main aim was to determine which parameterisation scheme works best under local conditions for producing accurate model results of precipitation events. Three case studies were selected, i.e., Berg River catchment (Western Cape) and Liebergsvlei catchment (Free State) for rainfall simulation, and the industrialised Highveld region, to run the WRFChem model. Each catchment required different schemes to suitably model daily rainfall when running 12 km model domains. Liebenbergsvlei results show that convective schemes trigger too early in the day and cause excessive rain days. Subsequently WRF is currently inadequate for modelling convective rainfall over the eastern part of South Africa at this resolution and improvements to the model are required when modelling at this resolution. While the Betts-Miller-Janjic convective scheme, with either the

WSM3 or Lin microphysics, was suitable for the Berg River, these schemes did not perform well for Liebenbergsvlei.

Cost: R748 651 Term: 2012–2014

Programme 2: Surface water / groundwater hydrology

Hydrology of South African soils and hillslopes (HOSASH)

University of the Free State; Central University of Technology; North East Cape Forests; University of KwaZulu-Natal (Pietermaritzburg); ARC (Institute for Soil, Climate & Water)
No. 2021

In order to predict runoff in ungauged basins and perturbations to runoff through land use or global change, we require simulation models which represent the dominant runoff-generating mechanisms. Typically, local to hillslope scale mechanisms generate accumulated flows which drive the catchment response. Successful hydrological simulation thus relies on representing these detailed mechanisms in a simple way in order to be applied at the catchment scale. Soils provide the dominant control of these mechanisms, not only in partitioning rainfall to runoff, soil water, vegetation and atmosphere, but also as a conduit controlling the accumulation of water in the landscape and release of water to streams and groundwater. The Hydrology of South African Soils and Hillslopes, (HOSASH) project has developed techniques which allow the dominant soil and hillslope runoff-generating mechanisms to be used in catchment-scale runoff simulations. The project confirmed the contribution of hydropedology using soil water regimes, hydrometry, natural stable isotopes and soil chemistry observations to improve conceptual hydrological response models for hillslopes. Combined with the improvement of soil survey techniques, the hydrological classification of South African soil forms and hillslopes now makes it potentially possible to produce the needed conceptual hydrological response models for catchments over a range of scales. The level of conceptualisation and the confirmation of these concepts with quantification in headwater catchments, now sets the scene for quantification of the hydrological soil indicators and controls, namely, soil horizons, soil forms, hillslopes and land types, to produce hydrological response functions for these units to serve hydrology and hydrological modelling with applicable functional units.

Cost: R5 000 000 Term: 2010–2015

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

University of KwaZulu-Natal (Pietermaritzburg); University of the Western Cape; South African National Parks
No. 2051

There is a tight coupling of hydrological, geological and ecological processes in the semi-arid setting of the lowveld savannas of South Africa. In the Kruger National Park (KNP) this has resulted in distinct landscape patterns closely organised around the hierarchical drainage network of seasonal and ephemeral streams which dominate the landscape. These patterns have resulted from a relatively stable geological template, the topographical redistribution of water and the resultant geomorphic setting one sees in the KNP today. Over time this has led to the establishment of unique soil and vegetation assemblages in the landscape at both the hillslope and catchment scale. Four sites were established as Supersites in the KNP in 2011 and the research presented here focuses on two in the south of the park: Stevenson-Hamilton on granite (Southern Granites or SGR); and Nhlowa on basalt (Southern Basalt or SBAS). Both sites are situated on the hydrological divide (watershed) between the perennial Sabie and Crocodile Rivers. The hydrological approach was the same for both sites in order to allow for inter-comparison of hydrological connectivity across geological settings and included: intensive geophysical surveys; drilling and characterisation of a piezometric borehole network; ephemeral streamflow gauging; hydro-chemical tracer sampling; hydro-pedological classification of catena sequences; associated soil moisture monitoring network; quantification of catena actual evapotranspiration through remote sensing, and a variety of other factors.

Cost: R1 800 000 Term: 2011–2014

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

Council for Geoscience; University of the Western Cape
No. 2053

Faults are one of the most important geological structures that control the occurrence of groundwater in hard rock terrain. Fault-controlled aquifers have been one of the most important target zones for water supply, especially for water-scarce areas, due to their unique nature amongst geological discontinuities. The

research project aimed to delineate and characterize fault-controlled fractured aquifers by using multiple approaches, and further to develop a sound method for estimating aquifer properties and groundwater flow based on established conceptual models, using well-calibrated numerical models. In order to select a site for further research, besides a general review of fault structures, two case studies for the Taaibos fault in Alldays, Limpopo and the Waterkloof fault in Rawsonville, Western Cape, were conducted. According to a previous study and field work, the Taaibos fault zone is highly fractured and the fault core weathered. As a result, groundwater largely occurs on the weathered fault core with boreholes never drilled to a depth in excess of 80 m. In contrast, groundwater occurs in the damage zones of the Waterkloof Fault, characterised by the occurrence of an unconfined aquifer on the east damaged zone and confined aquifer with artesian flow on the western zone. In this case, aquifers of the site can be regarded as composite groundwater conduit barriers.

Cost: R600 000 Term: 2011–2014

Favourable zone identification for groundwater development: Options analysis for local municipalities

Metago Water Geosciences (Pty) Ltd; Maluti GSM; Counterpoint Development

No. 2158

Groundwater is important today in many sectors, ranging from agriculture to domestic water supplies. It will make proportionately greater contributions to South Africa's water supplies in future as surface water reaches the limits of its availability. Considering its potential, groundwater in South Africa is underutilised and often neglected – it offers a substantial source of unallocated water in the country today, albeit one that is distributed over a large area. Groundwater is a 'proximal resource' – although yields from individual boreholes in South Africa are often modest, groundwater is distributed much more evenly across the country compared with surface water, often making it suitable for small-scale water supplies in rural areas and for smaller municipalities. The total volume of available, renewable groundwater in South Africa is estimated to be about 7 500 million m^3/yr, even in a dry year, and we currently use less than half of this. In contrast, the assured yield of our surface water resources is about 12 000 million m^3/yr – but most of this is already allocated. As South Africans we often underestimate groundwater – in fact, about two-thirds of South Africans rely on groundwater for their domestic needs. The big Metros of Tshwane and Johannesburg use groundwater for part of their water requirements and the city of Mahikeng is 100% reliant on groundwater, sourced from dolomite aquifers to the east. Other cities such as Port Elizabeth and Cape Town are currently investigating the potential of groundwater. Atlantis, Beaufort West, De Aar, Jamestown, Victoria West and several other towns rely mainly on groundwater. Although most large-volume water users now rely on surface water, the majority of small water supplies, which are critical to livelihoods, health and dignity, depend on groundwater. Groundwater's huge potential in South Africa, particularly for poor and rural communities, is still being unlocked. The resource also has important functions in improving food security, maintaining ecosystems, and insuring us against drought and climate change. Improved scientific understanding and management is necessary to further unlock groundwater's benefits. This study examined the reliability or sustainability of groundwater-based domestic water supplies, and concluded that the issue of Operation and Maintenance (O&M) is the single biggest factor in ensuring long-term success. Normally the responsibility of the municipal water services provider, or its appointed professional services provider, O&M is often underfunded or overlooked altogether. Better O&M not only ensures much higher levels of reliability and continuity of water supply, but has been proven to actually save money in the long-term.

Cost: R2 000 000 Term: 2012–2014

Programme 3: Water resource planning

Implementing uncertainty analysis in water resources assessment and planning

Rhodes University; University of the Free State; CSIR; Umvoto Africa (Pty) Ltd; Pegasys Strategy and Development (Pty) Ltd

No. 2056

Internationally, the science of hydrology has embraced the concepts of uncertainty, largely because of the enormous contribution that was made by the IAHS PUB decade. While South Africa has a long history of using models for water resource assessments, uncertainty approaches are relatively new to the country and have not been embraced by either scientists or practitioners. This report

provides the details of new methods of incorporating uncertainty into water resource estimation methods. The overall conclusion is that the project has demonstrated that including uncertainty analysis as part of the widely used Pitman hydrological model is a practical proposition and that the uncertainty outputs can be successfully linked to existing water resource yield models. The final chapter of the report offers some initial ideas about the use of uncertain information in decision making. Throughout this project attempts have been made to achieve a balance between the development of new scientific approaches based on sound hydrological principles and international experience together with the practical considerations associated with the use of models for water resource assessments, planning and management. The degree to which these overall objectives have been achieved can only really be measured by the impact of the project outcomes on the approaches applied in the future. The report makes an important recommendation that the hydrological science and water resources practice communities within South Africa (including those organisations that fund research and practice) start to take the concepts of uncertainty far more seriously than they have in the past.

Cost: R600 000 Term: 2011–2014

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Presence, levels, and potential implications of HIV anti-retrovirals in drinking, treated, and natural waters

North-West University (Potchefstroom Campus)
No. 2144

South Africa as a country currently has the greatest number of people that use HIV anti-retrovirals (HIV-ARVs) as anti-retroviral therapy (ART) in the world. A daily dose of combination therapy of HIV-ARVs (mean of 991 mg/day/person, range 590–1996) equates to a total of 529 000 kg of HIV-ARV compounds ingested per year (assuming 1.5 million people on ART). Excretion of HIV-ARVs varies depending on compound, but some, such as Tipranivir, are excreted at 80%. Assuming a mean 30% excretion to sewage via urine and faeces, it is estimated that about 159 000 kg of HIV-ARV could reach the aquatic systems of South Africa every year. Fish and other aquatic biota are therefore exposed to and may even accumulate HIV-ARVs directly from water via their gills, food, or both. More than 100 samples were collected, from natural waters, drinking water (including bottled water), fish plasma, final wastewater effluent and groundwater. The occurrence of 11 selected ARV drugs (Zidovudine, Stavudine, Didanosine, Tenofovir, Lamivudine, Abacavir, Efavirenz, Nevirapine, Lopinavir, Ritonavir, Saquinavir, Nelfinavir was studied. Efavirenz and Saquinavir were not detected in any of the 47 natural water samples. All other compounds were detected at least once, with Nevirapine found in 6 samples. The lowest concentration was 0.3 ng/L (Zidovudine) and the highest was Nevirapine at 6.7 ng/L. Only Nevirapine (0.4 ng/l), Zidovudine (0.3 ng/l) and Tenofovir were quantified in wastewater effluent. In the drinking water samples Lamivudine, Tenofovir, Efavirenz, Lopinavir, and Saquinavir were not quantifiable, whereas Nevirapine occurred in 5 samples (0.3–3.5 ng/L), and Didanosine in 3 samples (0.4–3.3 ng/L). Stavudine, Nevirapine, Tenofovir, Nelfinavir and Saquinavir were quantified from 7 of 18 groundwater samples. In 33 fish plasma samples from 4 sites, 9 samples had quantifiable amounts of HIV-ARVs: Stavudine (n=2), Didanosine (n=3), Abacavir (n=1), Efavirenz (n=1), Nelfinavir (n=1), and Saquinavir (n=2). Plasma concentrations ranged from 5.4–22 ng/L. All sites, including a supposed 'clean site', upstream of Upington, had one or more quantifiable HIV-ARV residues. No HIV-ARVs were detected in any of the 25 bottled water samples. In conclusion, all eleven HIV-ARVs selected for this study were quantifiable in at least one matrix. Two of the four WWTPs did not have quantifiable amounts of HIV-ARVs in their effluent, indicating that effective removal (below LOQ) is possible.

Cost: R471 000 Term: 2012–2015

Surveillance of viral, faecal indicator bacteria and *Vibrio* pathogens in the final effluents of wastewater treatment facilities in the Eastern Cape Province: a vehicle for capacity development in microbial water quality science in the Province

University of Fort Hare; University of California
No. 2145

This project investigated 14 wastewater treatment plants (WWTP) in the Eastern Cape in line with the priority areas as

identified by the Department of Water & Sanitation (DWS). The focus of the study was to determine the monitoring procedures in place, physico- and hydrochemical analyses carried out and general compliance with the Green Drop and other standards. This study found that there is little if any viral and bacteriological analysis, in particular for the pathogens associated with diarrhoea and cholera, being conducted, with the exception of total faecal coliforms. Furthermore, the study indicated that there is lack of consistent and scientifically-based disinfection (by means of chlorine) in these WWTP. In fact where the dosage is measured and consistently recorded is the exception rather than the rule. There were numerous cases recorded where there was excess dosing either as a result of the automated dosing machines being broken or because some of the staff members were inadequately trained. The study also indicated the presence of *Vibrio* and pathogenic strains in the water both at the discharge point and at the end of pipe.

Cost: R900 000 Term: 2012–2014

Investigating the occurrence and survival of *Vibrio cholerae* in surface water sources in KwaZulu-Natal Province of South Africa

University of Johannesburg; ERWAT; University of Venda; Mangosuthu University of Technology; Rand Water
No. 2168

This project investigated the occurrence of toxigenic and non-toxigenic *Vibrio cholerae* in the Msunduzi River (located in the Msunduzi Local Municipality) and the Isipingo and Umlazi Rivers (located within the Ethekwini Metropolitan Municipality) in the Province of KwaZulu-Natal. The study used culture-dependent and culture-independent real-time polymerase chain reaction (PCR) methods to detect and identify toxigenic and non-toxigenic *V. cholerae* presence in the selected rivers. Different niches that may facilitate survival of *V. cholerae* in the rivers were identified and sampled. These included zooplankton, phytoplankton, amoeba, invertebrates, animal stools (found near the river), sediments and the river water itself. The results from the study indicate that the culture-dependent method is the most effective/reliable methodology for detection and identification of *V. cholerae* from environmental samples. The non-toxigenic *V. cholerae* was detected in water samples (free-floating form) and attached to plankton, invertebrates and the sediment compartment of the rivers but was not detected in amoeba and cow stool samples. Although the study did not determine the prevalence and influence of seasonality, the non-toxigenic *V. cholerae* was found to occur throughout the 14 months of sampling. Toxigenic *V. cholerae* was not detected in any of the samples throughout the sampling period. There were observations made of blocked sewer mains being discharged into the environment close to the stream and this resulted in high total coliform and *Escherichia coli* counts from the selected rivers under study. Using the WRC/DWF guideline (1998) the *E. coli* and total coliform counts obtained for all the water samples would pose a serious health impact on the humans. Furthermore, even though the non-toxigenic *V. cholerae* detected in this study are not associated with cholera, they are associated with sporadic cases of gastroenteritis, septicaemia and extra-intestinal infections. Thus, the non-toxigenic *V. cholerae* strains detected and identified using the methods described in this study may have the ability to cause infections in sensitive population groups (e.g. immune-compromised individuals). There is a need to prevent blocked sewage mains from discharging into the environment as this may result in bacterial pathogens being deposited in the river water and subsequently being ingested by unsuspecting communities. The dwellings in this community use the river water mostly for recreational, cultural and religious activities. The community should be warned of the health risk associated with using untreated river water for the abovementioned activities.

Cost: R600 000 Term: 2012–2014

Programme 2: Water quality modelling

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

Stellenbosch University; CSIR
No. 2063

South Africa is in currently in a stage of transition between the old and new environmental and water legislation. This is causing a number of problems as a result of the slowness to adapt by the public and, similarly, the government officials and law enforcers. Though the transition was supported initially by public participatory workshops, we still find ourselves in the situation where there are water users that are unfamiliar with the new systems and

that do not know their specific roles in terms of these laws. It is also evident that water managers employed at Catchment Management Agencies (CMAs), old water boards and municipalities struggle with implementation and that the knowledge and capacity of these people to deal with water management problems are often irreplaceable. Thus a proposal was submitted to the WRC for the development of a methodology and guidelines for the management of dryland salinity which could decrease the water management challenges currently faced by managers. The project designed the solution through a stakeholder engagement and consultation process.

Cost: R1 000 000 Term: 2011–2013

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

Nelson Mandela Metropolitan University; Technical University of Berlin

No. 2065

ß-N-methylamino-L-alanine (BMAA) is a neurotoxic amino acid produced by most, if not all, cyanobacteria, and is linked to amyotrophic lateral sclersosis/Parkinsinism dementia complex (ALS/PDC). However, the reported BMAA content of cyanobacteria has varied substantially from none detected, to mg/g dry weight (DW). Lack of understanding of the causes of variation and possible environmental modulators makes management of risk exposure almost impossible. This project assessed the causes of BMAA content variation in cyanobacteria while confirming the cyanobacterial origin of BMAA and elucidating possible biosynthetic mechanisms of BMAA in cyanobacteria. This was done by:

- Determination of the effect of variation in nutrients on the production of BMAA with an emphasis on the effect of nitrogen on BMAA content
- Investigation of possible mechanisms of biosynthesis and metabolism of BMAA in cyanobacteria
- Investigating the possibility of estimating BMAA content based on a more easily measurable metabolite
- Assessment of a commercial BMAA ELISA kit (that became available during the course of this project)

The study was able to indicate that BMAA is a product of cyanobacterial metabolism, and is environmentally modulated. BMAA is not produced concurrently with proteinogenic amino acid anabolism (as has been postulated) but rather, in the laboratory cultures, BMAA content of cyanobacteria is controlled predominantly by medium nitrogen, indicating the need for evaluation of this finding in a long-term monitoring project aimed at the development of a predictive model. This is necessary because published methods for BMAA analysis are technically demanding, require sophisticated equipment, and are prohibitively expensive for the frequency of monitoring that should take place to limit public exposure to the toxin.

Cost: R500 000 Term: 2011–2013

Using an integrated water quality management model to support the implementation of National Water Act water use authorisations

Golder Associates Africa (Pty) Ltd; Jeffares & Green (Pty) Ltd; MHP GeoSpace (Pty) Ltd

No. 2159

A first real-time water monitoring reporting system that enables water users to input data/ report to the authorities has the potential to increase the DWS/CMA/ local government monitoring network without cost. The IWQMS developed is a web-based system that will be utilised for water quality/quantity reporting by water users with potential for enhancing and streamlining the reporting process by DWS. The main benefit of this system is that it will assist the Department to receive real-time and ongoing status reports for water resources. This will result in the data being available to DWA at least 6 weeks to 1 month after sampling is conducted. This is much faster compared to the current status where water users report to the department either once or twice annually. This process will enable the responsible DWS officer, either sitting in the Regional Office or CMA, to have real-time information and to implement intervention measures where there is failure to comply. The project enjoyed the approval of regional office personnel both at senior and lower level. The pilot of the project was also conducted in an area where there are organised water user associations (WUA).

Cost: R555 000 Term: 2012–2014

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

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

Council for Geoscience; GEOSS – Geohydrological and Spatial Solutions International (Pty) Ltd; CSIR; City of Cape Town; Oudtshoorn Municipality

No. 2070

The development of groundwater supply schemes is on the increase in South Africa. However, the sustainability of many of these schemes is threatened due to the presence of soluble iron (Fe^{2+}) and manganese (Mn^{2+}) ions in the groundwater. This risk manifests from the problems caused in the water quality and supply to consumers. The main water quality problems associated include the aesthetic (e.g. staining of laundry) and potable (e.g. metallic taste), which subsequently limits the use of the water. The World Health Organisation (WHO) recommends the removal of iron (Fe) and manganese (Mn) to concentrations below 0.3 mg/L and 0.1 mg/L, respectively, to circumvent the abovementioned issues. These concentrations levels can easily be achieved by above-ground water treatment after abstraction, but require high investment costs, skilled operators and high operation and management costs to succeed. It was found that the fourth injection technique of continuous injection and abstraction achieved the desired Fe removal to below the WHO potable and aesthetic threshold limit (i.e. < 0.3 mg/L). Although the Mn removal was not as effective it is known that Mn^{2+} oxidation takes longer in comparison to Fe^{2+} and requires higher pH conditions. For various reasons the duration of the injection runs was limited and the effect of longer-term treatment on Mn concentrations could not be verified. In addition, no significant changes to the overall water quality were observed. The use of ozone as the oxidant was found to be very effective as in the field the dissolved ozone concentrations measured in the injected water (i.e. 0.3–0.5 mg/L) reflected the typical ozone concentrations found in ex-situ treatment for Fe and Mn removal.

Cost: R809 054 Term: 2011–2014

Development of an interactive vulnerability map and preliminary screening-level monitoring protocol to assess the potential environmental impact of hydraulic fracturing

University of the Free State; University of Pretoria

No. 2149

The main aims of this study was to investigate hydraulic fracturing by performing a background review; developing an interactive vulnerability map; and developing a provisional screening-level monitoring protocol. This study aimed to contribute knowledge on issues associated with hydraulic fracturing and highlight vulnerable areas for specific aspects in South Africa. It also proposes a provisional screening-level monitoring protocol that can be used as a guideline to monitor unconventional gas extraction activities. In South Africa, where water demand will exceed water supply in the near future, unsustainable use of water resources will result in increasingly limited water resources for future health and well-being as well as for sustained socio-economic development. Society in general, and specifically the residents in the Karoo where access to water is already limited, needs to be assured of the sustainable use of the water resources for health and well-being by understanding and where possible avoiding the negative social impacts resulting from unconventional gas extraction by means of hydraulic fracturing. The interactive vulnerability map that was developed during this project focuses on specific aspects, which include surface water, groundwater, vegetation, seismicity and socio-economics, and was developed specifically for South Africa. The vulnerability map aims to provide decision-makers at national level and other practitioners with information on the vulnerability to unconventional gas extraction of the specified mapping themes on a regional scale. The vulnerability map was developed by using experts in their respective fields to decide on indicators that would indicate vulnerability of a theme to unconventional gas extraction specifically. Only regional-scale data was used for this regional map and the map cannot replace local-scale maps that may need to be developed to inform decision-makers of local-scale conditions of vulnerability to unconventional gas extraction. This map is intended as a reconnaissance tool to inform decision-makers on areas where additional detailed field work and assessments may be required as part of environmental impact assessment and licensing conditions.

Cost: R900 000 Term: 2012–2014

Programme 2: Land-water linkages

The effect of long-term fire frequency and season treatments on the soil hydraulic properties and soil water balance within semi-arid savannas in the Kruger National Park

South African National Parks; University of KwaZulu-Natal (Pietermaritzburg)
No. 2146

Soils are vital in supporting healthy and functioning ecosystems. Besides providing a medium for plant growth, soils play a major role in ecosystem functioning through nutrient cycling and water filtration through the system; thus when soils are degraded important ecosystem services are affected. Degraded soils may not be able to store and filter water as efficiently thereby affecting water quantity and quality. This in turn has a detrimental effect on catchment hydrological processes. Soils play a major role in landscape hydrology by providing a medium for water distribution and storage. The complex relationship between soil and water has been described as interactive; meaning that the physical, chemical and biological properties of soil influence the manner in which water is transported and stored within the landscape, which impacts the ecosystem. This study revealed that it is the time following a fire and not necessarily fire frequency which results in decreased soil infiltration, with the slowest infiltration rates occurring immediately after the fire. Findings suggest that fire primarily affected infiltration rates at the soil surface and that these fire effects would dissipate within approximately two years, suggesting the soil's ability to recover; at least in terms of their hydrological function. Soil compaction, which is recognized for impeding soil infiltration, was attributed to soil processes such as raindrop impact and splash but deeper compaction was linked to high concentrations of herbivores trampling the soil.

Cost: R324 000 Term: 2012–2014

THRUST 5: 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; South African Weather Service; University of KwaZulu-Natal (Howard College Campus); International Research Institute for Climate and Society; ARC (Institute for Soil, Climate & Water)
No. 2050

This project was aimed at developing a seamless forecasting system for predicting weather and climate at multiple time scales. In this regard, the defensible and actionable multi-decadal regional projections provide evidence that extreme weather and climatic events are likely to increase over southern Africa in a changing climate. Weather and seasonal climate model configurations, based on the conformal-cubic atmospheric model (CCAM), are subsequently described and verified. The major findings are that the CCAM model code can be used as a seamless forecasting system since it was successfully applied to produce short-range weather forecasts, seasonal climate projections and projections of future climate change. Temperatures are projected to rise over southern Africa and an increase in weather and climate extremes are expected to occur.

Cost: R950 000 Term: 2011–2014

Development of defensible regional climate change projections for adaptation and policy

University of Cape Town
No. 2061

This project addresses issues underlying the critical questions regarding assessment of the regional climate to support decision making processes. At the regional scale our choices are complicated by the large uncertainties in the degree and rate of change and our incomplete knowledge of how human and physical systems will respond. The methodological approach adopted considers the historical changes from observed data, changes in the driving circulation patterns, and the projected changes at the regional scale from the global circulation models (GCMs), and from the information downscaled from the GCMs. Findings indicate that the CMIP5 models have some skill in simulating the leading mode of global variability: ENSO. Most of the models tend to show dry conditions (although weaker in magnitude) over southern Africa during strong El Niños, and the newer versions of the GCMs are starting to produce marginally more realistic results. Also, biases between models and the diversity of frequency of regional circulation models highlight the critical importance of not using

any single one model. A clear message of warming over South Africa is seen in the raw GCM output as well as both downscaling methods. Warming is projected to be most intense over the drier parts of the interior, while less intense along the coast.

Cost: R1 317 750 Term: 2011–2014

The limits of predictability of the South African seasonal climate

University of Cape Town; University of Oxford; Pennsylvania State University
No. 2067

The project aimed to characterise the degree to which the predictability of seasonal forecasts varies from year to year, to identify causes of such variations; and to characterise the degree to which anthropogenic greenhouse gas emissions have altered the chance of extreme months. A case study extending the predictability and attribution methods to a hydrological case study: the streamflow discharge into the Okavango Delta, Botswana is also dealt with. Findings were that ranges of simulated temperatures exhibit a strong east–west gradient in the case of precipitation, and a strong coastal–inland gradient in the case of temperature. While the occurrence of El Niño and La Niña events in the tropical Pacific is linked to variations in the spread of the simulations, robust relationships are not found for other areas of the ocean considered to strongly influence the South African climate. The spread of model simulations shows long-term narrowing and widening trends for both monthly rainfall and temperature, with the nature of the trends varying as a function of location and season. It was found that event attribution estimates are not sensitive to the choice of climate model used, or to downscaling methods, when examining the chance of flooding events in a hydrological system.

Cost: R1 200 000 Term: 2011–2014

CURRENT PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional 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

Natural resource governance system in South Africa

Pegasys Strategy and Development (Pty) Ltd
No. 2161

- To conduct an analysis of the advances made and the challenges being faced in the international arena regarding governance frameworks, and how these inform the local/national level discourse
- To review the current governance framework (at both policy and implementation levels) highlighting opportunities and

constraints in the current institutional, strategic and regulatory frameworks for sustainably managing water resources
- To explore the priority issues highlighted in the document, 'Current and emerging governance systems in terms of water governance' (1514/1/06), which require further elaboration
- To review and update the above-mentioned Water Research Commission (WRC) document
- To recommend strategies and action plans on enhancing the knowledge base and addressing current challenges to improve and ensure good water governance
- To conduct information-sharing sessions and workshops to build capacity as well as create an aligned understanding of the governance framework and its implementation

Estimated cost: R1 000 000 Expected term: 2012–2014

Key Interventions to improve local groundwater governance

University of the Western Cape
No. 2238

The aims of this project are:

- To identify the key components of good local groundwater governance
- To identify the components lacking in good local groundwater governance in South Africa
- To identify key interventions needed to improve local groundwater governance
- To test the implementability of the key interventions
- To disseminate the findings to key role-players

Estimated cost: R300 000 Expected term: 2013–2015

A compendium of the legal narrative of the South African White Paper and National Water Act of 1998

GHT–Southern Africa
No. 2250

The aims of this project are:

- To document all information (oral and written) in the public domain and state archives related to the water law review which led to the development of the White Paper on a National Water Policy (1997) and the National Water Act (1998) in South Africa
- To review all available sources of information related to water law in South Africa
- To identify major departure points from the previous law of 1956 and document how the different elements were debated and in the process, analyse and profile the main driving factors for the water reforms
- To source and document all major discussion documents prepared for the above purpose including oral knowledge
- To identify major deviations of interpretation, implementation and debates and identify gaps
- Based on results from the documentation process and critical assessments, recommend appropriate policy options, strategies and institutional steps that may enhance the water reform implementation process for better impact on the ground

Estimated cost: R1 500 000 Expected term: 2013–2016

Institutional arrangements for implementing water equity mechanisms in South Africa

Prime Africa Consultants (previously CIC International)
No. 2255

The aims of this project are:

- Investigate the potential benefits of two water equity enforcing mechanisms: domestic water supply and the General Authorisation (Government Gazette No. 20526 8 October 1999)
- Design the institutional requirements for implementing these water equity enforcing mechanisms
- Determine the costs and risks to the fiscus of these institutional requirements
- Develop a case (in National Treasury format) for implementing these mechanisms.

Estimated cost: R 1 162 600 Expected term: 2013–2016

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: (i) can optimise water allocation in multi-purpose

multi-reservoir systems in water scarce environments, based on economic values and socio-political preferences; that (ii) can continuously adjust these allocation policies based on seasonal flow forecasts and knowledge of their uncertainties; and that (iii) can hedge against inflow risks using adaptive, risk dynamic, management and operation strategies. This project adds two extra components to the RISKOMAN research: i.e. (i) 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; (ii) 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

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

Stellenbosch University
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

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

A methodology to create a South African river network with hydraulic intelligence

ARC (Institute for Soil, Climate and Water)
No. 2164

The aim of this project is to develop a semi-automatic methodology to create a robust, co-extensive (countrywide) and accurate river network coverage for use in GIS projects and other planning initiatives.

Estimated cost: R1 000 000 Expected term: 2012–2015

Establishment of an observation network to improve understanding of global change in the sensitive and critical water supply area of the Drakensberg

University of KwaZulu-Natal
No. 2236

The aims of this project are:

- To classify land cover/use in the area
- To develop a drainage-system model for the Mooi River
- To determine the diurnal and seasonal variation in the chemical characteristics of the surface water of the system

- To determine the diurnal and seasonal variation in the chemical characteristics of the sediment of the system
- To compile a survey regarding the presence/absence of microbial and diatom indicators or extreme species

Estimated cost: R900 000 Expected term: 2013–2016

Revision of the mean annual precipitation (MAP) estimates over Southern Africa
Pegram and Associates (Pty) Ltd
No. 2241

The aims of this project are:

- To first assess the quality of the rain-gauge data and, where necessary, clean it, mindful that CSAG have already given the set a careful screening using NOAAs Quality Control, Homogeneity Testing, and Adjustment Procedures
- To temporally infill CSAG rainfall database and provide Confidence Limits (CLs) since 1950 using copula-based methods
- To interpolate daily rainfall on a 1-minute grid over RSA and provide CLs since 1950
- To derive a new Mean Annual Precipitation map over RSA, with accompanying map of CLs augmented by monthly and seasonal breakdowns, and decadal shifts

Estimated cost: R1 800 000 Expected term: 2013–2016

Sediment yield modelling in the uMzimvubu River catchment
ARC
No. 2243

The aim of this project is to assess the sediment yield in the uMzimvubu Catchment by means of a distributed modelling and remote sensing approach.

Estimated cost: R500 000 Expected term: 2013–2015

The use of GIS and remote sensing techniques to evaluate the impact of land-use and land cover change on the hydrology and water resources of Luvuvhu River Catchment in Limpopo Province
University of Venda
No. 2246

The aims of this project are:

- To review literature on existing methods for assessing land-use and land cover changes and their impacts on hydrology and water resources
- To classify and quantify the land-use and land cover changes in the LRC between 1970 and 2010
- To determine the present and potential water resources of the LRC
- To extract the geomorphologic and hydrologic properties of the study area from digital elevation models (DEMs)
- To model the impact of land-use and land cover changes on water resources in the LRC

Estimated cost: R555 000 Expected term: 2013–2015

Programme 2: Surface water / groundwater hydrology

Investigating projected changes in the nature of extreme rainfall over South Africa during the 21st century
University of Cape Town
No. 2240

The aims of this project are:

- Identify extreme rainfall regimes across South Africa using synoptic circulation data and station-based ETCCDMI indices
- Downscale projection data to the station scale and identify changes in these over different regions of the country
- Use native resolution GCM projection data as well as dynamically downscaled projection data from the CORDEX project to identify changes in the frequency of occurrence of synoptic circulations associated with extreme rainfall
- Explicitly examine known circulation features that are associated with extreme rainfall such as cut-off lows and tropical temperate troughs and identify trends in these systems

Estimated cost: R418 000 Expected term: 2013–2016

Programme 3: Water resource planning

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

Update of water resources of South Africa (WR2005): Phase 1

SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2143

The aims of this project are to:

- Critically evaluate the outcomes of the WR2005 study in terms of uses, users, impact and knowledge gaps
- Enhance the groundwater data and provide a review of catchments where groundwater is a significant resource
- Incorporate the WRC unified assessment of groundwater methodology
- Develop a folder system based on WMA of all major land uses that have impact on water availability
- Develop simulated, present-day analyses of key gauges (of the order of 100) throughout the country
- Develop a web-based database for WR2012 study for the purpose of national water resource planning which can be continually updated
- Enhance the WRSM2000 model to suit user requirements; develop the Pitman daily time-step and daily calibration facility
- Provide extended training to 8 universities and 2-week training to the Department of Water Affairs on WR2012 and the WRSM2000 model thereby enhancing the user-support system for WR2012 products
- Recommend the optimal monitoring requirements and strategic monitoring points for South Africa in respect of rainfall, streamflow gauging, groundwater and water quality for the efficient assessment of the country's water resources
- Develop a rating system for quaternary catchments that will give users a measure of the confidence they should have in using naturalised and simulated streamflow in that quaternary catchment. Climate change sensitivity analysis.

Estimated cost: R4 000 000 Expected term: 2012–2016

Implementation of a South African National Standard for Water Retaining Structures

Stellenbosch University
No. 2154

The overall aim of this project is to provide the South African engineering community with their own South African standard for the design of water retaining structures, by supporting the development of this standard up to the stage of a voted SABS committee draft (CD), which is ready to be converted by SABS into a Draft South African Standard (DSS) for public comment and subsequent publication through normal SABS procedures as a National Standard (SANS). The standard will take account of local conditions and materials and be calibrated to our corresponding loading code SANS10160:2010 and concrete design code SANS10100-1/SANS EN 1992-1-1.

Estimated cost: R790 000 Expected term: 2012–2015

Integrated water use quantification methodology for South Africa

University of KwaZulu-Natal
No. 2205

The aims of this project are to:

- Critically assess approaches and methodologies of quantifying water use directly and indirectly and carefully assess the accuracy levels of these methods
- Integrate appropriate sources of data, information and methodologies into a single internally-consistent water use quantification and accounting system
- Apply the system to assess sectoral water use and all components of the hydrological cycle in selected study areas in South Africa
- Using available observed/measured and simulated fluxes of the components of the hydrological cycle, assess the impact of errors on the water balance, quantify the uncertainties associated with poor and/or unavailable data

Estimated cost: R2 500 000 Expected term: 2012–2013

Dam surveillance and monitoring using dynamic and static measurements

University of the Western Cape
No. 2244

The aims of this project are:

- Develop best practices in ambient vibration testing of dams
- Best practice procedure for finite element model calibration of arch dams
- Develop framework for long-term structural monitoring of dams
- Transfer of experience gained to DWA and industry

Estimated cost: R890 000 Expected term: 2013–2016

Extending the Ogee spillway relationship to accommodate the unsymmetrical upstream cross sectional details, the relative orientation of the wall structure and the influence of the curvature of the dam structure

University of Pretoria
No. 2253

The aims of this project are:

- Determine the influence of un-symmetric upstream channels on the required form of the Ogee spillway relationship
- Determine the influence of relative orientation of the spillway relative to the upstream approaching flow direction
- Determine the influence of curvature of the wall in relationship to the total upstream energy on the required form of the Ogee spillway relationship
- Develop guidelines to assess if it is required to review other parameters in the design of uncontrolled spillway

Estimated cost: R300 000 Expected term: 2013–2015

Programme 5: New water and water security

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 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Encouraging citizens' water quality management through subcatchment forums

Mvula Trust
No. 2151

The aims of this project are:

- To bring together existing literature on catchment forums in South Africa that is relevant to dealing with water quality issues in a comprehensive overview
- To survey and understand the workings of existing catchment forums, and the factors influencing their sustainability, inclusivity, effectiveness and legitimacy
- To develop recommendations and guidelines for the functioning of catchment forums that are sustainable, inclusive, legitimate and effective
- To discuss the findings and recommendations with stakeholders involved in catchment forums
- To test the guidelines by piloting them in selected forums

Estimated cost: R600 000 Expected term: 2012–2014

Screening study to determine the distribution of common brominated flame retardants in water systems in Gauteng

Tshwane University of Technology
No. 2153

The aims of this project are to:

- Characterize exposure to BFRs using common aquatic organisms found within the water systems
- Investigate seasonal trends of those BFRs found within the water systems
- Develop an environmental contamination profile of landfills, surface water, wetlands, groundwater, sediment, landfill and biota within the study area with respect to BFRs
- Employ derivatisation techniques to develop a treatment kit that can be used to analyse high molecular weight BFRs
- Attempt to identify the sources of BFRs if found present in relation to land use

Estimated cost: R900 000 Expected term: 2012–2016

Polycyclic aromatic hydrocarbons (PAHs) in the aquatic ecosystems of Soweto/Lenasia

North-West University (Potchefstroom)
No. 2242

The aims of this project are:

- To determine the nature and extent of 16 priority PAHs at a site previously found to exhibit high levels of PAHs
- To assess the possible sources using PAH fingerprinting
- To perform a preliminary assessment of possible associated risks to local fish and human health

Estimated cost: R375 000 Expected term: 2013–2016

Water resources management in South Africa: towards a new paradigm

Rhodes University
No. 2248

The aims of this project are:

- To write a starter discussion document that elaborates the framework and process for the project
- To build a transdisciplinary team to undertake the project
- To develop a systems-based project design that integrates the case study focus areas (resource protection, eutrophication and microbial pollution); place-based case studies at different scales; and overarching concepts including complexity, complex social ecological systems, transdisciplinarity, resilience, social learning and strategic adaptive management
- To develop, workshop and finalise the detailed aims, methods, and outcomes at each site, for each case focus, and the whole project
- To undertake and clearly link the theoretical, conceptual framework to a specific set of methodologies, to lay a foundation for the development of robust transdisciplinary scholarship and practice; and to explore a richer understanding of 'integration'
- To provide a rich and clear understanding of the 'new paradigm' together with inherent implications (intended and unintended consequences)
- To develop a set of guiding principles for IWRM in South Africa
- To undertake relevant research in place-based case study areas in respect of each case focus area (eutrophication, microbial pollution, water resource protection)
- To have facilitated the development of appropriate software and data curation to support 'new paradigm' thinking and practice
- To have proposed and selectively practised the 'new paradigm' of water resource management in South Africa
- To have contributed to the scholarship and practice of transdisciplinarity, particularly in the linked development of concept, theory and method
- To recommend a principle-based and adaptive contribution to the ongoing review and writing of the National Water Resource Strategy

Estimated cost: R5 000 000 Expected term: 2013–2017

Programme 2: Water quality modelling

Development and application of a simple South African water quality model for management of rivers and reservoirs under current and future development and climate change scenarios

Rhodes University (Institute for Water Research)
No. 2237

The aims of this project are:

- The construction of a water quality systems assessment model (WQSAM) to work in conjunction with both the WReMP or WRYM yield models and the Pitman model, to simulate the frequency of certain water quality concentration thresholds being exceeded, using predominantly available observed data, and a simplified conceptual framework
- Investigation of freely available remote-sensing data for parameterization and calibration of WQSAM
- The application of WQSAM to various catchments in South Africa, for comparison of model simulations to historical data, so as to assess the model's performance
- The assessment of various future development and climate change scenarios using WQSAM within the case study catchments, so as to assess the possible future impacts of development and climate change on water quality, and for comparison with results from previous studies

Estimated cost: R500 582 Expected term: 2013–2015

A feasibility evaluation of the total maximum daily (pollutant) load (TMDL) approach for managing eutrophication in South African dams
DH Environmental Consulting cc
No. 2245

The aims of this project are:

- Literature survey of the TMDL approach and its values for the strategic management of surfaces, in particular, reservoirs
- Formulation of a short-list of priority-need reservoirs for further analysis; this list would be developed in conjunction with the DWA and relevant stakeholders
- Selection of three to four dams for TMDL analysis; selection of the reservoirs will be based on the criteria of flow, data, types of sources (one each from the TMAPL study groups), data for point sources (WWTWs)

Estimated cost: R638 250 Expected term: 2013–2015

Programme 3: Impacts on and of water quality

Microbial pathogens in water resource sediments: their dynamics, risks and management
CSIR
No. 2169

The aims of this project are to:

- Characterise and model the pathogen loads from point, non-point and land use practices in two selected areas (this will be undertaken in close cooperation with WRC project K5/1984)
- Develop simulation model/s based on the outcome of the hypothetical models and the processes that drive the remobilisation of pathogens from sediments to ultimately predict pathogen loads under different climatic conditions (above- and below-normal rainfall events) and seasons (dry versus wet) of the year
- Develop a tool that links derived turbidity measurements obtained from remote sensing data with microbial contamination levels under different climatic conditions
- Use the Basins-4 framework to make the models' availability and outcomes standardised within the research community
- Build capacity in relevant stakeholders with regard to the use of the developed models to improve decision making

Estimated cost: R1 300 000 Expected term: 2012–2015

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

The selection and validation of sediment toxicity test methods to be included in the National Toxicity Monitoring Programme
Golder Associates Research Laboratory
No. 2160

The aims of this project are:

- To conduct an extensive survey on national and international toxicity methods utilised as well as new methods to evaluate sediment contamination
- To test and validate the sediment toxicity tests using the in-house cultures according to international methodologies
- To test and validate available sediment toxicity test kits available in order to identify the most cost- and time-effective methods to screen sediment samples
- To provide final method and vadidation documentation
- Training and implementation of the method

Estimated cost: R1 715 150 Expected term: 2012–2015

Groundwater remediation technologies manual for South Africa – a theoretical treatise and practical guide

Hydro Aqua Earth

No. 2167

The aims of this project are as follows:

- The principal aim or objective of this proposed project is to provide a source of reference documentation for improved knowledge on technologies to remediate contaminated groundwater for the use of stakeholders
- Subsidiary objective 1 – to provide guidelines for characterisation of sites of groundwater contamination
- Subsidiary objective 2 – to provide a compilation of an inventory of available technologies for the remediation of contaminated groundwater
- Subsidiary objective 3 – to provide technical manuals relating to specific technologies that apply to the field of groundwater remediation (including the scientific basis, processes involved, and design systems)
- Subsidiary objective 4 – to develop guidelines for choosing appropriate and effective technologies for the remediation of contaminated groundwater, taking into account the particular contaminant (or contaminant mix), and the geological and biophysical environment of the impacted site or location

Estimated cost: R1 000 000 Expected term: 2012–2015

The hydrogeology of Groundwater Region 65: Northern Zululand Coastal Plain

North-West University (Potchefstroom Campus)

No. 2251

The aims of this project are:

- Analyse and present the related groundwater data in a concise manner
- Estimate how much water is available for use and how much is currently being used
- Quantify possible pollution sources and associated impacts
- Provide guidelines for the future development and management of groundwater resources
- Provide a document (in the standard format for the groundwater regions as set out by Vegter), a database and tools to assist in the management of groundwater resources within the study area

Estimated cost: R550 000 Expected term: 2013–2015

Characterising the chemical composition of deep and shallow groundwater in an area considered for shale-gas exploration in the Main Karoo Basin

Groundwater Africa

No. 2254

The aims of this project are:

- In a selected area in the Main Karoo Basin where shale-gas exploration is envisaged, characterise shallow (cold) and deep (warm) groundwater by analysing the waters (borehole and spring) for chemistry including trace elements, heavy metals, rare earth elements, isotopes and possibly noble gases
- Identify specific determinants (out of the above) that distinguish shallow from deep groundwater and whether specific areas associated with shallow water samples contain traces of deep groundwater
- For regulatory purposes, develop a list of determinants that should be analysed in both shallow and deep boreholes in future shale-gas exploration and development areas

Estimated cost: R1 000 000 Expected term: 2013–2015

Groundwater use by alien invasive plants: assessing the impact of *Prosopis* spp. invasions on water supply to groundwater-dependent communities

CSIR

No. 2256

The aims of this project are:

- To establish the long-term water use trends by *Prosopis* invasions and co-occurring deep-rooted indigenous vegetation in order to determine impacts on groundwater
- To characterize the hydrogeology of a *Prosopis*-invaded aquifer
- To determine the sources of water used by the vegetation and to quantify the proportion of the total water use that is derived from groundwater
- To quantify potential increases in groundwater recharge as a result of clearing *Prosopis* invasions

- To evaluate a physically-based model for predicting water use by *Prosopis* invasions integrating in situ and remote-sensing data
- To apply the model to scale up estimates of groundwater use by *Prosopis* to selected invaded sites in the country

Estimated cost: R1 324 700 Expected term: 2013–2016

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

GCS; University of the Western Cape
No. 2288

The aims of this project are:

- Build on DWA project by including international best practice regarding complex aquifer settings
- Evaluate fractured rock aquifer data collection methodologies
- Develop initial guideline for complex aquifer systems
- Test initial guideline at Rawsonville TMG research site
- Investigate data needs and application of risk analysis modelling software
- Effect of seasonal variation on protection zones
- Minimum requirements to establish protection zones in complex aquifer settings
- Finalise guideline for protection zoning strategy in complex aquifer settings

Estimated cost: R510 000 Expected term: 2013–2014

Programme 2: Land-water linkages

Groundwater yield-reliability analysis and operating rules for rural areas

University of Venda
No. 2157

The aims of this project are:

- To review literature on existing methods for yield-reliability analysis and deriving operating rules
- To select and delineate a water-scarce rural area on a fractured aquifer with no groundwater yield time series data as a groundwater resource unit (GRU)
- To monitor soil moisture, groundwater abstractions and groundwater yield, and compute runoff for the GRU
- To compute groundwater recharge for the GRU
- To assess groundwater resource availability for the GRU
- To perform yield-reliability analysis and derive groundwater supply operating rules for the case study village
- To generalise the groundwater operating rules for rural areas with fractured aquifers in South Africa

Estimated cost: R700 000 Expected term: 2012–2015

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Investigating climate change effects under altered land uses on water yield and downstream ecosystem services

Golder Associates Africa (Pty) Ltd
No. 2156

The aims of this project are:

- To investigate the impacts of invasive plant species and degraded land on hydrological responses, particularly on sustained water yields, under present and projected future climatic conditions through the refinement of hydrological modelling methods at appropriately fine spatial scales
- To investigate the effects of projected climate changes on downstream ecosystem services and their economic values, and ascertain how these could affect human wellbeing and the resilience of natural systems
- To develop a strategy and guideline for adaptive catchment management towards improved water yield, based on the modelling results

Estimated cost: R900 000 Expected term: 2012–2015

Stratospheric and tropospheric radiative forcing of Southern African climate variability and change

CSIR
No. 2163

The aims of this project are:

- To test if the inclusion of realistically varying GHG as well as stratospheric sulphur dioxide and ozone concentrations in

an AGCM will improve on seasonal forecasts of rainfall and temperature over Southern Africa
- To quantify the improvement in terms of season (spring, summer, autumn and winter), variable (rainfall and temperatures) and lead-time (up to 6 months' lead)
- To investigate to what extent stratospheric ozone depletion interacts with the enhanced greenhouse effect to impact on Southern African circulation and rainfall patterns
- To investigate the circulation dynamics by which the effects of stratospheric cooling are communicated to the subtropics, and Southern Africa in particular
- To obtain plausible projections of how ozone recovery and increased greenhouse gas concentrations will interact over the coming century to cause climate change over Southern Africa

Estimated cost: R1 008 100 Expected term: 2012–2015

Using satellite data to identify and track convection over southern Africa

South African Weather Service
No. 2235

The aims of this project are:

- To install the code for the RDT on a dedicated server in SAWS using information from the MSG satellite as well as model input from the local version of the Unified Model input instead of ECMWF
- To create a two-fold system – one for operational runs using operationally updated data and one for case studies, in 'archive' mode
- To test and validate the system on South African and southern African case studies and validate the results against the occurrence of lightning data in order to provide evidence of the usefulness of the system
- To transfer skill to forecasters from South Africa as well as southern Africa to understand the RDT product and its usefulness (through workshop)
- To make the RDT operationally available to all forecasters in southern Africa

Estimated cost: R400 000 Expected term: 2013–2015

Managing limits in skill for seasonal climate forecasting

University of Cape Town
No. 2249

The aims of this project are:

- Identify the signal to noise ratio over southern Africa using observations and GCM datasets in response to the forcing of global modes of variability
- Identify the spatial and temporal time scales of robust regional response to global modes of variability
- Develop a new methodological approach to explore the climate system on seasonal and sub-seasonal timescales using the phase space of the daily evolution weather states
- The integration of regional responses using a hydrological model forced by daily (or finer) meteorological variables (temperature, humidity, wind speed, radiation and precipitation) derived from regional climate signals
- An understanding of the theoretical limits to predictability from seasonal forecast models, utilizing ensemble-based prediction techniques in the perfect model scenario
- Explore which physical parameters of the regional climate system best reflect a deterministic response signal
- Test emergent understanding of how models may be developed to improve forecasts

Estimated cost: R2 025 640 Expected term: 2013–2017

Dynamics of climate variability over the all-year rainfall region of South Africa

ARC
No. 2257

The aims of this project are:

- Determine the relative contribution of the various rain-producing weather systems to monthly and seasonal rainfall totals over the all-year rainfall region; the relative contribution during spring and autumn is of particular interest
- Determine whether the occurrence of the bi-modal rainfall distribution is consistent at inter-annual time scales

Estimated cost: R312 000 Expected term: 2013–2016

Programme 2: Climate change risk, vulnerability and adaptation

Pinpointing human infectious disease risks and climate vulnerability: An integrative approach using cholera as a model

CSIR

No. 2147

The aims of this project are:

- To develop an early warning system for waterborne infectious disease outbreaks using *Vibrio cholerae* as a model organism
- To delineate areas and populations at risk under future climate scenarios
- To develop risk maps indicating the possible extent of infectious disease outbreaks under different climate scenarios
- To develop a generic guidebook for adaptive management and preparedness
- To demonstrate water use, access, storage and collection technology adaptation on a small scale in one area

Estimated cost: R1 500 000 Expected term: 2012–2015

Planning for adaptation: Applying scientific climate change projections to local social realities

Umphilo waManzi

No. 2152

The aims of this project are:

- To develop and test a process of translating scientific climate and hydrological model output into community accessible, local-level scenarios of future climate and water resources to allow for community-led development of adaptation strategies
- To understand socio-political and institutional issues that arise at the community level in planning for climate change and water resource adaptation with local communities
- To pilot, test, and improve an approach and methods, for application to other catchment areas in South Africa
- To engage national Government and water resource stake-holders in dialogue about climate change and water resource adaptation at the local level

Estimated cost: R1 100 000 Expected term: 2012–2015

Water–energy nexus in the context of climate change: investigating trade-offs between water use efficiency and renewable energy options for South Africa

Pegasys Strategy and Development (Pty) Ltd

No. 2239

The aims of this project are to investigate renewable energy choices for SA and their water requirements (consumption).

Estimated cost: R1 500 000 Expected term: 2013–2016

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

Future climate change impacts on flood and drought hazards in South Africa for planning and decision-making

South African Weather Service

No. 2247

The aims of this project are:

- Evaluate the performance of the combined GCM/downscaling technique/hydrological model's skill in simulating observed droughts and floods in the present/control climate
- Analyse changes in drought and flood hazards in South Africa by examining extreme discharge levels simulated by a hydrological model
- Investigate the main physical mechanisms likely to result in changes in the hazards found above
- Compare the uncertainty sources for climate change impacts on future droughts and floods
- Develop information for decision makers on future drought and flood hazards that is insensitive to the various sources of uncertainty involved in the modelling process

Estimated cost: R1 113 000 Expected term: 2013–2017

NEW PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

Lessons learnt from the establishment of catchment management agencies in South Africa
University of KwaZulu-Natal – Centre for Water Resources Research (CWRR)
No. 2320

Aims:

- Tell the story of the establishment and evolution of Breede-Overberg CMA and Inkomati CMA to date
- Identify the processes that either had positive or negative impacts on CMA establishment
- Determine how stakeholders perceive the successes and strengths of the CMA establishment process
- Examine causal links between elements of the establishment process and its successes and failures
- Determine who acts and what the consequences are
- Identify new opportunities and challenges regarding future CMA establishment

Estimated cost: R1 000 000 Expected term: 2014–2016

When and under what conditions should a CMA become a responsible authority?
Crossflow Consulting (Pty) Ltd
No. 2334

Aims:

- To define the powers, duties and functions that are required for CMAs to manage, monitor, conserve and protect water resources and to implement catchment management strategies
- To assess the risks, including concerns related to feasibility (financial and technical) and desirability (legally and operationally) for CMAs to be become Responsible Authorities
- To define the specific requirements for a CMA to undertake certain powers, duties and functions and for the regulation of these functions
- To develop a road map for CMAs to be become Responsible Authorities

Estimated cost: R1 000 000 Expected term: 2014–2016

Water governance of groundwater and surface water resources in South Africa
Umvoto Africa
No. 2332

Aims:

- Review the lessons learnt from the Global Groundwater Governance Study and compare it to the South African situation
- Apply the methodologies developed through surface water and groundwater governance studies in previous WRC reports to selected catchments
- Develop a framework to improve groundwater and surface water governance within the existing legal and institutional arrangements that span all the relevant institutions

- Test the framework with realistic case studies
- Develop an action plan to enhance uptake of the framework

Estimated cost: R1 000 000 Expected term: 2014–2016

Catchment management fora: the evolving priority in effecting subsidiarity principles in water management

Pegasys Strategy and Consulting; AWARD; North-West University (Vaal Triangle Campus)
No. 2411

Aims:

- To synthesize existing information on forums' histories in South Africa, against the background of international practice, with a focus on the agency of active citizens
- To address issues of redress and equity through understanding the reasons why current participation in forums is not representative, what the obstacles to participation are, and how these can be removed
- To bring current CMF participants and potential new CMF participants together in regional and in one national workshop, to co-create a vision to revitalize forums, and attract citizens that will make the forums truly representative of all water interests
- To explore the functions that can be delegated to CMFs, including citizens' monitoring for compliance, and awareness raising in schools and communities
- To develop recommendations on how CMFs can function better, how they can be supported by DWS and CMAs, and how they fit into the catchment management architecture
- To share the knowledge developed in this process

Estimated cost: R56 000 Expected term: 2014–2015

Assessment of implementation of all national water-related policies and the development of the framework for monitoring the extent of the implementation of the NWA

Prime Africa Consultants cc
No. 2417

Aims:

- To conduct a comprehensive performance assessment of the nature and extent of implementation of the water policies and the NWA in South Africa. This performance assessment will include assessment of progress in implementation of water polices and the NWA against policy/legislative objectives, targets and recommendations
- To identify the gaps and lessons learnt from the implementation of these water policies and the NWA
- To inform the amalgamating of the NWP and NWA, based on a consultative process of assessment
- To develop a framework for the assessment of the resources required for the implementation of the amended/new and amalgamated NWP and NWA
- To apply the framework to formulate different resource dimensions required to implement, and monitor progress of, the reviewed/amalgamated NWP and NWA
- To establish the means of determining the obstacles and/or contradictions that may hamper implementation of the NWA and NWP.
- Using scenarios, identify the kinds of investments that are needed

Estimated cost: R1 000 000 Expected term: 2015–2016

Programme 2: Compliance and enforcement

Citizen monitoring of the National Water Resource Strategy 2

Environmental Monitoring Group
No. 2313

Aims:

- To pilot, test and improve an approach that empowers community-based and other civil society groups to participate in local water governance, using forms of knowledge and analysis appropriate to their context and experience, through monitoring and engaging on key issues from the NWRS2
- To use the NWRS2 as a case study to contribute to an understanding of how South African water policy is developed and implemented, and what role civil society can play in these processes
- To test the application of social learning approaches to capacity building in the water sector
- To strengthen community-based organisations and networks within the water sector through peer support and social learning

- To contribute to the effective and just implementation of the NWRS2

Estimated cost: R1 764 300 Expected term: 2014–2017

Programme 3: Pricing and financing WRM

Approaches for emerging farmer participation in water resource management: The case of the Breede-Overberg Catchment Management Agency (BOCMA), Western Cape
Cape Peninsula University of Technology
No. 2310

Aims:

- Review progress in accessing water resources by emerging farmers in two selected areas in the Breede-Overberg Catchment Management Agency
- Explore the role and challenges faced by emerging farmers in participating in water user associations
- Explore opportunities for engaging emerging farmers to participate in water user associations and water allocation processes
- Develop a general approach for engaging emerging farmers to participate in water user associations in the Western Cape (and South Africa)

Estimated cost: R1 303 000 Expected term: 2014–2017

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 4: Water resource infrastructure

Hydrological Heritage Overview: Cape Town and Johannesburg
University of Pretoria
No. 2308

Aims:

- Acknowledge the importance of water and earth science in the development of South Africa's major cities, focused on Cape Town and Johannesburg
- Acknowledge the importance of these sites in the history of South Africa and subsequently the need to create awareness at all levels (local resident, education and scientific) to preserve not only the natural history of the areas, but also to ensure public understanding and awareness
- Embark on such a public awareness campaign for the selected sites, aiming to capture the history of the site and to elaborate on the scientific aspects for public awareness
- Address available data (what and if available) for brief interpolation of historical trends and to address the importance of protection of water sources
- Supply the products in the forms of coffee-table books and short documentary films for educators, municipalities, leisure and heritage sites, and the scientific fraternity

Estimated cost: R440 000 Expected term: 2014–2016

Programme 5: New water and water security

Sustainability indicators and decision framework for sustainable groundwater use
Helen Seyler Consulting
No. 2311

Aims:

- To provide an understandable and accessible description of the equilibrium approach to sustainable groundwater use
- To promote use of the equilibrium approach for sustainable management of groundwater use, especially for moderately and highly used aquifers
- To develop a decision framework tool to guide a user through the adaptive management cycle of managing groundwater use sustainably, especially for moderately and highly used aquifers
- To develop sustainability indicators that can be used to qualitatively and quantitatively manage groundwater use

Estimated cost: R700 000 Expected term: 2014–2017

EXSMET: Exporting PyTOPKAPI and HYLARSMET over SADC including RSA with extended spatial and computational capacity of soil moisture and evapotranspiration for flood and drought monitoring
Pegram and Associates (Pty) Ltd
No. 2312

Aims:

- To ascertain what rainfall data are available in the SADC countries outside our borders and perform checks on their suitability for modelling
- To obtain suitable ground cover and soil maps over the whole SADC region (e.g. FAO and others), for comparison with those already available in SA
- To exploit the sensitivity calculations performed on the SA dataset under HYLARSMET
- To determine the best way to compare FAO datasets with our SA sets of ground-based data
- To determine if there are better alternative rainfall inputs to TRMM, for near real-time precipitation data input; if not, exploit bias adjustment of the TRMM product
- To exploit the soil moisture estimates of the European Space Agency's SMOS mission when they are ready for using in model inter-comparisons
- To determine how best to cope with the uncertainties associated with input parameters and forcing variables (TRMM in particular) when computing ensembles of historical and forecast data streams
- To devise means of increasing computing capacity and the speed of calculations by improving key parts of the code and employing parallel (or high performance) computing power
- To determine the best ways of cold-starting calculations (model initialization) for both gauged and ungauged catchments

Estimated cost: R1 980 000 Expected term: 2014–2018

Finding 'new' water in an 'old' catchment: the case of the Heuningnes Catchment, Breede-Overberg Water Management Area
University of the Western Cape
No. 2324

Aims:

- To determine the contributions of sub-catchments of the Heuningnes River to inflows into the Soetendalsvlei and Heuningnes Estuary
- To establish the effects of land uses and water uses on quantity and quality of inflows into the Soetendalsvlei and Heuningnes Estuary
- To establish the extent to which marshes occurring along stretches of the Nuwejaars River and tributaries modify inflows into the Soetendalsvlei
- To determine how river inflows, the interactions between surface water and groundwater affect the water balance dynamics of Soetendalsvlei, and outflows into the Heuningnes Estuary

Estimated cost: R1 400 000 Expected term: 2014–2017

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Collecting high quality baseline and ongoing monitoring data in the Karoo, and taking the opportunity to train rural disadvantaged women and youth as accredited Ground Water Monitoring Technicians to enable them to offer an independent service to farmers
Nelson Mandela Metropolitan University
No. 2319

The overall objectives are:

- To collect the baseline and ongoing monitoring data that is essential for the protection of groundwater resources from contamination by gas exploration, mining or other activities, and to minimise the cost and maximise the effectiveness of groundwater data and sample collection, in addition to necessary weather data collection, in the Eastern Cape Karoo, using community participation (for roll-out to other areas of SA), thereby also helping to improve the understanding and management of groundwater resources in the Eastern Cape Karoo. The emphasis is on training local unemployed people to collect high-quality data (equivalent to that obtained by acknowledged trained professionals).
- To acquire high-quality baseline and ongoing groundwater monitoring data at a lower cost than is currently possible, by training and utilizing local people
- To use the opportunity to provide quality employment opportunities in deprived areas by training unemployed youth, or single parents, in a skill with long-term demand, enabling them to earn an appropriate qualification to enable them to collect accredited

data, with the hope that they can be helped, via the Business Development Centre at NMMU, to start their own businesses

Estimated cost: R1 000 000 Expected term: 2014–2017

Programme 2: Water quality modelling

Simulation of pollutant transport, sediment concentration and nutrient budget for uMngeni river
University of KwaZulu-Natal (Howard College Campus)
No. 2328

Aims:

- To analyse the existing water quality data
- To investigate the main drivers for the river water quality issues
- To understand pollutant transport processes for the river environment under various flow conditions
- To develop a mathematical hybrid model for simulation of pollutant concentrations with sediment flux and nutrient budget
- To test and calibrate the developed model using the dataset
- To develop a user-friendly software package

Estimated cost: R667 000 Expected term: 2014–2017

System for patching river and reservoir water quality data
Umfula Wempilo Consulting
No. 2327

Aims:

- Develop a user-friendly integrated water quality patching system
- Incorporate enhancements of the existing MOVE program

Estimated cost: R986 850 Expected term: 2014–2016

Programme 3: Impacts on and of water quality

Combined effect of urbanisation, industrialisation and population growth on water quality of the Palmiet River and its tributaries in the Overberg West sub-catchment of the Breede Water Management Area: An integrated catchment risk assessment
Cape Peninsula University of Technology
No. 2329

Aims:

- The overall aim of the study is to conduct an integrated catchment risk assessment to determine the impacts of the combined effects of urbanisation, industrialisation and population growth on water quality in the Palmiet River and its tributaries in the Overberg West sub-catchment of the Breede Water Management Area
- Conduct an environmental hazard assessment to identify and quantify the sources of selected micro-pollutants (organic waste, nutrients and pathogens) in the sub-catchment; this assessment will culminate in a conceptual site model for the Overberg West sub-catchment
- Characterise the hazards by gathering, generating and evaluating data on the pollutants and conclude on their toxicological effect and environmental fate; this will allow for the evaluation of the nature of the adverse effects associated with biological, chemical and physical agents
- Develop an integrated fate and transport model by Identifying the principal/dominant flow pathways, determining the dominant hydro-chemical processes controlling the fate and transport of the contaminants, and the potential for polluting
- Develop a quantitative microbial risk assessment and chemical risk assessment model to predict and evaluate the risks emanating from contamination and pollution
- Determine best management options and translate these into management and policy recommendations

Estimated cost: R850 000 Expected term: 2014–2017

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Integrating structural geology, geophysics and hydrochemistry to identify and investigate geological features in the Karoo which may provide hydraulic connectivity between deeply-sourced contaminants and shallow groundwater
Nelson Mandela Metropolitan University
No. 2316

Aims:

- In areas of the Main Karoo Basin where unconventional gas exploration/mining is envisaged, use advanced structural geological methodologies and remote sensing to identify potentially deep-penetrating zones of weakness which may provide current or future hydraulic connectivity between deep saline groundwater or fracking chemicals and shallow ground water
- Interactively co-operate with the allied WRC projects (vulnerability map; chemical signature of deep groundwater) to ensure mutual guidance and support
- Co-operate with the other researchers in combining the results to produce the state-of-the-art 3D hydrogeological map of the Main Karoo Basin, for use by the regulatory body in guiding the locations and special regulations applicable to unconventional gas exploration/mining in the Karoo

Estimated cost: R1 800 000 Expected term: 2014–2017

Modelling studies and analytical methods for monitoring organic pollutants in selected surface water and treated water systems in Gauteng Province

University of Johannesburg

No. 2321

Aims:

- To prepare a database of chlorinated organic compounds found in South Africa water systems. This database will include the factors that determine the levels of chlorinated organic compounds (COCs) in water
- Use the determined factors that influence the amounts of COCs to predict levels of COCs in a given water system
- To analyse real water samples so as to determine the levels of various COC pollutants in selected water systems found in Gauteng Province
- To develop a computer model that would predict the contamination level of COC pollutants in selected water systems found in the Gauteng Province
- To generate various predictions of organic pollutants using various water system scenarios. Compare the predicted levels with the analysed values.
- To determine the prediction efficiency of the model by testing real water samples through analysis for COCs and compare the experimental data with the predicted model values

Estimated cost: R665 000 Expected term: 2014–2017

Impact of underground coal gasification on the groundwater environment

Digby Wells & Associates

No. 2331

Aims:

- To advise the government on UCG policy in relation to the environmental regulations
- To develop an industry-recognised best practice guideline
- To evaluate the operational and post-operational monitoring requirements and data collection guidelines
- To understand the migration pathways for gaseous contaminants
- To understand the migration pathways for non-aqueous phase liquids as well as aqueous phase contaminants
- To develop a hydrogeological conceptual model that incorporates the induced and/or modified aquifers due to UCG subsidence
- To suggest methods and guidance for evaluating risks to groundwater
- To identify the optimal remedial measures suitable for aquifers contaminated with UCG-related activities

Estimated cost: R242 862 Expected term: 2014–2015

Quantification of hydraulic parameters of the intermediate vadose zone relating to fractured rock mass

University of Pretoria

No. 2326

Aims:

- Address unsaturated and saturated flow through fractured rock through geotechnical centrifuge modelling
- Improve the local and international understanding of modelling flow through rock mass in a geotechnical centrifuge
- Strengthen the inherent link between rock engineering and hydrogeology by using the typical rock mass descriptors in fracture flow modelling

Estimated cost: R700 000 Expected term: 2014–2016

Programme 2: Land-water linkages

Unconventional gas exploration and mining and its impact on South Africa's water resources

SLR Consulting (South Africa) (Pty) Ltd
No. 2322

Aims:

- Update the WRC state-of-the-art report (KV294/11) to include all unconventional gas sources and other available reports focusing on among others, hydrogeology of areas where unconventional gas mining is being considered, water use, contamination and remediation
- Do a gap (and barrier) analysis of the technical, policy and regulatory requirements related to unconventional gas mining
- Perform a risk-based assessment of selected aquifers, recharge areas and surface water bodies to enable adequate protection of these systems
- Develop a water resource early warning monitoring system that could inform regulatory policies, strategies and responses
- Develop best-practice guidelines and regulatory responses based on a variety of approved and workshopped scenarios
- Develop the best-practice framework in a manner that accounts for the technical and socio-economic considerations

Estimated cost: R2 500 000 Expected term: 2014–2017

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Flow regime types for South African rivers

Institute of Natural Resources NPC
No. 2315

Aims:

- To describe natural flow time series at the spatial resolution of the 5 838 quinary catchments delimited for South Africa (i.e. SA, Lesotho and Swaziland) using indices for magnitude, duration, frequency and timing of flow events
- To develop a spatial map of flow regime types for SA at the quinary level as a basis for undertaking environmental flow assessments at a regional scale
- To provide guidelines for the use of this tool for flow assessments
- To provide guidelines for extending this framework to include additional components, e.g., water temperature

Estimated cost: R550 000 Expected term: 2014–2015

Quantification of uncertainty in weather and climate prediction and its effective communication for better decision making

CSIR
No. 2325

Aims:

- To quantify (through estimation of the reliability of weather and climate forecasts) and reduce (through ultrahigh horizontal resolution simulations for cloud-resolving purposes) the uncertainties associated with predicting and projecting future weather and climate variability as well as change over the southern African region, with an emphasis on extreme events
- To optimize the configuration of the variable-resolution atmospheric model CCAM, applied at various time scales for equivalent horizontal resolutions and domains, as part of the endeavour to build an Earth System Model (ESM), since the generation of simulations on these time scales provides a test-bed for the atmospheric model that will form an integral part of the ESM
- To develop plausible scenarios of future changes in the attributes of extreme weather events over the continent, of sufficient reliability to be actionable
- To construct large ensembles of predictions/projections at the short-range, medium-range, long-range and decadal time scales over southern Africa, by considering initialization techniques, vertical resolutions, cloud schemes, and dynamical land-surface coupling in the model

Estimated cost: R600 000 Expected term: 2014–2016

Open water evaporation measurement using micrometeorological methods

University of KwaZulu-Natal (Pietermaritzburg)
No. 2335

Aims:

- Review studies conducted and approaches followed internationally, aimed at estimating open water evaporation
- Define the theoretical framework for the estimation of open water evaporation using sound physical procedures
- Define the theoretical framework for the real-time estimation of evaporation using the surface renewal and temperature variance methods and their application to open water
- Define the theoretical framework for applying the MOST method for determining sensible and latent energy fluxes and determine the accuracy of the air temperature and water vapour pressure sensors
- Application of sound open water evaporation procedures for obtaining open water evaporation
- Field application of all methods for obtaining open water evaporation

Estimated cost: R1 100 000 Expected term: 2014–2016

Programme 2: Climate change risk, vulnerability and adaptation

Towards gender-sensitive strategies for responding to challenges posed by climate-related impacts

University of the Western Cape

No. 2314

Aims:

- Investigate enabling factors and constraints for women's participation in decision-making processes within the water sector
- Undertake a pilot study on vulnerability assessment of rural women under changing climatic conditions
- Investigate the challenges that women encounter around water security
- Evaluate the extent to which policy frameworks and strategies that address access to resources are gender sensitive
- Identify barriers to women's access to resources such as land, water and finance and recommend how these could be addressed
- Recommendation and institutionalisation of good practice in policy practice and design a framework for mainstreaming gender into climate change adaptation

Estimated cost: R1 200 000 Expected term: 2014–2017

Programme 3: Integrated flood and drought management

Regionally-extensive droughts and climate change in Southern Africa: mechanisms, model reliability and projections

University of Cape Town

No. 2317

Aims:

- Incorporate evapotranspiration (ET) into drought indices to obtain a better characterisation of agricultural and hydrological droughts over Southern Africa
- Understand the mechanisms by which remote and local forcing of drought are translated into surface moisture deficits (P-ET)
- Evaluate climate model's abilities to represent regionally extensive droughts and the associated mechanisms
- Understand the potential impacts of climate change on regionally-extensive droughts in Southern Africa

Estimated cost: R1 150 000 Expected term: 2014–2017

Soil moisture–climate interactions under climate change: Implications for droughts, heat waves and desertification over Southern Africa

South African Weather Service

No. 2309

Aims:

- Identify CMIP5 simulated hotspots of soil moisture–climate interactions in the historical runs
- Investigate future changes in soil moisture regimes and the possible impacts on the locations of the hotspots identified
- Investigate the contribution of changes in soil moisture to the accelerated warming rates over south-western Africa (Northern Cape, Namibia and Botswana)
- Understand the implication of the higher warming rates for the frequency and intensity of 21st Century heat waves
- Establish the effects of changes in soil moisture regimes on the pattern and intensity of meteorological droughts
- Investigate the likely change in the spatial extent of semi-arid regions

Estimated cost: R1 080 000 Expected term: 2014–2017

Validation of the variables (evaporation and soil moisture) in hydrometeorological models: Phase II, application of cosmic ray probes for soil water measurement
University of KwaZulu-Natal – Centre for Water Resources Research (CWRR)
No. 2323

Aims:

- 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 and K5/2066)
- Provide accurate field and satellite estimates of the variables (ET and SM) for the calibration of hydrometeorological models
- Evaluate the spatial variability of SM at catchment scale; test the suitability of the Cosmic Ray Probe for providing spatial estimates of soil moisture at the same scale as the remote-sensing products from HYLARSMET

Estimated cost: R1 000 000 Expected term: 2014–2017

CONTACT PERSONS

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KSA 2

WATER-LINKED ECOSYSTEMS

SCOPE

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

The KSA research portfolio is structured around five (5) thrusts that address a diverse range of issues in ecosystem processes, management, rehabilitation and restoration, utilization, and ecosystems and global change. The implementation of the strategy is focused on addressing a wide scope of R&D issues relating to water and the ecosystems that our people and economy depend on. In cognisance

Stanley Liphadzi:
Executive Manager

of the complex and evolving needs of the society and communities that the KSA's R&D serves, it was necessary for KSA 2 to adapt its portfolio in order to remain relevant and appropriate. The five-year research strategy has been crafted to support and advance the WRC key objectives articulated in the Knowledge Tree, national legislation, national strategies and priorities and Government Outcomes, South Africa's international obligations, new scientific trends, and other stakeholders' views and needs. The KSA seeks to extend more of its R&D output to the broader South African society, in order to capacitate all stakeholders in making knowledge-based decisions that encourage protection and sustainable use of ecosystems. The KSA will continue to explore different avenues and opportunities that R&D outputs provide to enhance ecosystem goods and services (natural capital). The WRC Knowledge Tree advocates the production of new products and services and the promotion of sustainable solutions from R&D. To advance these objectives, the KSA will continue to assist researchers and communities to utilise the WRC's R&D outputs to create new products and services and thus create new markets and industries. This is important in South Africa and Africa because there are natural resources in our ecosystems that are factors of endowment, which through research and development can be used to create new jobs and markets.

OBJECTIVES

The strategic objectives of KSA 2 are as follows:

- To enhance the knowledge on healthy ecosystems and conserve biodiversity
- To generate knowledge that informs ecosystem management and the implementation of policy and legislation
- To support the social and economic requirements of society from ecosystems
- To generate innovative approaches that can be used in rehabilitation and restoration of ecosystems
- To develop innovations and knowledge that demonstrate the actual value of ecosystems and support to people's livelihoods
- To improve understanding of the connectivity between land, water, atmosphere and people

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: River, wetland, groundwater and dam processes	***Scope:*** Programmes to investigate the ecosystem functioning, structure 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, is a topic attracting international interest.
Programme 2: Estuarine, coastal and marine processes	***Scope:*** Estuarine, coastal and marine systems are fragile, while they are highly productive ecosystems and are highly sought after as places to live and establish various enterprises. Catchment activities and land uses affect terrestrial water resources and ultimately the estuarine environment, while marine water conditions also have an impact on the estuarine environment and ecosystems. Projects in this programme will generate knowledge about the ecological processes, structure, and functions of ecosystems of these systems. The programme will also address the impact of land uses and marine conditions on ecological processes in the estuarine and coastal environment.
Programme 3: Aquatic, riparian and land connectivity	***Scope:*** Research will be conducted to develop understanding of the interconnections among various ecosystems and ecological processes and functions of water resources, terrestrial systems (soil, air and vegetation) and to assess their value to both the catchment and people.
Programme 4: Surface and groundwater interactions	***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.

Thrust 2: Ecosystem management

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

Programme 1: Ecological Reserve	***Scope:*** Research in this programme will be conducted to develop and refine methods for determining and operationalizing the ecological Reserve as required by the NWA. The programme will address the more strategic issues, such as the development of new and improved methods, as well as the shorter-term issues, such as implementation of the Reserve. This programme is managed in close association with DWA.

Programme 2: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems	***Scope:*** Within this programme research will be conducted to develop an understanding of the effect of anthropogenic disturbance on aquatic ecosystems in various water resources. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage water resources sustainably.
Programme 3: Land-use and aquatic ecosystem management	***Scope:*** This programme focuses on enhancing understanding of the effect of human interventions (land uses and decision making) on the environmental health of various water resources and/or ecosystems. As such the programme covers all water resource types, hence the inclusive name of National Aquatic Ecosystem Health Monitoring Programme is used, whereas the name River Health Programme focuses only on rivers.
Programme 4: Integrated environmental and drinking water quality	***Scope:*** Within this programme research will be conducted to develop integrated methods and procedures which will be employed to protect people and the environment from the effects of poor water quality. The programme will develop methods and competence to support issuing of water use licences. This will promote the use of research knowledge in managing environmental water quality as required in the ecological Reserve, and thus reduce drinking water treatment costs.
Programme 5: Ecosystem risks and disaster management	***Scope:*** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation. Tools and procedures will be assessed with the intention of developing them. The success of the programme will be achieved by working closely with water resource managers and relevant government departments.
Programme 6: Biodiversity and conservation	***Scope:*** The overall objective of this programme is to develop and integrate knowledge needed by the country in efforts for protecting and preserving our unique biodiversity and natural landscapes. The projects will look at drivers (sociological, political and economic) that are critical in developing the understanding and competence necessary to sustainably manage the aquatic environment and its biodiversity. Collaboration and partnership with other institutions will be considered for this programme to achieve its aim.
Programme 7: Ecosystem governance, legal framework and ethics	***Scope***: Implementation of research outputs and regulations require appropriate governance systems and structures. 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. The research under this programme should develop knowledge needed for good governance of water resources. The research will develop knowledge needed to support policy, planning and development that promote protection of ecosystems and water resources.
Programme 8: Transboundary ecosystem management	***Scope:*** This programme will support projects that enhance ecosystem processes and functions, conservation and planning across regional and national borders. Transboundary research has gained some interest in recent years, and neighbouring countries or catchments will have to manage shared natural capital in an integrated manner. Collaborations with neighbouring countries and international funding agencies will be considered for research under this programme.

Thrust 3: Ecosystem rehabilitation, remediation and restoration

***Scope**:* This thrust addresses the rehabilitation, restoration and remediation 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. Remediation is the only addition to this portfolio. This is proposed to encourage innovative approaches that can be used in rehabilitation and restoration of water resources and their ecosystems. Research in this thrust will be carried out in collaboration with key stakeholders.

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)	***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 2: Socio-economic dynamics	***Scope:*** The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment.
Programme 3: Environmental risk management	***Scope:*** Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation.

Thrust 4: Sustainable ecosytem utilisation and development

Scope: This research portfolio investigates issues relating to ecosystem goods and services. The research 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 ensure that individuals and communities derive benefits (social, economic, and environmental) from ecosystems. Support will be provided in building the capacity to implement and apply the research findings. The projects in this thrust will develop innovations and knowledge that demonstrate the actual value of ecosystems to people's livelihoods, well-being, and business sustainability.

Programme 1: Environmental economics (goods & services) and accounting	***Scope:*** The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment. This programme investigates ways to evaluate economic benefits of ecosystem products (goods and services). Appropriate methods and their implementation to local conditions will be promoted by research in this programme. The economic opportunities that are presented by ecosystems will be evaluated so that they can be appropriately developed. Different evaluation and accounting methods and tools will be developed and adapted to local conditions.
Programme 2: Ecosystem value-chain and markets	***Scope:*** Research in this programme will develop knowledge about developing and strengthening markets for ecosystem goods and services. The research will cover the whole value chain of the ecosystem services' market. There is a growing interest in developing markets for ecosystem services to support local economies in rural and peri-urban areas. The development of tools or procedures to promote payment for goods and services needs to be further developed and implemented appropriately. Product development for various markets will also be the focus of this programme. For instance, environment-based business opportunities should be explored and developed since different ecosystems have different products and services that they offer.
Programme 3: Gender, culture and heritage for ecosystems	***Scope:*** In their design or implementation, natural resource management (NRM) initiatives overlook critical socio-cultural dimensions of the challenge to advance sustainability. This programme will investigate relationships and associations of gender, culture, heritage and aquatic ecosystems. The relationships and tensions related to gender, ethnicity, population, age and socio-economic status are among the threads in the larger tapestry that comprises the socio-cultural dimension in natural resource management and access to ecosystem services. The programme will also investigate ideas and innovations from indigenous knowledge systems that relate to natural resource management.
Programme 4: Green economy and sustainable (green) innovations	***Scope:*** People in rural and peri-urban areas rely on ecosystems for their livelihoods. The research in this programme will support economic development that does not violate the sustainability of socio-ecological processes. Projects in this programme will encourage the production of green technologies and innovations supporting service- and commercial-based sectors. Outputs from research should contribute to improving the lives of people while also contributing to improving the conditions of water resources and the environment as a whole. The involvement of the business sector and other individual companies will be sought to fast-track implementation of the research output. The projects will contribute to the Water–Energy–Food Nexus Lighthouse of the WRC.

Thrust 5: Ecosystems and global change

Scope*:* This thrust will address research to improve our understanding of the connectivity between land, water, atmosphere and people. Any change in the environment may have an impact on every other environmental factor and this impact should be assessed to be able to quantify the risks and to implement IWRM. This thrust will also focus on the movement of people (migration) and the response of aquatic ecosystems to these population dynamics.

Programme 1: Ecosystems and population dynamics	***Scope:*** The impact of social dynamics on ecosystems and the environment will be addressed in this programme. As human population increases, moves and changes in different areas, sociological studies in relation to ecosystems (environment) are needed to support planning and development of rural and urban areas. In most cases, informal settlements are established in the riparian zones of water resources, which exerts pressure on those resources as people demand more goods and services from those resources. In most cases, water resources such as wetlands and rivers become the only available service infrastructure for the homeless and for poor immigrants in urban and peri-urban areas.
Programme 2: Ecosystems and climate change	***Scope:*** This programme will deal with all aspects of climate change in relation to ecosystems. The research will develop knowledge about mitigation of and adaptation to climate change by aquatic biodiversity. The impact of climate change on ecosystem processes, functions, and structure will be given attention in this programme. The knowledge generated will be used to inform policy makers, businesses, and water managers.
Programme 3: Ecological thresholds	***Scope:*** Research aimed at determining ecological thresholds will be supported in this programme. These studies will assist in developing understanding about how much degradation the environment or ecosystems can tolerate before collapsing or losing resilience. The research will also analyse the costs of restoring ecosystems and their functionality after total collapse.

RESEARCH PORTFOLIO FOR 2014/15

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Estuarine, coastal and marine processes

Trajectories of change in wetlands of the Fynbos Biome
Freshwater Research Centre; University of the Western Cape, University of Cape Town; North-West University (Potchefstroom)
No. 2183

An analysis of the change in environmental condition for the study wetlands for which an ecological health score could be assigned over the past 25 years shows that: 29% of wetlands are in a better/slightly better category; 24% of wetlands are in the same condition as when sampled 25 years ago; 8% of wetlands show a slight deterioration; 23% of wetlands have deteriorated significantly. For the remainder of the wetlands (16%), the change in ecological health either could not be determined or the wetland is no longer in existence. Although some wetlands have been lost, the proportion of these in the total of 65 wetlands is lower than was expected.

Though without much data, the study suggested that the main drivers of deterioration, with regards to the impacts facing wetlands in theFynbos Biome, certainly include: invasion by alien plants (acacias, pines, eucalyptus), urban development, and agricultural development. For those wetlands that have shown improvements in health, this could be attributed to protection of some within new conservation areas – both at the national level and at the local level involving both state institutions and private landowners.

Cost: R1 500 000 Term: 2012–2015

The resilience of South Africa's estuaries to future water resource development based on a provisional ecological classification of these systems

CSIR; Anchor Environmental Consulting; Nelson Mandela Metropolitan University; independent consultant; SA Institute for Aquatic Biodiversity; IWR Water Resources (Pty) Ltd
No. 2187

Reflecting on the health assessment of the estuaries in South Africa's Cool- and Warm-Temperate regions, the PES (present ecological state) shows that overall 20% of the systems are considered to be in Category A, 43% in Category B, 27% in Categories C or D, and 10% in Categories E and F. Estuaries in near-natural condition (Categories A or B) are mainly located in the Warm-Temperate region, while systems in the Cool-Temperate region show relatively even distribution across Categories B to E. The above analysis (based on the number of estuaries) is biased towards the state of the large number of small temporarily open/closed estuaries occurring along this stretch of the South African coast. However, analysing results based on 'estuarine area' (rather than the number of estuaries), most of the estuarine habitat in the Temperate region (67%) is in a C or D Category with only about 2% remaining in a near-pristine state (Category A), the latter mainly located in the Warm-Temperate region. The Cool-Temperate region was found to support estuarine habitat mainly in the C and D categories reflecting the large number of degraded and small temporarily open/closed systems near coastal urban centres (e.g. Cape Town). In contrast, the Warm-Temperate region was characterised by estuarine habitat in Categories B and C, possibly due to the undeveloped nature of large parts of this region. However, there is a risk of further deterioration if key recommended mitigation measures are delayed.

Cost: R1 400 000 Term: 2012–2014

Programme 3: Aquatic, riparian and land connectivity

Development of a methodology to determine the appropriate buffer zone width and type for developments associated with wetlands, watercourses and estuaries

Institute of Natural Resources NPC; Diatom and Environmental Management; Ground-Truth; Nelson Mandela Metropolitan University; University of KwaZulu-Natal (Pietermartizburg); Eco-Pulse
No. 2200

An eight-step assessment procedure provides the user with a step-by-step approach for determining appropriate buffer zones. The assessment procedure detailed in this report, as well as the management practices that need to be taken into consideration, provide the guidelines for determining and managing appropriate buffer zones. The Buffer Zone Tools on the spreadsheet developed in conjunction with this report provide the user with the primary tool for determining appropriate buffer zones. In addition, practical testing of the buffer zone methodology reports can also provide useful information critical for further refinement of the tools.

Cost: R600 000 Term: 2013–2014

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Adaptability and vulnerability of aquatic biota to climate change – developing tools for assessing biological effects

Freshwater Research Centre/ University of KwaZulu-Natal (Pietermaritzburg); independent consultant
No. 2182

Upper thermal limits, expressed as CTmax values (critical thermal maximum) and 96 h ILUT(incipient lethal upper temperature) varied spatially amongst regions, with differences most evident amongst winter- versus summer-rainfall regions. Within-region variation was also apparent in the Western Cape, where both CTmax values and 96 h ILUT varied by approximately 2 degrees amongst sites. CTmax values and 96 h ILUT varied temporally with distinct differences between summer (highest) and winter (lowest), and less distinct and more variable differences in spring and autumn. CTmax values varied significantly amongst genera within families for five of the seven comparisons undertaken, suggesting that family-level indicators of thermal alteration are not appropriate; instead finer taxonomic levels must be used. The thermal optimum for growth of *L. penicillata* was between 16°C and 18°C. Successful egg development and hatching occurred between 10°C and 20°C for *L. penicillata* and *Aphanicercella scutata*. For *C. ambulans*, successful hatching occurred at a wider range of temperatures from 10°C to 25°C. These variations further suggest that generalisations in terms of thermal guidelines made at a broad national scale for the ecological

Reserve are inappropriate and should at the very least be conceived at a regional or even local or site-specific scale. A connectivity index that incorporates longitudinal (in-stream barriers), lateral (catchment transformation) and temporal (function of changes in flow and water temperature regimes) connectivity was developed using rivers in KwaZulu-Natal. The resultant disconnectivity layer was overlayed with the areas of conservation importance as developed for the provincial freshwater conservation plan. The combination of these data show areas of high conservation value relative to degree of connectivity, and when plotted together allow conservation planners to make choices between areas of high conservation value when resources are limited. Ultimately, the utility of the connectivity index will be a function of the combination of vulnerability and connectivity as a measure of resilience. This connectivity index may be used for ranking catchments in terms of vulnerability and resilience.

Cost: R1 000 000 Term: 2012–2015

Programme 3: Land-use and aquatic ecosystem management

Biodiversity and ecological processes in Nelson Mandela Bay temporary wetlands

Nelson Mandela Metropolitan University; Working for Wetlands; SANBI

No. 2181

In order to standardise and formalise the identification, delineation and typing of wetlands, many tools and methods have been developed to assist researchers, managers and practitioners. The research presented in this report was designed to utilise the tools that have been developed nationally and apply them to wetlands in the Nelson Mandela Bay Metropolitan (NMB) area. In arid and semi-arid regions of the country, such as the NMB, the climatic conditions tend to favour a greater number of ephemeral or temporary wetlands. These ephemeral systems often include endemic species of fauna and flora that are adapted to wet and dry periods. Consequently, these systems potentially have a relatively high biodiversity compared to other more permanent systems. Therefore, the focus of our sampling effort was placed on ephemeral wetlands in NMB, concerning those temporary systems that range from seasonal (inundation for 3 to 6 months within the wet season) to intermittent (inundation from weeks to months in times of good rains) to episodic (inundation from days to weeks during extreme rain events). Overall, the main aims of this project were to locate, demarcate and classify (type) wetlands in the NMB area using the CS guidelines and to gather baseline data on abiotic variables and biotic parameters in a broad range of ephemeral wetland types. NMB wetlands were mapped as a desktop study at a scale of 1:2500. Wetlands were groundtruthed to confirm, modify and add information to the maps and give additional detail to the classification of selected sites. A sub-set of field sites were then chosen across the NMB area to represent the range of rainfall distribution and terrestrial vegetation areas across the Metro including the spatial distribution of wetlands. A group of 46 sites were each sampled once, between 2012 and 2013, and were classified to Level 6 of the CS. A number of parameters were measured in the field, and soil and water samples were taken to the laboratory for further analysis. Several different types of biological data were collected: vegetation, algae, aquatic invertebrates and tadpoles. Of those 46 sites, 6 sites were chosen to return to for monitoring at either weekly, monthly or quarterly intervals to investigate changes in abiotic variables and biotic communities linked to changes in inundation level.

Cost: R1 600 000.00 Term: 2012–2015

Develop and test a landscape-based multidisciplinary and multi-sectoral decision support system to support integrated water resource management in Mpumalanga

SANBI; Department of Water and Sanitation; CSIR (NRE); Mpumalanga Tourism & Parks Agency

No. 2281

An updated spatial dataset of wetlands for the Mpumalanga Highveld was developed (MHWet). Wetlands amounting to a total area of 590 391 ha were mapped, which represents 19.8% of the surface of the study area. This contrasts strongly with the previous state of knowledge, in the form of the National Wetland Map 4, which contained wetlands amounting to 213 579 ha (or 7.2%) in the same area. The final MHWet map identified 49 wetland ecosystem types in the study area, including one that has not been previously described in the country (Mesic Highveld Grassland Group 7_Floodplain wetland), and two types that are new to the study area (Central Bushveld Group 1_Floodplain wetland, Central Bushveld Group 2_Seep). Approximately 30% of wetlands in the region are now mapped with a high degree of accuracy. By comparing the improved dataset to the existing National Wetland Map 4 (NWM4), it was shown that the national-scale NWM4 data had a wetland detection accuracy of 40% and a spatial extent

accuracy of only 22%. Thus, the new dataset presents a significant improvement in wetland mapping for the region. The improved dataset shows that 39% of the wetlands in the region are in good ecological condition and 18% are in moderate condition, while 43% are in poor condition. As a result of the improved data, changes were made to the ecosystem threat status, protection level and FEPAs for the relevant wetlands. The threat status of 23 wetland ecosystem types was decreased, and no ecosystems were upgraded to higher threat status. FEPAs were increased from 27% of the wetland area in Mpumalanga Highveld to 36%. This increase is a result of the increased extent of the newly mapped wetlands in MHWet, combined with the increased extent of good condition wetlands.

Cost: R1 000 000 Term: 2013–2014

Programme 4: Integrated environmental and drinking water quality

Survey of potential ecological and human health risks posed by persistent organic pollutants in aquatic ecosystems in a densely industrialised and urbanised area

CSIR; University of KwaZulu-Natal (Howard College Campus)
No. 1977

The concentrations of persistent organic pollutants (POPs) selected for the study mainly exceeded the limits. For example, 17 organo-chlorine pesticides and/or metabolites were detected in sediment at concentrations exceeding the method detection limit. Toxaphene was the most frequently detected pesticide, at 13 of the 54 stations sampled. Pesticides and/or their metabolite concentrations at numerous stations exceeded sediment quality guidelines. Based on a comparison to sediment quality guidelines derived to be protective of sediment-dwelling organisms in North America, there is likelihood that polycyclic aromatic hydrocarbon concentrations in sediment in some rivers and estuaries posed a toxic risk to sediment-dwelling organisms. The greatest toxicological risk was for sediment in the Amanzimnyama River, though all estuaries showed higher than acceptable concentrations of POPs in sediment. The suite of organic chemicals detected in the tissue of fish and mussels generally reflected the suite of chemicals detected in sediment within each system studied. The notable exception was for chlordane, which was fairly frequently detected in sediment but was never detected in the tissue of fish and mussels. The fish and mussel species sampled thus appear to provide a reliable indicator of contaminants that are introduced into the catchments of Durban Bay and Mngeni and Isipingo River estuaries, while high concentrations pose a serious threat to fisherman, especially subsistence ones. This needs further research; however the eThekwini Municipality will be alerted to this risk, including impacts on Blue Flag beach status and tourism.

Cost: R1 543 176 Term: 2010–2014

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

Rhodes University
No. 2038

In addition to providing nurseries for marine fish and feeding/staging sites for migratory birds, estuaries provide opportunities for tourism and recreation. Stresses on estuaries have escalated because of urban, agricultural and industrial development. Many studies have been completed on the macro-fauna and macro-flora of estuaries, but few have examined the microbial foodweb. This study set out to characterise microbial communities in four estuarine systems of the Eastern Cape, and to establish links between physic-chemical characteristics of the estuaries and their microbial diversity. Protocols were developed for sample collection and template preparation to complete next-generation sequencing (NGS) and analysis of 16S rRNA sequences from estuarine water and sediment. It was found that: (i) bacterial communities in the estuaries examined differed significantly from reported data; (ii) microbial assemblages in the water column differed from those in the sediment; (iii) species diversity in the sediment was several-fold higher than that in the water column; (iv) changes in the abundance of dominant microbial species in sediment samples were not observed in the water column along the length of estuaries with apparently small salinity and nutrient gradients. The findings strongly support the need to focus on sediment sampling when monitoring estuary health. Advances regarding the new NGS technologies have substantially decreased the cost of generating sequence datasets which could make this a feasible technology for monitoring of sensitive estuarine systems.

Cost: R800 000 Term: 2011–2014

Pollution mapping in freshwater systems: using aquatic plants to trace N-loading

Rhodes University
No. 2262

In recent years, aquatic ecosystem health has been monitored using a number of techniques, of which the most widely applied in South Africa is the South African Scoring System. Bio-monitoring, however, typically identifies eutrophication problems only after ecosystem-level impacts have already occurred, and where ecosystem health has been disrupted it is often not possible to link biotic changes to identifiable causes (especially in the case of non-point source pollution). Any methods that would allow for the detection of emerging eutrophication which can also trace and identify nutrient sources would greatly improve our ability to effectively manage our aquatic resources. High loads of nitrogen are often associated with enriched δ15N values of aquatic vegetation relative to pristine conditions and consequently may act as early warning indicators of nitrogen pollution in aquatic ecosystems, prior to the onset of system degradation. Using stable isotopic values of indicator plants in a particular catchment, it is often possible to determine both the spatial source and the composition of nitrogen sources. This technique, referred to as sewage plume mapping, has been used in numerous countries to identify and map the sources, dilution and sinks of nutrients in aquatic ecosystems. The baseline work for calibrating isotopic responses for the indicator organism *Spirodela* sp. in response to nutrient concentrations was completed in WRC Report No. KV 280/11, which identified the need for intensive field tests of the sewage plume mapping technique in the natural environment. Sewage plume mapping combines a quick assessment of ecosystem health, provides a spatial and temporal map of-N loading hotspots over a 10-day integration period and has the ability to classify anthropogenic loads from different N sources (e.g. sewage/ manure or synthetic fertilizer). It is a versatile tool for the monitoring and assessment of ecosystem health which provides more resolution than current biotic indices. Its application will allow us to identify dynamic changes in nitrate and ammonia within a river system, help to correlate water chemistry with nutrient loading and broaden our understanding of the consequences of eutrophication in freshwater systems. Moreover, δ15N and C:N values should allow for the mapping and identification of pollution hotspots and gradients which may identify areas of particular management interest. Using δ15N and C:N ratios, potentially in combination with other chemical parameters, we may eventually be able to predict the ultimate sources of N pollution, which will aid in the conservation, rehabilitation and management of South Africa's waterways.

Cost: R275 000 Term: 2013–2015

Programme 7: Ecosystem governance, legal framework and ethics

Determination of the status of the Nile crocodiles in north-eastern KwaZulu-Natal and conservation management recommendations

University of KwaZulu-Natal (Pietermaritzburg); Ezemvelo KZN Wildlife; CSIR; University of Pretoria; Kruger National Park

No. 2188

The concurrent research on Nile crocodiles in Lake St Lucia, NGR and Pongolapoort Dam showed how these populations differed in their ecology and human pressures faced, thus affecting the crocodiles in different ways. The study revealed numerous novel insights into the ecology, behaviour and health of Nile crocodiles in KwaZulu-Natal, and some of these findings may be applicable to other crocodilian taxa. There are concerns about protection of nesting sites, increased anthropogenic disturbance, poaching of crocodiles, and human–wildlife conflict. There is an urgent need for research on ecological, behavioural and health aspects of Nile Crocodile populations in Kosi Bay, Lake Sibaya and Hluhluwe-iMfolozi Park. Furthermore, the population declines in, especially, unfenced populations, such as Kosi Bay and Lake Sibaya, are driven by illegal killing for crocodile body parts, blood and fat. We need to understand the trade in Nile crocodile products and neighbouring communities' attitudes, behaviours toward and perceptions of crocodiles, in order to formulate effective conservation programmes for Nile crocodiles in KwaZulu-Natal. In particular, the following recommendations need to be implemented at all study sites:

- Continuation of annual Nile crocodile aerial surveys
- Continuation of annual Nile crocodile nesting surveys
- Limiting anthropogenic disturbance, especially destruction of riverine vegetation, including unsuitable agricultural activities and the resultant destruction of nesting sites
- Limiting competition for food resources
- Prevention of poaching of live crocodiles
- Reduction of human–wildlife conflict
- Reduction in use of lead sinkers by fishermen to prevent lead poisoning of crocodiles.

Cost: R884 000 Term: 2012–2015

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

To understand the unintended spread and impact of alien and invasive fish species in order to develop mitigation and prevention guidelines

Golder Associates Africa (Pty) Ltd; SA Institute for Aquatic Biodiversity; North West Department of Agriculture Conservation and the Environment; Rhodes University

No. 2039

The study illustrated the use of the decision support tool with examples from the Sundays, Marico, and two additional case studies, i.e., Nseleni and Swartkops. In the Sundays example, the study demonstrated that while alien fish populations within the irrigation network itself are unmanageable, the invasive catfish population in the Coerney River can be managed, and that the decision tree recommends 'manage against impacts and further spread' because eradication is not deemed to be feasible within the stream. Similarly the study investigated three discreet populations of bass in the Groot Marico catchment, and determined through the decision tree that only the population in the Marico Eye is an appropriate target for eradication, due to its small geographic extent and its proximity to a vulnerable stream reach (the Kaaloog se Loop stream) that could easily be invaded, with human assistance. The study also demonstrated that the Loricariid catfish in the Nseleni and Centrarchid basses in the Swartkops cannot be eradicated for logistical reasons.

Cost: R1 596 350 Term: 2011–2014

Consolidation and optimization of wetland health assessment methods through development of a Decision Support Tree (DST) that will provide guidelines

Freshwater Consulting Group; Freshwater Research Centre

No. 2192

A decision support matrix (DSM) for the rapid assessment of wetland present ecological state (PES) and an overarching decision-support Framework for Wetland Assessment in South Africa have been produced. The separate modules from the WET-Health (Level 1) and Wetland-IHI assessment methods have been incorporated into the DSM, according to their relevance to different wetland types. While the use of the DSM, and of the existing methods included in the DSM (i.e. WET-Health and Wetland-IHI), are considered to be the best available options for the rapid assessment of wetland PES at present, there is clearly a dire need for the development of a single wetland PES assessment method. It is also critical that DWS alerts all wetland practitioners of the existence of the consolidated method, while a new method must be developed based on weaknesses and strengths of the available tools.

Cost: R300 000 Term: 2012–2014

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: River, wetland, groundwater and dam processes

Ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Phongolo River

North-West University

No. 2185

Following the construction of the Pongolapoort Dam in 1974, concerns related to the influence of the resulting changes in water flows into the Phongolo floodplain led to extensive studies by Heeg et al. As there is increasing pressure from local communities to access and utilize the ecosystem services of the Ndumo Game Reserve, it has become essential to determine to what degree this conservation area maintains the aquatic biodiversity of the floodplain as whole. In this project the quantity and quality drivers in the Phongolo system will be related to the ecological responses at different levels of biological organisation. The influence of aquatic

ecosystem health will be assessed by determining the ecological status of the Phongolo River and associated floodplain through fish, amphibian and bird community studies. Collectively the knowledge derived from this project can be utilized within specific species conservation plans and broader-scale risk assessments. This will enable the relevant conservation authority, Ezemvelo KZN Wildlife, to meet their mandates to establish conservation plans for the ecologically threatened species in the Phongolo floodplain. These management interventions will make a valuable contribution to the sustainable maintenance of the ecological services of this unique ecosystem that were originally identified in the early studies, i.e. the importance of the floodplain to the society, economy, health and ecosystem in general.

Estimated cost: R2 552 800 Expected term: 2012–2015

Programme 2: Estuarine, coastal and marine processes

Identification of wetland processes impacting water resources at catchment scale

CSIR (NRE)
No. 2191

In South Africa wetlands are recognized as fundamental components of catchments as they not only serve to maintain biological diversity but also serve as linkages between aquatic and terrestrial ecosystems. Their important roles include flow regulation, water purification, etc. Wetlands are thus important for management of both water quality and quantity in catchments, but no indicators have been developed for monitoring wetland integrity at this scale; only local wetland-specific indices exist. Besides catchment scale health integrity indicator development, the research will add a dimension of catchment level process-based indicators to wetland delineation as a way of improving wetland delineation in cases where biological and soil-based indicators are insufficient to show boundaries clearly.

Estimated cost: R684 500 Expected term: 2012–2015

Understanding estuarine processes in uMfolozi/uMsunduzi/St Lucia estuary from earth observation data of vegetation composition, distribution and health

CSIR (Earth Observation)
No. 2268

Remotely-sensed information on the estuarine vegetation coupled with other ancillary information, e.g., topographic and land-use data can provide a regional temporal and spatial understanding of estuarine processes and could thus inform adaptive management of estuaries. Understanding the regional context of this large estuarine system is essential in multifunctional landscape design and conservation management of this resource and the ecosystem services it provides. This information will be invaluable in the planning of the reconnection of the uMfolozi River to the St Lucia wetlands, to ensure biodiversity conservation and production and to sustain the various ecosystem services provided by the system. The geoportal and spatial data interactive viewer envisaged in this project will facilitate the development, implementation and monitoring of a management plan for the region. Furthermore, human capacity development in the domain of remote sensing of estuarine or wetland biological processes will be achieved through the implementation of the project. Specific aims of the project are:

- To spectrally discriminate and map estuarine tree and grass/reed species
- To assess the estuarine vegetation condition/health using new multispectral imagery – RapidEye and WorldView images
- To accurately map land use/land cover (LULC) types, estuarine habitat types, habitat heterogeneity and effects of habitat fragmentation on biodiversity, e.g., alien species invasion
- To explain the physicochemical processes underlying the composition and distribution of vegetation
- To ensure that the knowledge generated serves to inform sustainable management of the uMfolozi/uMsunduzi/St Lucia estuary, by developing a data dissemination system based on a geoportal consisting of a data viewer for relevant stakeholders and conservation managers
- To train key personnel in EO methods (ensuring uptake) and interpretation of results

Estimated cost: R2 100 000 Expected term: 2013–2016

Programme 3: Aquatic, riparian and land connectivity

Connectivity through allochthony: Reciprocal links between adjacent aquatic and terrestrial ecosystems in South Africa

Rhodes University
No. 2186

Central to issues of quality and availability of water is the question of whether organisms (including humans) are under threat due to pollution, food limitation, or over-harvesting in both fresh- and salt-water systems. The dynamics of nutrients in ecosystems is captured in the concept of allochthony, whereby material produced outside a given area is transferred elsewhere, hence providing links between adjacent habitats and communities that established ways of thinking do not routinely consider to be connected. Different forms of nutrients and energy move across the conceptual boundaries of ecosystems via organism activities or physical processes such as wind or water currents, and these transfers can represent important food subsidies. The study is aimed at understanding the trophic connections between adjacent habitats that are usually conceptually partitioned and considered in isolation (land, stream, river, estuary and ocean). Human activities constantly reshape these connections, with consequences for both humans and the natural environment. A key challenge is to create a vehicle through which several different aspects of transfer can be studied concurrently within the same region (at least at the scale of a hydrological catchment), with the ultimate aim towards creating a reliable large-scale flux budget.

Estimated cost: R1 700 000 Expected term: 2012–2015

Linkages between the hydrodynamic and biological drivers of the Mgobezeleni Catchment

Nelson Mandela Metropolitan University

No. 2259

The understanding gained from an integrated system will develop the tools and understanding to be able to predict the impacts of changes on the hydrology and ecology, and hence on the local communities in the area, in the Zululand Coastal Plain. The project brings together lead scientists with over 150 years of collective research experience, knowledge and management application in the different disciplines of hydrology, ecology, water quality and estuarine system dynamics. The knowledge generated is expected to be applicable to other communities, in particular, in Mozambique and Madagascar. The interaction between surface and subsurface water resources is dependent on many factors that influence the hydrodynamic processes and flow paths in various ways. The plethora of pathways that water can travel from its source to the various points of departure within a catchment are too numerous to mention and impossible to measure. Consequently, the most pragmatic approach to understanding and describing these pathways is through the development and application of three-dimensional numerical models. However these models are very simplistic representations of the natural system. In the Zululand Coastal Plain, groundwater is an important component of the aquatic system and consequently the numerical model must provide a suitable representation of the groundwater hydrodynamics that include direct linkages to the surface water resources and the ecological system. The overriding aim of the project is to determine/understand the goods and services rendered to the ecological system by the hydrological system in a developing environment on a coastal aquifer with various surface water resources that are dominated by the groundwater. The specific aims are:

- Create conceptual and numerical models of the surface and groundwater components involving the interactions of the hydrological systems to support the investigation of biotic and abiotic linkages in a coastal system incorporating the groundwater, lakes, rivers, wetlands, estuary and marine environments
- Create conceptual models of the interactions of the biotic and abiotic components of the hydrodynamic system based on field studies of the groundwater, lakes, rivers and wetlands; these will include a classification of the wetlands based on their drivers, and identification of their sensitivities to change – a special focus will be on peat and how it could be affected by a reduction in water availability
- Create conceptual models of the interaction of the biotic and abiotic components of the hydrodynamic system based on field studies of the hydrology of the estuary and the export of water and nutrients to the marine environment. There will be two components:
  - The export of water, inorganic nutrients and organic matter from the catchment into the near-shore zone of the sea
  - The dynamics of the estuary which are controlled by water inflows from the catchment, the growth and breaching of the beach berm that controls the estuary mouth and hence water levels in the estuary; and the vertical and horizontal patterns of salinity within the estuary
- Identify and quantify actual and predictable anthropogenic impacts on the natural environmental components of the Mgobezeleni catchments on the hydro-biological components of the coastal environments

- Create platforms for the capturing, storage and dissemination of spatial and other forms of the biotic and abiotic data collected from the field studies at Mgobezeleni and utilised in the creation of the conceptual models

Estimated cost: R2 700 000 Expected term: 2013–2016

Investigating the impact of landscape connectivity on water-linked ecosystems

Rhodes University (Geography)
No. 2260

Connectivity is being embraced increasingly by hydrologists, geomorphologists and ecologists as a concept that allows integration of landscape structure and function at a number of temporal and spatial scales. Connectivity allows the free flow of energy and materials through the system and, as a result, mutual adjustment between system components. Connectivity is counterbalanced by storage sites, which allow material to be retained in the system. The ecologist Ward (1989) introduced the idea of four-dimensional connectivity that acts in the longitudinal, lateral and vertical directions through time. Kondolf et al. (2006) argued that hydrological connectivity is the defining feature of all riverine ecosystems and ascribe river degradation to changes in connectivity, and stress the need to restore the natural connectivity regime. Geomorphic connectivity is a key indicator of system health. Geomorphologists Harvey (2002), Hooke (2003) and Fryirs et al. (2007) have embraced connectivity concepts to conceptualize sediment dynamics, stressing the importance of both connectivity and sediment storage. Connectivity is well suited to describe process response systems in fluvial geomorphology and can be used to assess the health of water related ecosystems. Rowntree and Du Preez (2008) recommended that the present ecological state (PES) of a river's geomorphology be evaluated with respect to both increases and decreases in connectivity. This project is an extension of a community-based catchment rehabilitation project that aims to reduce erosion and improve water conservation. Community members will be directly involved in monitoring sediment load in the two study rivers under the umbrella of the WSP. Feedback will be given at local workshops organised by the WSP project managers. Research findings will also be reported on a regular basis (at least once a year) to the ECRP so that, where relevant, they can be incorporated into policy and decision making.

Estimated cost: R594 000 Expected term: 2013–2016

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Integrating a daily disaggregation modelling tool into a water resources simulation model

IWR Water Resources (Pty) Ltd
No. 2263

One of the key principles of integrated water resource management (IWRM) is sustainable management of rivers to preserve ecosystems. To address this need, ecosystem scientists are working to establish (or have established) environmental flows within rivers. To determine the future reliability (ability to consistently meet environmental flows in future) of environmental flows, there is need to integrate environmental flows into catchment-wide water resource management models. However, technical issues arise during integration which need to be resolved. Increasingly ecologists are demanding daily hydrological models to improve their understanding of the link between river flow and ecological response. This issue was addressed in WRC Project K5/1979 and tools were developed to generate daily flow time-series which are consistent with monthly hydrological time-series currently used in water resource planning models. The next step is to integrate this daily aggregation tool into existing water resource models. The water resources planning models currently in use in South Africa all operate at a monthly time step. This is a major stumbling block in assessing the increasingly complex scenarios that ecologists require water resources modellers to evaluate. As an example, the recently published guidelines for the evaluation of estuarine flow requirements require estimates of flood frequencies and how these flood frequencies change under changing development scenarios. This is not possible with the existing monthly models. Within the context of river ecology, the frequency and flood magnitude of spills from dams is becoming increasingly important as catchments become increasingly impounded. Again, these crucial parameters cannot be assessed with the current monthly models. A secondary consideration within the framework of daily versus monthly modelling is that of sediment transport modelling. Geomorphologists have for many years only been able to provide broad guidelines to ecologists based on monthly hydrology. A recent positive development within the gemorphological realm of determining ecological flow requirements

is WRC Project K5/1797 'Implementation of Strategic Adaptive Management for freshwater protection under the South African National Water Policy', commonly referred to as the *Breonadia* Model. The *Breonadia* Model is essentially a rule-based matrix population model coded in Visual Basic. It requires daily hydrological and rainfall data and starting proportions of different substrate types (which are defined by the site being modelled and which change with time depending on flows) as input data. Hence the provision of daily water resources modelling capabilities will be of huge benefit to the *Breonadia* model. A logical extension of the *Breonadia* model would be to incorporate sediment transport procedures into the proposed daily water resources model. This will then replace the rule-based substrate model with a more scientific approach with the added ability of scenario modelling. A specific request has been made by the *Breonadia* development team to carry out this development. Project aims are:

- Integrate the daily disaggregation model into a water resources model in order to provide ecologists with daily water resources modelling capabilities
- Incorporate flow and sediment routing algorithms into this daily model

Estimated cost: R300 000 Expected term: 2013–2014

Programme 3: Land-use and aquatic ecosystem management

Development of a strategic framework for the sustainable management of water resources found within catchments where ESKOM operates, with initial focus on wetlands

Eon Consulting
No. 2222

With the view to facilitating water resource management by ESKOM and Government departments, this project sets out to develop a sustainable environmental planning framework for the conservation (and rehabilitation) of wetlands, within a catchment perspective. In order to develop and test this proposed conservation management approach for wetlands where ESKOM operates 'coal to customer', it is intended to:

- Conduct a situation analysis of methods available to ecologically sustainable energy generation
- Test an adaptable plan at catchment level that can be applied at national level
- Apply and evaluate the environment conservation plan at selected ESKOM sites
- Establish capacity needs for the establishment of monitoring tools and train a core group of implementing / training officers

Estimated cost: R1 000 000 Expected term: 2013–2014

The design of a National Wetland Monitoring Programme (NWMP) following a phased approach

Sustento Developments cc
No. 2269

Wetlands are highly productive ecosystems and due to their ecological complexity and high biodiversity provide a variety of goods and services of value to society. Wetlands in Southern Africa have been shown to contribute to the livelihoods of rural communities by providing valuable grazing land, cultivation area, building materials and medicinal goods. In addition to these, wetlands provide a host of other services, which are often indirectly used by society. These services include the maintenance of hydrological regimes, flood attenuation and water purification, amongst others. Despite their importance and the legislation designed to protect them, wetlands are currently at risk from a number of sources and it has been estimated that half of the world's total wetlands have been lost already, a similar trend to South Africa. The drivers behind wetland loss are several, and include mining, agricultural practices, change in hydrological regimes and habitat destruction, all anthropologically caused. DWA conceptualized (but did not design) a Wetland Monitoring Programme (WMP) in 1994 as part of the National Aquatic Ecosystem Health Monitoring Programme (NAEHMP). The long-term vision of the NAEHMP is to implement, maintain and improve biomonitoring for all inland aquatic ecosystems in South Africa, including wetlands. A functional National Wetlands Monitoring Programme (NWMP) would provide decision makers with appropriate information on the condition of wetlands. The information generated by the NWMP and by other aquatic programmes such as the National Freshwater Ecosystem Priority Areas (NFEPA) database, would allow wetland managers to make informed decisions on the development of wetlands and of the associated trade-offs to be considered. Some of the key project objectives are:

- To develop a national wetland-monitoring programme aimed at assessing, reporting and triggering managerial responses to wetland integrity
- Determining and illustrate fully the links with the NAEHMP, Working for Wetlands and other related programmes operated by national departments and provincial conservation authorities, as well as Eskom, amongst others
- Phase 2: monitoring programme design and development of an implementation plan
- Pilot testing; specific aims of this phase include producing, testing and refining, where necessary, the scientific viability of the Implementation Manual(s) based on selected sites

Estimated cost: R1 000 000 Expected term: 2013–2016

Programme 4: Integrated environmental and drinking water quality

Development of an immobilized receptor based EDC detection kit

Stellenbosch University (Zoology)
No. 2271

The first reports of synthetic compounds that could interfere with the normal physiological functioning of the endocrine system in mammals, amphibians and reptiles emerged several years ago. The physiological effects of these compounds, later collectively named endocrine-disrupting compounds (EDCs), were observed in lakes, rivers and surface waters in North America and subsequently Europe. A hallmark of EDC contamination is the low concentrations (lower than mg/L levels) at which these substances can occur in various water sources. Despite the rapid development of detection and screening techniques for specific EDCs, the chemical diversity of EDCs that have the same biological effect is severely hampering the indication of these compounds. It is therefore important to continue the search for sensitive and reproducible assays based on the biological effects of compounds rather than their specific chemical structures. Current consensus is that EDCs pose a significant, long-term environmental risk to the wellbeing of both humans and wildlife. At present, there are no rapid on-site detection systems available for the detection of EDCs with potential estrogenic or androgenic activity. The construction of a rapid, on-site monitoring system could give an initial indication whether particular bodies of water, including wastewater effluent and municipal water supplies, contain EDCs and are, thus, in the long term, fit for use. This kit is not to be used in isolation but rather to serve as the first step in identifying water sources that may be contaminated with EDCs. The key objectives of the project are:

- Synthesis and modification of a PVP spacer arm
- Synthesis of a membrane surface chelating agent, PGEAH
- Assembly of SMA-PVP co-polymer affinity membrane
- Immobilization of ligand binding domains of the androgen and oestrogen receptors on SMA-PVP co-polymer affinity membrane
- Testing EDC binding by immobilized ligand binding domains of the androgen and oestrogen receptors
- Developing a colorimetric visualization method for detection of EDCs
- Validation of membrane based detection method against an ELISA-based method
- Estimated cost: R1 070 000 Expected term: 2013–2015

Programme 6: Biodiversity and conservation

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

North-West University
No. 2204

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: 2010–2015

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

Evaluating fish and macroinvertebrate recovery rates in the Rondegat River, Western Cape, after river rehabilitation by alien fish removal using rotenone

SA Institute for Aquatic Biodiversity
No. 2261

One of the greatest threats to South Africa's native freshwater fishes is the negative impact of invasive alien fishes. These impacts include predation, arguably the most serious threat, competition and hybridization. Native fishes in the Cape Floristic Region are characterised by high diversity, endemism and geographic isolation. This makes them vulnerable to the impacts of alien fishes which have extirpated many native fishes from lower reaches of rivers resulting in decreased distributional range and genetic isolation. Many native freshwater fish in the Cape Floristic Region are now red-listed as critically endangered, endangered or vulnerable. In addition, there are strong indications that the loss of native fishes has profound impacts on the aquatic food web.

What is significant from a river rehabilitation perspective is that in many river areas the only impact is the presence of invasive alien fish. By eradicating the alien fish, it is often possible to rehabilitate several kilometres of a river, with very significant benefits for the endangered fish species present and for the associated aquatic biota. To fully evaluate the use of rotenone as an alien fish removal and river rehabilitation tool it is important that both the immediate and long-term impact of rotenone on community composition and recovery is evaluated. Such research is critical as it will determine whether native fish and invertebrate communities recover after the removal of alien fishes or if the system moves towards an alternative state. To fully assess the consequences of alien fish eradication on the faunal communities in the Rondegat River will require recovery monitoring for a period of at least three years; hence this study. The project will be achieved through the following objectives:

- Determine how the Rondegat River ecosystem responds to the removal of alien fishes over a three-year period
- Assess rates of recovery of invertebrate and fish communities after rotenone treatment over a three-year period
- Test the hypothesis that native invertebrate and fish communities rebuild to approximate those in the non-invaded zone of the river
- Develop post-fish eradication monitoring guidelines for fish and invertebrates
- Provide recommendations for future river rehabilitation projects where alien fish are to be eradicated using rotenone

Estimated cost: R445 320 Expected term: 2013–2016

The development of a comprehensive manual for river rehabilitation in South Africa

Freshwater Consulting Group
No. 2270

In South Africa, water courses are increasingly degraded despite the plethora of legislation regulating use and affording protection of the country's water resources, with the National Freshwater Ecosystem Prioritisation Areas (NEFEPA) project reporting that more than 50% of South Africa's rivers are degraded. Among the most threatened reaches of South African rivers are foothill and lowland rivers, and those in urban areas are particularly degraded. Internationally, the science of river and wetland rehabilitation is relatively well-advanced, and a number of manuals and guidelines for river rehabilitation exist in the international literature. Some guidelines have been produced for South African systems too, with a recent large focus on wetland systems in particular. These manuals identify a wide range of possible rehabilitation options for watercourses, but none streamlines rehabilitation with South African legislation. The main objective of this project is to provide guidelines as to the most appropriate rehabilitation solution that should be implemented in different circumstances. The methodology proposed here takes account of different social, economic, ecological and land-use issues, as well as looking at riverine degradation holistically, so that the roles of different drivers of impact or river function are not misinterpreted, leading to solutions that are not sustainable and may in fact be overtly damaging. Some of the key objectives for this project are:

- Design one or more, as applicable, step-by-step technical, adaptable and scientifically viable river rehabilitation manuals
- To identify key stakeholders and develop a framework that will ensure inclusivity of disciplines thereby facilitating manual uptake and implementation
- Streamline the manual(s) into existing programmes such as DEA Environmental Programmes, Catchment Management Strategies, Reserve determinations, water sensitive urban design and others
- Recommend further research on best practises for future and sustainable river rehabilitation, incorporating risks imposed by climate change

Estimated cost: R1 000 000 Expected term: 2013–2016

Programme 2: Socio-economic dynamics

Current and future impacts of alien plant infestations on water temperatures and freshwater biodiversity

Freshwater Research Centre

No. 2264

Clearing of alien riparian vegetation is often done based on ad-hoc decisions, where a more structured approach based on an objective basis, such as costs versus ecological gain, would greatly assist this process. This project aims to quantify ecological gains versus costs of associated clearing. Essentially, clearing of alien riparian vegetation, and restoring riparian zones to either a desired future state or a natural state, will theoretically restore flow and water temperature regimes underpinning community patterns. Numerous techniques could potentially be applied in clearing alien vegetation, which include, inter alia, wholesale clearing of target areas and follow-up planting of indigenous vegetation, versus selective (phased) clearing over a given time period and gradual replacement of alien vegetation with indigenous vegetation. Different clearing techniques will have different associated costs and potentially achieve different levels of ecosystem restoration, although what these costs and benefits are remains to be quantified. What is also not known in terms of water quality impacts of alien vegetation are the relative impacts on water temperatures of different species and densities of alien vegetation. One way of answering these questions is to use field studies using reference versus impact sites, and to assess costs and benefits based on real costs of clearing under different management options, versus quantifiable improvements in water temperature regimes, to derive a cost per degree change towards desired thermal state. Such an approach allows for assessing which management interventions produce the best ecosystem benefits for the least cost. The project will address the following objectives:

- To define relationships between alien plant densities in the riparian zone and changes to water temperature regimes as reflected in changes to the structure of aquatic macroinvertebrate communities
- To establish the effect of different clearing techniques/ approaches in the riparian zone on water temperatures and associated aquatic habitat integrity and community response
- To estimate the most cost-effective clearing techniques in terms of financial efficiency and ecological returns

Estimated cost: R934 900 Expected term: 2013–2015

Building resilient landscapes by linking social networks and social capital to ecological infrastructure

CSIR (NRE)

No. 2267

We live in a time of unprecedented global complexity and change. Whilst exemplified most clearly by the effects of global climate change, the nature of the changing world we live in is far broader. The concept of 'global change' encompasses the interlinked effects of changes in climate, land use and human population demographics, social and economic development, governance regimes and changes to the buffering capacity of the earth's ecosystems. The substantial changes that are happening in the social-ecological landscape are severely affecting the resilience of these systems and their ability to absorb, adapt and recover from disturbance. This in turn exposes society to a wide variety of increasing risks, so much so that contemporary societies have been termed 'risk societies'. Failure to understand and proactively respond to the risks and opportunities that are embedded in this dynamic social-ecological landscape can have grave consequences to society. Society's current trajectory is clearly not sustainable, and a series of social-ecological transformations are required to move social-ecological systems threatened by climate change towards an alternative, more desirable and more resilient state. This project focuses on integrated and systemic ways of

approaching risk by linking the concepts of social capacity for governance and social capital to ecological infrastructure in order to build resilient landscapes.

- The overall vision of the project is to promote social-ecological transformation towards a more sustainable future in the Gouritz catchment through influencing the way decision makers think within the context of droughts, storms and other risks
- Provide opportunities for knowledge exchange, reflection and learning about the role of ecological infrastructure and social governance
- Use these learning interactions and engagement with role-players to identify in a participatory way, map key social and ecological risk hotpots where both the likelihood and consequence of risks are high and identify alternatives
- At a finer scale, within selected risk hotspots, identify and quantify the ecological infrastructure most needed to enhance resilience and reduce the associated risks

Estimated cost: R2 200 000 Expected term: 2013–2015

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1: Environmental economics (goods & services) and accounting

Upscaling understanding of water movement, land degradation and carbon cycle in support of effective payment for ecosystem services

University of KwaZulu-Natal (Agriculture, Earth & Environmental Sciences)
No. 2266

Natural ecosystems provide key functions essential to the sustainable economic development of societies. Concerns about long-term sustainability and high environmental costs support the need for an increased understanding of the processes and consequences of land degradation. Land degradation is not limited to an impact on water resources and agricultural production (crop and animal); the living system of the soil also provides a range of ecosystem services that are essential to the wellbeing of farmers and society as a whole. Initially focused on the water resource, Payment for Ecosystem Services (PES) systems now focus on land-water interactions and highlight that catchment condition and, where necessary, rehabilitation, are key to sustained water supply and water quality. However, we still lack an understanding of carbon (C) and nutrient cycles and their role in land rehabilitation techniques. Additionally, there still remain a myriad of unresolved questions and problems related to scale, water quantity and quality, and C and soil nutrient cycles. Addressing these issues remains one of the outstanding challenges in the field of hydrology and environmental sciences and is fundamental in order to foster sustainable economic development in rural areas of South Africa. Moreover, because both the expected results and scale issues are not unique to hydrology there is a range of disciplines, such as meteorology and climatology, geomorphology, soil science/biology and social sciences, which will also benefit from this field of research. As a consequence, we seek through this interdisciplinary project to understand organic C and nutrient cycles from hillslope to basin level, to promote optimal functioning of natural ecosystems. The aims of the project are:

- Upscaling understanding of carbon and nutrient cycles, from the small agricultural catchment to the basin level, through: (i) out-scaling (lateral extension across similar landscapes), and (ii) up-scaling to assess how processes change as the catchment size increases
- Select and evaluate best management practices (BMP) for improved ecosystem functioning and link understanding of carbon and nutrient cycles to remediation activities and Payment for Ecosystem Services (PES)
- Apply BMP at large scale (both spatial and temporal) by running scenarios through improved modelling

Estimated cost: R2 907 000 Expected term: 2013–2018

Evidence-based analysis of environmental degradation: Impact of ecological degradation on water resources, ecosystems and socio-economic development

Prime Africa cc
No. 2272

Degradation of aquatic ecosystems has negative impacts on the economy, and on the health of people and water resources through losses in ecosystems goods and services (EGS). In some cases, the

use of the precautionary principle can prevent damage, but this can also prevent economic development. It is thus poor communities who are most often affected by changes in EGS. Rivers, the arteries of a catchment, reflect the health of the environment and the social-ecological system (SES). Any problems in a river basin are reflected in the health of the rivers. The DPSIR model (Driving forces, Pressures, State, Impacts and Responses) provides a framework which enables the drivers exerting the pressure causing the change in the state of the environment to be identified. This directs the response of management to address the drivers, so providing a long-term solution to degradation. There is a lot of research (research outputs include databases and scientific findings) on the degradation of inland waters, but this has not been drawn together into a cohesive whole. The rigorous evidence-based methodology employed by E-BASES (WRC Project K5/1978) will provide a thorough review of the existing knowledge. This, combined with the ecosystem service valuation methods developed by WRC Project K5/1644, will indicate what the cost of environmental degradation has been to the SES. An important part of this work will be to develop a legal view on the standards and level of evidence that would be sufficient to prove liability for ecological degradation. By example, a recent EU directive (EU 2004) has developed a framework of environmental liability based on the polluter-pays principle to prevent and remedy environmental damage, which may provide a way forward in implementing this principle. Specific objectives are:

- To develop appropriate approaches for assessing the causal effect of degraded water resources resulting from catchment land uses on socio-economic development
- To review the subject in the context of water resource and thus aquatic ecosystem goods and services
- To develop or refine approaches and tools needed to analyse the socio-economic impact of environmental destruction or degradation, with special focus on the health and integrity of water resources
- To investigate possible effects of degraded water resources on users and associated food chains and the effect on the benefits derived from the ecosystem goods and services used in both rural and peri-urban/urban catchments
- Apply and provide a critical analysis of the results, including policy implications, opportunities, and threats to local communities and to the country

Estimated cost: R2 000 000 Expected term: 2013–2017

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 2: Ecosystems and climate change

A climate change risk assessment of water hyacinth biological control

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

No. 2265

Alien weed control costs South Africa approximately R6.5 billion per annum, and climate change will impact the effectiveness of those efforts. This project seeks to develop a tool to help manage the outcome of future climate scenarios on alien weed control. Water hyacinth is one of the world's most invasive aquatic plants, originating from South America and invading many ecosystems; its control is crucial. Multiple methods such as mechanical, herbicidal, and biological control have been used against it. However, biological control is considered to be the best long-term, sustainable approach, and is potentially many times more cost effective than other methods, when successful. With such an economic benefit, understanding and improving the success of biological control of water hyacinth is essential. This study proposes to incorporate the effects of biological control by *Neochetina* weevils, with temperature and nutrients, into a model of water hyacinth growth which will give site-specific predictions of population growth of both weevils and water hyacinth, and have applications in climate change risk assessment and management, e.g., by Working for Water. The key project objectives are:

- Model the relationship between environmental temperature and water hyacinth weevil population density and growth
- Model the relationship between water nutrients and water hyacinth population density and growth
- Model the relationship between nutrients and weevil population density and growth
- Combine the above elements to determine how effective biological control of water hyacinth by *Neochetina* weevils will be under different climate scenarios

Estimated cost: R500 000 Expected term: 2013–2016

NEW PROJECTS

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

The use of long-term, large-scale data combined with historic ecological data to support Reserve implementation
Southern Waters Ecological Research & Consulting
No. 2345

Aims:

- To use a variety of sources of data to establish a timeline of temporal change in river and wetland ecosystem nature and/or condition at a basin scale
- To identify the main drivers of historical change and, if possible, isolate flow-driven changes
- To augment the basin-level data with site-specific information on riverine community composition, set in the context of the basin-level drivers of historical change
- To provide a template of long-term changes in aquatic ecosystems against which future monitoring of potential impacts associated with abstraction can be evaluated
- To assess key assumptions used in the determination of the ecological Reserve and suggest changes, if necessary and/or appropriate
- To investigate the occurrence and nature of ecological thresholds

Estimated cost: R1 700 000 Expected term: 2014–2018

Quantification of transmission losses along the Letaba River for improved delivery of environmental water requirements (ecological Reserve)
SAEON Ndlovu Node
No. 2338

Aims:

- Determine environmental water requirement real-time implementation model uncertainties due to transmission loss parameterisation
- Select river reaches under various geological/hydrogeological settings where transmission losses need to be determined
- Select river reaches under various land management types where transmission losses need to be determined
- Quantify abiotic mechanisms for transmission losses in these reaches through groundwater–surface water interaction determination
- Quantify biotic mechanisms for transmission losses in these reaches through determination of actual evapotranspiration losses in the riparian zone
- Upscale the quantified processes through extrapolation with remote sensing, geophysical, hydrochemical and modelling techniques
- Develop accurate transmission loss parameters and incorporate in real-time Reserve implementation models
- Provide added-value by transcribing the findings to other rivers in the Lowveld

Estimated cost: R882 000 Expected term: 2014–2017

FEPAs and flows: Developing methods for ecological Reserve compliance monitoring in freshwater ecosystem priority areas (FEPAs): a case study in the Kouebokkeveld, Western Cape
Freshwater Research Centre
No. 2340

Aims:

- To provide specialist hydraulic, hydrological and ecological support to the Endangered Wildlife Trust's Cape Critical Rivers (CCR) Project which aims to assist the water user association (WUA) in the Kouebokkeveld with ecological Reserve compliance in FEPA-listed rivers
- To develop rated cross-sections at flow monitoring sites on two rivers for which stage-loggers have been installed by the CCR project downstream of the most intensively farmed areas of the Kouebokkeveld
- To use this data to reconcile present-day hydrology in these rivers with up-to-date information collected by the CCR field officer on water abstraction levels by landowners upstream
- To use HABFLO to assess current ecological Reserve recommendations specifically with regards to the requirements of the threatened endemic freshwater fish fauna of the catchment

- Using the most up-to-date hydrology, together with data gathered during the course of this study, to assess whether the ecological Reserve is currently met and, if not, to suggest management interventions that may be required to meet it in future
- To engage the Kouebokkeveld WUA using members of the study team and the CCR project team and to workshop management solutions with them
- To investigate elementary, cost-effective monitoring tools and protocols for monitoring Reserve compliance in catchments of high ecological importance (i.e. FEPAs), which can be broadly applied by non-technical personnel within CMAs, WUAs and conservation organisations

Estimated cost: R315 900 Expected term: 2014–2016

Programme 2: Rivers, wetlands, groundwater, lakes, coastal and marine (and estuarine) ecosystems

Investigation of peatland characteristics and processes as well as understanding of their contribution to the South African wetland ecological infrastructure

ARC (Institute for Soil, Climate and Water)
No. 2346

Aims:

- To update and recalibrate the peatland eco-region database and map to show where peatlands occur and where conditions favourable for peatlands exist
- Improve the existing model to identify potential peatland areas and groundtruth certain of these.
- To develop a strategy for peatland protection
- To develop a South African peatland classification system based on international systems and the SA wetland classification
- To quantify the peatland component in SA's sustainable practice (e.g. cultivation in peatlands)
- To document the cultural heritage associated with SA peatlands.
- To identify peatlands suitable for palynological and related natural archives to study development of the SA landscape over time, climate change and historical human adaption to changes over time in this landscape
- To improve our understanding of threatened and protected species, specifically plant species, that could occur in peatlands, and to simultaneously publish an annotated list of plant species that occur in peatlands based on available sources

Estimated cost: R1 000 000 Expected term: 2014–2017

Programme 3: Land-use and aquatic ecosystem management

Geospatial analysis of microbial community structure and antimicrobial resistance analysis in the management of natural streams and selected wetlands

North-West University (Environmental Sciences & Management)
No. 2347

Aims:

- To determine and establish water quality of selected surface water sites and classify these based on physico-chemical and microbiological conditions
- To optimize microbial DNA extraction and next generation sequencing methods for establishing microbial biodiversity indices
- To determine the accumulation and attenuation of antibiotic resistant bacteria (ARBs) and genes (ARGs) in water environment at the various sample sites using culture-dependent and culture-independent methods
- To track the origin and movement of ARBs and ARGs from the terrestrial watershed to water environment using comparative and statistical analysis
- To map the landscape to link anthropogenic activities (animal and agriculture operations) with the concentration of ARB and ARGs in the watershed

Estimated cost: R990 000 Expected term: 2014–2017

The investigation of selected Ramsar wetlands biodiversity status and tourism value in support of the Ramsar convention information requirements

North-West University (Biological Sciences)
No. 2352

Aims:

- Review of available aquatic information for South Africa's RAMSAR sites

- Compilation of available aquatic information of RAMSAR sites into a database
- Management of land use surrounding selected South African RAMSAR sites

Estimated cost: R1 774 700 Expected term: 2014–2017

Aligning and integrating biodiversity and environmental water quality into the mining development life-cycle

Rhodes University (Institute for Water Research)
No. 2355

Aims:

- To conduct an analysis of available resource and catchment-based tools aimed at sustainable development of water resources and management
- To investigate and evaluate the decision-making processes followed in issuing mining authorizations
- To determine the relationship between licensing processes and eco-logical infrastructure from a landscape and connectivity perspective
- Propose an integrative decision making process and institutional arrangement

Estimated cost: R2 000 000 Expected term: 2014–2019

Programme 4: Integrated environmental and drinking water quality

The development and application of periphyton as indicators of flow and nutrient alterations for the management of water resources in South Africa

Freshwater Research Centre
No. 2351

Aims:

- To broaden the relevance of scientific understanding of periph-yton communities in both winter and summer rainfall regions of South Africa to a greater geographical extent
- To test the robustness of periphyton indicators for predicting and monitoring change in the ecological integrity of rivers
- Extend current efforts to test the validity of using rapid in situ methods for determining periphyton biomass in South Africa rivers in general
- To develop a draft protocol for the use of these tools in aquatic biomonitoring in general as well as the RHP and the ecological Reserve process
- To develop preliminary thresholds of change in the trophic state of rivers based on periphyton biomass
- To develop and transfer skills in the use of periphyton as an indicator of change in ecological integrity of South African rivers

Estimated cost: R1 223 574 Expected term: 2014–2017

Programme 7: Ecosystem governance, legal framework and ethics

The role of environmental ethics in social-ecological systems and water resource management

Rhodes University (IWR)
No. 2342

Aims:

- Review the subject of environmental ethics, and its applicability to the context of integrated water resource management, and of aquatic ecosystem use and protection
- Investigate case studies, both South African and international, showing the impact of environmental ethics on water resource management and aquatic ecosystems; pay particular attention to best practice cases, and identify the ethics-related factors involved in these situations
- Identify opportunities for application and improvement of envi-ronmental ethics in South Africa for constructive management of socio-ecological systems and water resources
- Identify ways in which environmental ethics can constructively be applied in South Africa, and what institutional and other foundations need to be laid/changes need to be made for this to be possible
- Analyse how environmental value and ethical systems operate at different levels of scale – local, regional and national – and the problems and possibilities of integrating such systems across such differences
- Propose future research in relation to environmental values and ethics in socio-ecological research and water management

Estimated cost: R700 000 Expected term: 2014–2016

Programme 8: Transboundary ecosystem management

Development and innovative use of community-based water resource monitoring tools to research and mainstream citizen science and improve transboundary catchment management

Groundtruth cc
No. 2350

Aims:

- In collaboration with partners in South Africa and each of the six neighbouring transboundary countries, identify and develop existing and new rapid tools for citizen and school learner monitoring of river and catchment health indicators
- Package the tools into an integrated river and catchment monitoring toolkit for roll-out within South Africa and neighbouring countries
- Dissemination of the developed toolkit to promote citizen and school-level education and awareness of catchment and river health
- Through application of the toolkit and geo-database, initiate the growth of a transboundary citizen science dataset of river and catchment health covering South Africa, neighbouring countries and beyond
- Through collaboration with specialists in each neighbouring country, foster research around transboundary water resource management at citizen level
- Assess the successes and barriers to the application of the citizen science tools in effecting meaningful change in the challenges of transboundary water resource management

Estimated cost: R1 432 180 Expected term: 2014–2017

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Programme 1: Rivers, wetlands, coastal and estuarine systems, and lakes (dams)

Assessing the impact of selected methods of removal of alien invasive trees and biomass on fynbos riparian ecosystem functioning

Stellenbosch University
No. 2343

Aims:

- Evaluate the impact of recommended levels of herbicides used to control alien invasive growth and regeneration on soil microbial diversity and on selected beneficial groups of microbes in situ and ex situ and in riparian soils from two different longitudinal zones
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil microbial diversity and on selected beneficial groups of microbes in situ, and measure regeneration of various native plant species grown in soil from slash-and-burn scars ex situ
- Determine the impact of slash-and-burn of *Eucalyptus* and *Acacia mearnsii* biomass on soil physical and chemical properties in situ
- Determine the biomass and nutrient content of *Eucalyptus* and *Acacia mearnsii* trees of different sizes growing at different stem densities in riparian sites from two different longitudinal zones

Estimated cost: R1 500 000 Expected term: 2014–2017

Evaluation of the socio-ecological outcomes of wetland rehabilitation in South Africa

Groundtruth cc
No. 2344

Aims:

- Develop (through iterative application and testing) a monitoring and evaluation framework for the socio-ecological outcomes of wetland rehabilitation in South Africa
- Provide a formative and outcomes-based evaluation of wetland rehabilitation within South Africa, with a focus on the Working for Wetlands operations
- Skills development within the Working for Wetlands programme to allow an internal evaluation of a sub-set of rehabilitated wetlands
- Deepening our understanding of wetland socio-ecology in terms of rehabilitative management
- Specific evaluation of rehabilitation methods employed with the objective of identifying those methods most suitable for labour-based approaches and inform further research

- Contextualize the value of the wetland rehabilitation when viewed as an investment in ecological infrastructure

Estimated cost: R2 500 000 Expected term: 2014–2019

THRUST 4: SUSTAINABLE ECOSYTEM UTILISATION AND DEVELOPMENT

Programme 1: Environmental economics (goods & services) and accounting

Demonstration of how healthy ecological infrastructure can be utilized to secure water for the benefit of society and the green economy through a programmatic research approach
University of KwaZulu-Natal (Centre for Water Resources)
No. 2354

Aims:

- To investigate and report on the status of catchment land-use and water resource quality in the selected catchment(s)
- Cost the impacts of the degradation of ecosystem infrastructure on water users from different stakeholder experiences using an evidence-based approach
- Investigate how an intact ecological infrastructure could secure and enhance the benefits provided to society and economy in the catchment
- Investigate how investment in the protection and enhancement of the environmental asset base (or ecological infrastructure) of the uMngeni catchment could contribute to resilient economic growth, greater social equity and justice and the reduction of environmental risks, thereby addressing the goals of the green economy
- With the aid of the stakeholder water resource management framework produced in Phase 1, develop a cost-effective conservation management strategy based on the principles of the green economy
- Develop and train actors in the catchment in an appropriate governance model/approach, which includes social learning, knowledge production (including spatial knowledge), participatory engagement and technical methods (models, guidelines, indicators, procedures) necessary to achieve a paradigm shift to transform society and the economy towards a healthy relationship with the ecological infrastructure within the catchment, i.e., to change the socio-ecological relations in the catchment to ensure greater resilience through the development of a transformative governance approach
- Describe the catchment connectivity in terms of both bio-physical and social aspects that are core in understanding drivers of the catchment processes and characteristics
- Recommend further research on the social and ecological interface critical to improve natural resources governance at the catchment scale

Estimated cost: R5 000 000 Expected term: 2014–2020

Programme 2: Ecosystem value-chain and markets

Investigation of aquatic ecosystem services, their value chain, and markets in South Africa
CSIR (NRE)
No. 2341

The study explores aquatic ecosystem goods and services in South Africa within the context of a value chain assessment:

- To investigate the forward linkages in the value chains of aquatic ecosystem services and their markets in South Africa
- To identify challenges and opportunities in the value chains and existing markets
- To investigate the ripple effects of aquatic ecosystem goods and services in South Africa
- Recommend ways to improve not only aquatic ecosystem goods and services themselves but also the associated value chains

Estimated cost: R1 000 000 Expected term: 2014–2016

Programme 3: Gender, culture and heritage for ecosystems

Explore and incorporate indigenous knowledge systems into natural resource planning policies and government strategies in order to create space for rural community engagement and empowerment aimed at improving their livelihood while sustaining infrastructure

University of the Western Cape (PLAAS)
No. 2353

Aims:

- To conduct an extensive review on the current uptake of the diversity of indigenous knowledge systems in water resource management policies and strategies
- To establish the implications of the extent to which cultural or indigenous knowledge is considered in the development of strategies meant for decentralization of water resource management, such as catchment management strategies, national biodiversity framework, etc.
- To understand the socio-economic and political perspectives of the value of aquatic ecosystems by rural communities
- Understand how the current distribution of power and gender dynamics impacts decision making in water resource planning strategies and policies
- Develop and test an approach for the inclusion of all knowledge systems (indigenous, scientific and governmental) in policies and strategies for more holistic water management
- Identify future research pathways for the integration of indigenous knowledge systems in policies and strategies

Estimated cost: R1 000 000 Expected term: 2014–2017

Programme 4: Green economy and sustainable (green) innovations

Green water innovations for sustainable aquatic ecosystems and socio-economic development

African Centre for a Green Economy (Africege)
No. 2349

Aims:

- To evaluate the impact of green innovations on water resources and aquatic ecosystems
- To evaluate the effects of green innovations on corporate performance and society; special focus on South African companies will be prioritised
- To investigate the usefulness and appropriateness of the metrics or indicators that are used to determine the efficiency of green innovations on water resources; recommend a set of indicators that are most appropriate for South Africa
- To recommend specific green innovations that companies should consider to improve the triple bottom-line in South Africa

Estimated cost: R1 000 000 Expected term: 2014–2016

Investigation and demonstration of how integrated green innovations and technologies can be utilized to create entrepreneurship/jobs that improve the economic conditions of communities in the upper Umzimvubu River (Ntabelanga) and Okhombe, within Jo Gqabi and Thukela District Municipalities, respectively

Department of Environmental Affairs; Umhlaba Consulting Group (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); University of Fort Hare (Agronomy); Aquamet; Renen Energy Solutions (Pty) Ltd
No. 2423

Aims:

- Identify drivers of poverty, opportunities offered by natural ecosystem, and develop community-based vision of a Green Village using a bottom-up approach
- Through integration of indigenous knowledge, green innovations, research, and technology, develop a toolbox of green solutions that can address the impact of climate change and help communities or sectors to adapt to climate change
- Identify and develop a business (economic) framework that poor and local communities can use to improve their livelihoods without furthering land-use degradation
- Develop and test practical and appropriate mechanisms, manuals and guidelines for landscape development and management that will protect the infrastructure and improve ecosystem services
- Train communities (mainly the youth) on appropriate skills/capacity necessary to sustain the businesses and ecosystem services that transform the poor community to be more self-sufficient
- Integrate the green solutions toolbox and business framework with core line-functions of government departments in order to ensure sustainability of the intervention and to forge partnerships with all key stakeholders
- Develop models on how to expand the green toolbox of solutions and business framework utility, from household/village to the national or country-wide scale

Estimated cost: R2 000 000 Expected term: 2015–2018

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 1: Ecosystems and population dynamics

Response of urban and peri-urban aquatic ecosystems to riparian zone land uses and human settlements

Nxt2u (Pty) Ltd
No. 2339

Aims:

- To complete a literature study on work previously done on challenges regarding informal settlements and consequential degradation of natural resources
- To investigate the regulatory framework that governs human settlements, including processes associated with spatial planning as well as effectiveness of the implementation thereof
- To investigate issues arising from the influx of people into areas that are characterised by sensitive ecosystem and infrastructural resources, including water provision, access and use
- To undertake a pilot study of human-induced impacts on sensitive aquatic ecosystems and changes in ecological dynamics, particularly due to informal settlements
- To investigate the impacts of riparian land-use activities on aquatic ecosystem goods and services
- To develop a framework to propose how ecological resilience can be attained, or how a balance can be struck between human settlements and good ecosystem functioning

Estimated cost: R1 500 000 Expected term: 2014–2017

Programme 2: Ecosystems and climate change

A multi-proxy investigation into past and present environmental change at Lake St Lucia

University of the Witwatersrand (Chemistry)
No. 2336

Aims:

- To investigate both the long-term and short-term geomorphic and sedimentological evolution of Lake St Lucia through a combination of geophysical, geochemical, and palaeoenvironmental techniques
- To relate these changes to long-term change in climate, lake water chemistry, and shorter-term anthropogenic influences on the system
- To provide an analysis of climatic controls on the geomorphic and sedimentological evolution of the lake system
- To inform system management practices using insights gained from a longer-term evolutionary perspective

Estimated cost: R849 500 Expected term: 2014–2017

Assessing the effect of global climate change on indigenous and alien fish in the Cape Floristic Region

Freshwater Research Centre
No. 2337

The overall aim of the project is to determine the vulnerability of indigenous fishes to a changing environment:

- To map the current distribution of indigenous and alien fish species in the CFR based on existing and new data
- To evaluate the vulnerability of indigenous fish species and the threat of invasive alien fish species in the CFR under projected climate change
- To characterise flow, habitat and thermal requirements of target fish species
- To determine the thermal ranges and/or thermal preferences of target fish species using field data, niche models, in situ and ex-situ experiments
- To evaluate the likely consequences of climate change on fish species through scenario analysis
- To provide recommendations for the conservation of indigenous fishes in the CFR with a criterion-based evaluation of extinction risk

Estimated cost: R1 860 100 Expected term: 2014–2017

Ecosystem process and function of temporary wetlands: baseline data for climate change predictions

Nelson Mandela Metropolitan University
No. 2348

Aims:

- Determine the level of biogeochemical cycling generated by primary producers (e.g. micro- and macro-alage) in temporary wetlands

during different levels of inundation in order to refine understanding of this process for use in global climate change models
- To examine trophic relationships in temporary wetlands under different levels of inundation and link these to different climate change models
- To experimentally determine different temperature, water level and nutrient regimes that affect the growth and production of various algal taxa, for use and refinement in climate change and eutrophication models
- To determine loss of ecosystem services from temporary wetlands associated with changes in global climate

Estimated cost: R1 500 000 Expected term: 2014–2017

CONTACT PERSONS

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KSA 3

WATER USE AND WASTE MANAGEMENT

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

Jay Bhagwan:
Executive Manager

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 consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, 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 strategic objectives of KSA 3 are as follows:

- To support the efficient functioning of water service institutions and their viability in order to sustain water services in rural and urban areas
- To develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality
- To develop technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector
- 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 with the aim to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries
- To provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector

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.

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.

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

Thrust 3: Sustainable municipal wastewater and sanitation

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

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

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.

Programme 1: Emerging challenges and solutions for the 21st century	***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.
Programme 2: Integrated management	***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.
Programme 3: Quantification, prediction and minimisation of water use and waste production	***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.
Programme 4: Governance, policy, regulatory, and economical instruments to improve industrial water management	***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.

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

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.

Programme 1: Water use and waste production	***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.

Programme 2: Regulatory, management and institutional arrangements	***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).
Programme 3: Minimising waste production	***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.
Programme 4: Mining in the 21st century	***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).
Programme 5: Low-volume mined products	***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.

Thrust 6: Watersmart fund

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

RESEARCH PORTFOLIO FOR 2014/15

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Adapting and piloting the new concepts of Community-Led Total Sanitation (CTLS) into the South African municipal environment

Cape Peninsula University of Technology; African Institute for Community-Driven Development (Khanya-aicdd); Rural Support Services

No. 2088

This study was premised on the global assumption that all approaches aim to achieve open-defecation-free (ODF) neighbourhoods; How to achieve this aim remains a core question facing society. The premise of the study held that community responsibility and appropriate support from surrounding institutions have equivalent bearing upon the success of sanitation programmes. The study confirmed that adapting CLTS concepts to the South African municipal context has currency in fostering partnerships between communities and authorities. Achieving the potential for resource sharing, rather than entitled delivery, calls for improving communication flows between communities and support institutions. Partnering across levels of stakeholders brought support institutions together to confirm target sites, identify municipal champions and recruit facilitators for training.

Cost: R2 500 000 Term: 2011–2014

Social protests and water service delivery in South Africa

University of the Western Cape

No. 2133

In 2012 the frequency, geographical spread and violence of service delivery-related social protests in post-apartheid South Africa reached unprecedented levels. Water service delivery issues rose in prominence among various reasons cited for protests. While this ascendance is remarkable, grievances over water services are not new. Water service delivery issues have been (and still are) a part of a range of conflated grievances that masquerade under the general rubric of 'service delivery' issues and underpin many rallying calls for social protest action. Although such conflation reflects the inter-relatedness of social services, it also masks the precise nature of the specific water service delivery issues in question. It is perhaps worth mentioning that although social protests are complex phenomena, for those protests in which water is cited as a grievance issue, a key policy issue is that water insecurity is at the core of dissatisfaction, alongside grievances over the delivery of related social services, poor governance and municipal capacity constraints, especially funding and human resources. Research findings show that the majority of social protests associated with water service delivery tend to occur in low- and middle-income working-class urban and peri-urban neighbourhoods that are characterized by:

- Poverty, unemployment, inequality and unhappiness about perceived relative deprivation and/or marginalization
- Dissatisfaction with water services delivery and the delivery of related social services (e.g. sanitation, housing, electricity, refuse removal and roads)
- Disjuncture (including communication breakdown) primarily between municipal authorities at local levels and water users at plot and neighbourhood levels
- Negative perceptions about governance in general and municipal governance in particular
- Municipal capacity constraints in dealing with longstanding backlogs for access to water and related social services (e.g. sanitation, housing, electricity, refuse removal, roads and stormwater drains), particularly amid rapid urbanization and a changing demographic profile of citizenship expectations and aspirations

Cost: R1 500 000 Term: 2012–2015

Development of a framework for sanitation governance in South Africa

Hlathi Development Services; Cozinet (Pty) Ltd, Mthengenya and Associates; Tshwane University of Technology

No. 2206

This study was initiated to respond to the recommendations from a WRC study which concluded that poor sanitation governance was responsible for the slow progress in the eradication of the basic sanitation backlog from all settlements, especially in dense urban informal settlements and rural communities. The main goal of this study was to develop a framework for effective sanitation governance that would provide the South African local government with tools for the implementation of good sanitation governance in order to ensure accountability to citizens through the building of appropriate stakeholder forums, facilitation of partnerships for sustainable sanitation service delivery that involve municipal councils, service providers, non-governmental organisations (NGOs) and civil society organisations (CSOs). The review of international experience of sanitation governance showed that most Sub-Saharan countries were faced with a huge challenge of weak sanitation governance which contributed to the slow progress in the achievement of Millennium Development Goals (MDGs) for access to sanitation. South Africa was in a better position than most of its African counterparts because it has a policy and legislative framework that makes provision for implementation of good governance as a part of developmental local government agenda. The weak governance that characterized the majority of municipalities could be attributed to poor provincial government oversight and ineffective national regulation of the sanitation sector.

Cost: R700 000 Term: 2013–2015

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 3: Drinking water quality

A national water R&D and innovation roadmap for South Africa

Mutualfruit Limited

No. 2305

The Department of Science and Technology is engaged in fostering innovation, job creation and enterprise development within the South African waste sector, through the implementation of a 10-year national Water Research, Development and Innovation (RDI) Roadmap. The Water RDI Roadmap provides a baseline assessment of the water and wastewater sectors, against which future scenarios can be measured in order to assess the effectiveness of any interventions which are implemented. The status quo was assessed using workshops combined with literature reviews to identify the current capacity and activity in higher education institutions (HEIs) and the private industrial sector. An assessment of South African intellectual property using records held by the TIA, NIPMO and other relevant organisations was included. The impact and implementability of such intellectual property and its relevance to the intended end user or target market was interrogated. The Water RDI Roadmap provides a four-stage programme to improve quantity, quality and relevance of skills in the sector over the next 10 years. Finally, the Roadmap describes in detail the instruments required to create a world-class water sector in South Africa, the phases of their introduction and maintenance, and the investment required to implement the national roadmap.

Cost: R1 898 300 Term: 2013–2015

Programme 4: Water distribution and distribution systems

Practical guidelines for operation and maintenance of water distribution systems in South Africa

University of Cape Town

No. 2135

The O&M guide for water distribution focuses on distribution systems including pipes, pumps, valves, storage reservoirs, meters and other fittings. It does not deal with other equally important elements of the water supply chain such as the protection of water sources, raw water systems, water treatment plants and plumbing systems. In addition, the book focuses on technical issues of operation and maintenance, and does not deal with associated factors such as human resources management, data systems, funding, and public participation and accountability. The approach adopted in the book is to provide the reader with an understanding of the processes leading to system decline, measuring system performance and the best practices in operation and maintenance

of water distribution systems. It aims to provide guidance to empower the reader to implement a proper operation and maintenance system in practice, focussing on the most common and important aspects.

Cost: R757 000 Term: 2012–2014

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

The development of nanocomposite polysulphone membrane with reduced fouling properties for use in wastewater treatment

University of the Western Cape; Ikusasa Water (Pty) Ltd; Scientific Services Branch

No. 2006

The research programme was designed to facilitate capacity building in the field of design and preparation of novel polymer composites with the desired characteristics for water treatment applications, to demonstrate the suitability of electrochemical methods as analytical tools to evaluate membrane materials and to demonstrate membrane performance capacity in laboratory-scale experiments. Polysulfone modified with selected catalytic metal nanoparticles was successfully achieved. The polysulfone composite based on homogeneous incorporation of Ni nanoparticles, before film casting, was observed to have the smallest pore size and highest pore distribution per unit area. The Ni nanoparticles adopted the hexagonal close-packed unit arrangement with a packing efficiency of up to 74%. In the analytical evaluation of PSF/Ni composites drop coated to form thin-film chemical sensors, a very good sensitivity towards tannic acid and alginic acid was observed with a linear response in the micro-molar concentration range. A second synthetic approach was evaluated that does not involve metal nanoparticles, based on chemical crosslinking of polysulfone with a hydrophilic polymer to produce mechanically stable hydrophilic hydrogels. Polysufone and polyvinyl alcohol were chemically cross linked using a short chain di-aldehyde to produce hydrogels with greatly reduced hydrophobicity, irrespective of the ratio of the starting polymers. All hydrogels showed similarities to the metal nanoparticle modified polysulfone in terms of surface morphology and electrochemical evaluation of mass transport properties to the thin film hydrogel surface in a three-electrode arrangement. All hydrogel materials showed very good sensitivity and linear response to tannic acid and alginic acid at micro-molar concentrations. Overall the project has been successful in achieving all its objectives for materials design, development and testing at a laboratory scale.

Cost: R1 235 000 Term: 2010–2014

Characterization of indigenous anaerobic ammonium oxidizing (anammox) bacteria grown in anaerobic environments

University of Pretoria

No. 2117

In this study, a process for the start-up and enrichment of anammox bacteria from wastewater treatment was developed and tested in laboratory batch reactors. The anammox cultures were enriched from three sludge sources from treatment plants around Pretoria. Identification of anammox bacteria in batch reactors was done by PCR analysis. These results showed that anammox bacteria are ubiquitous in wastewater treatment plants in South Africa. The detected anammox bacteria belonged to the *Brocadia* species (fulgida and anammoxidans).A sequencing batch reactor (SBR) was set up and operated for the removal of nitrogen compounds in wastewater. Samples of biomass from successfully enriched cultures were used as inoculum for the SBR. The systems worked effectively, achieving a nitrite removal rate of 97%. Samples of biomass obtained from the SBR were analysed for identification of the main bacterial populations present in the reactor. Next-generation sequencing (NGS) was used for identification of bacterial population. The reactor was found to be dominated by different *Bacillus* species with abundance of 84%. Although the reason for the over-abundance of these bacterial species is not clear, it could be associated with the nature of the bacteria of being very resistant and able to survive in most environmental conditions. Additionally, their involvement in the nitrogen assimilation process could also explain their over-abundance in the reactor. However, a total of 5%

anammox and planctomycetes bacteria was also seen in the reactor. *Nitrosomonas* species which are known ammonia oxidizers were also present in the reactor though in very small amounts (0.2%).

Cost: R460 400 Term: 2012–2015

Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems

CSIR; Tshwane University of Technology; University of Johannesburg

No. 2122

Among the increasing emerging contaminants into wastewater are engineered nanoparticles or materials (ENPs/ENM's) corresponding to the dramatic introduction of nanomaterials in consumer products and industrial applications. Yet, the impacts of these contaminants, including metal oxide ENPs, on the treatment efficiency of WWTPs are largely non-quantified. In addition, the fate and behaviour of ENPs from influent point to the effluent discharge point is poorly established. This study looked at two aspects: the removal mechanisms of ZnO in a pilot wastewater treatment plant; the effect of nanomaterials on bacteria found in wastewater systems.

The study focused on evaluating the release of zinc into wastewater as pH and ionic strength are varied, and the consequent interactions of ions and ENMs with sludge. The release of zinc from ZnO ENMs in wastewater was found to be more significant under acidic conditions (low pH) and low ionic strength. However, the release of zinc from ZnO ENMs in wastewater was lower in comparison to deionised water where the biomass present in wastewater played a role in the removal of dissolved Zn. Under the alkaline conditions, a large percentage of the ENMs showed strong affinity to the sewage sludge. The deposition of ENMs on sludge suggests their removal by biosorption and biosolid settling mechanisms. Therefore, in typical wastewater treatment systems, they are likely to be introduced into the environment through the use of sludge for agricultural purposes and possible release as fly ash in cases where the sludge is incinerated. Toxicity of commercial ENMs towards demonstrated pH-dependence. Exposure of target bacteria and protozoans to NMs results in cell growth reduction, which progressively led to cell inhibition. The toxicity effects of the target ENMs towards wastewater bacterial and protozoan populations may diminish the performance of biological treatment processes and affect the efficiency of wastewater treatment plants in producing effluent of high quality. Further work is required to elucidate the accumulation of ENMs on biofilms and their long-term effect.

Cost: R680 000 Term: 2012–2015

Development and testing of timber frame pour flush sanitation blocks for use in schools and informal settlements

Partners in Development (Pty) Ltd; Department of Water and Sanitation

No. 2407

Two of the most critical sanitation needs in South Africa are those in schools and in informal settlements. At many schools, particularly rural schools, the quality of the sanitation is dismal and even unsafe and unhealthy. Many informal settlements have no sanitation provision at all. Thus the objective of this initiative was to develop and test a timber-frame pour-flush sanitation design for use in schools. The combination of pour-flush with timber frame has been proven to be a very appropriate solution for use in schools. The initiative has indicated the opportunity and potential for extensive application in informal settlements, where authorities are opposed to sanitation solutions which involve brick and mortar.

Cost: R1 430 000 Term: 2014

Programme 2: Application of appropriate technologies and tools

Ultra-sensitive electrochemical nanobiosensor array devices for real-time determination of estrogenic endocrine disruptors in municipal wastewater (ENDOTEK)

University of the Western Cape; City of Cape Town

No. 1999

The ENDOTEK project focused on the development of biosensor methodology for real-time determination of low levels of oestrogens in municipal wastewater effluents, with particular emphasis on 17beta-estradiol as a model e-EDC. An electrochemical DNA aptasensor for the determination of 17βestradiol (E2) was fabricated with a 76-mer biotinylated DNA aptamer. The response dynamics of the sensor involved the attenuation of the square wave voltammetric current as E2 binds to the ssDNA aptamer component of the biosensor were recorded. The aptasensor was very selective and reproducible for E2. The dynamic linear range (DLR) of the sensor for E2 was 8.17 – 307

pg/mL and the limit of detection (LOD) of 0.043 g/mL. The response parameters of the sensor showed that it was more sensitive than most other techniques, including dissociation enhanced lanthanide fluorescence immunoassay (DELFIA), enzyme-linked immunosorbent assay (ELISA), electrocatalytic detection at carbon nanotube/Nicyclam composite electrode, GC/MS method and bis (trimethylsilyl)trifluoroacetamide derivatisation method. In addition, the aptameric sensor technology can be adapted to develop sensor systems for other types of water pollutants including cyanotoxins. The ENDOTEK project demonstrates the suitability of aptamers as the biological sensing element or bioprobe in sensor development. The DNA aptamer was found to be superior over enzymes and antibodies since they are inherently more environmentally stable. It will therefore be possible to produce biosensor systems that have longer shelf life with DNA aptamers. In its present form, the project and its findings represent a proof of concept. Further work is required in development of sensor devices that will integrate the mechanics, electronics and electrochemical microfluidics reactor cell with the electrochemical signal transduction microchip. Further work is also required to develop new aptameric biosensors for other e-EDCs, including 17alpha-ethynylestradiol, estriol and estrone, as well as a combinatorial aptamer biosensor that will be used for the determination of the total e-EDC content of a water sample.

Cost: R1 665 000 Term: 2009–2014

Self-regulation of the package plants/SWWTW industry: Development of framework of standards, a conceptual model for a test facility and an accreditation system for each technology provided by suppliers

SSI

No. 2193

Small wastewater treatment plants (inclusive of package plants) are a common form of service utility in sewage treatment for smaller communities and are needed where sewerage reticulation is absent due to inadequate space, difficult terrain, and remoteness of areas in need, and where standards set are higher than the effluent quality obtained from simple septic tank systems. The SWWTW industry in South Africa has grown rapidly from a small base and is currently unregulated in terms of process design, construction materials, etc. This report provides an introduction to the frameworks of standards which could be adapted for use in South Africa, and discusses their strengths and weaknesses, together with the feasibility of scaling them up for use on larger works. It draws from current industry know-how as well as Australian, European and the United States NSF standards. It examines the current South African legislative standards for discharge of treated effluent to the environment, together with the corresponding monitoring requirements. It further examines the current General Authorisation Discharge Requirements, and makes strong recommendations with respect to:

- The quality of water to be used for lawn irrigation
- The issue of satisfactory compliance which needs to properly defined, including the method of calculation and the percentage compliance

A categorization framework for SWWTW sizes was discussed and a three-tier system recommended after consultation with the industry body SEWPACKSA and the WISA SWWTW Division. Furthermore, a proposed SWWTW Treatment Efficiency Testing Standard was formulated inclusive of proposed process design standards. Volume 2 of this report examines the development of the Green Droplet System for Small Wastewater Treatment Works (SWWTW).

Cost: R800 000 Term: 2012–2014

Development of web-enabled (and supportive spreadsheet-based) wastewater risk abatement planning tools

Emanti Management (Pty) Ltd; Water Group Holdings (Pty) Ltd

No. 2217

The objective of this project was to develop a web-enabled and a spreadsheet-based wastewater risk abatement tool for the sector. The principles and approach outlined in the WRC-developed W2RAP guideline document were used to produce the following outputs:

- Wastewater Risk Abatement Plan Tool – web-based and supportive spreadsheet-based tools, and allows development and tracking of a W2RAP and could include sections such as: (1) Formulate the W2RAP team, (2) Describe the system (collection, treatment, fate of effluent and sludge), (3) Assess/evaluate the wastewater system, (4) Hazard/risk assessment, (5) Identify control measures and associated corrective actions, responsibilities, timeframes, and costs (for subsequent W2RAP implementation)

- Wastewater Risk Abatement Planning Status Checklist Tool – web-based and supportive spreadsheet-based tools, and allows the user to determine status of W2RAP processes:. Where are we? What have we completed? What must we still do?)

Web-based reporting systems and automatically-generated risk assessment reports offer cost saving, time saving, reliability advantages and the potential for enhanced management oversight. A key benefit of the approach is also the development of a national database of wastewater hazardous events; therefore WSIs have access to a supported database where their peers and dedicated professionals share common experiences and challenges, resulting in a more appropriate, and therefore more widely accepted and used tool.

Cost: R510 000 Term: 2013–2015

Best practice in wastewater treatment in small- to medium-sized municipalities in South Africa – roadmaps to Green Drop excellence

Water Group Holdings (Pty) Ltd; Sarah Slabbert and Associates
No. 2304

The WRC has supported and provided strategic and operational guidance towards the formulation of the WIN-SA Green Drop Lesson Series since 2010. At the onset of the Green Drop programme it was decided that while the sector was reading about many examples of poor wastewater management, there were champions in smaller and less-resourced municipalities that were doing really well and striving to make a difference. It was therefore, important to give these individuals and their municipalities a chance to describe how they were making a difference in the sector and striving for excellence. The aim was to ensure that these individuals become champions for the sector and therefore build communities of practice, and that the recognition would be an enabler towards sustainable wastewater services. This would then stimulate learning and sharing around issues and challenges, thereby supporting creative solutions. The Lessons are supported by ancillary learning opportunities built into the contracts facilitated by WIN-SA through the researchers in order to strengthen people-to-people learning. In light of the success of the first two Lessons in this series, two additional Green Drop Lessons were completed in 2014:

- Kruger National Park chooses green technology to achieve a Green Drop
- Eastern Cape Wastewater Services : From bottom rung on the Green Drop ladder to good performance\

Cost: R500 000 Term: 2013–2014

Programme 3: Stormwater and sewerage systems

Pressure drop prediction for efficient sludge pipeline design

Cape Peninsula University of Technology
No. 2216

The measurement of the flow behaviour of non-Newtonian fluids such as sludge, also called rheology, is not a simple matter. Wastewater treatment sludges due to their non-Newtonian behaviour do not have a simple constant viscosity and therefore require more complex modelling. This has been researched world-wide but because the properties of sludges vary so much from plant to plant, there have not been much success in presenting pressure-loss predictions. This study set out to measure the pressure drop versus flow rate in the wastewater plants in existing pipes, as well as the concentration of the sludges, to independently test the design protocol developed. The study found that the rheological properties of 21 sludges from 6 WWTP's in the Western Cape ranged in solids concentration between 2% and 7.8%. Most tests were done in tube viscometers which are really small pipelines. The sludges tested comprised of primary and secondary as well as filter bed sludge.

Cost: R224 000 Term: 2013–2014

Programme 4: Wastewater sludge and faecal sludge management

Quantifying the fertilizer value of municipal sludges for agriculture

University of Pretoria; ERWAT
No. 2131

Beneficial use of treated municipal sludge in agricultural lands is a well-known practice around the world, because of its soil-conditioning effect and as a source of low-grade fertilizer. Municipal sludge contains appreciable amounts of N and P. In addition, it is a good source of Ca and Mg and essential plant micro-nutrients, including Zn, Fe, Cu, Mo, Mn, and B. Beneficial agricultural use of sludge accounts for 28% of the total sludge produced from South African

wastewater treatment plants. In order to accommodate the complex interactions between sludge, soil, climate and cropping systems, a mechanistic N and P balance cropping systems model (SWB-Sci) model was developed as a reasoning support tool. This model is a fairly complex scientific research tool and requires detailed weather, soil, crop, and sludge parameters. Due to its complexity, routine use of this reasoning support tool by industry or extension officers in its current form is highly unlikely.

The key findings of the study were:

- Simple user-friendly database model development
- Characterization of sludge N and P pools
- Simple heavy metal mass balance development

Cost: R2 100 000 Term: 2012–2015

Programme 5: Sanitation technology and innovations

Eastern Cape school sanitation – pour-flush pilot

Maluti GSM

No. 2406

This study stemmed from support from the Department of Science and Technology under its ASEDE programme, to demonstrate the WRC-developed pour-flush latrine technology as an option for rural school sanitation. The study was initiated with the understanding of typical costs associated with household pour-flush toilets. The standard school toilet design issued by the Department of Education was used to call for quotes from contractors for the toilet buildings. To the project team's amazement, the quotes received were way beyond budgets and benchmarks. Thus, under this pressure the research team set about researching more cost-effective ways to reduce the cost and the delivery time of the school toilets. The option considered was prefabrication panels. Working with manufacturer CEMFORCE, a single demo unit was installed at Arthur Mfebe High School, Cofimvaba. This was very well received by the teaching staff and matric students, as a huge improvement over pit toilets. A standard building unit comprising of 4 girls' toilets and two boys' toilets with urinals, using prefab glass-fibre panels was constructed. The achievement was that the team was able to deliver, construct and install these units in a period of two weeks. The capital cost achieved was around R220 000. Further design options were considered to lower cost even further. The outcome was that at the additional two schools completed the team was able to reduce the cost to R140000. Thus this project has offered three key outcomes: three schools were serviced by the use of pour-flush technology (Arthur Mfebe, St Marks and Zamuxolo), three new design options using new materials and techniques were developed for use in school sanitation, and the time and costs associated with school sanitation have been significantly reduced, especially where anticipated costs were initially around R1 million and 6 months of construction time.

Cost: R671 500 Term: 2014–2015

Investigation into risks of exposure of workers and households to pathogens through current desludging practices and development of guidelines to minimise risks

Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Howard College Campus); University of KwaZulu-Natal (Westville Campus); eThekwini Municipality

No. 2134

This project evaluated the exposure of pit workers, the public and the environment during pit-emptying programmes. The study revealed that the pit-emptying programmes used by the contractors resulted in exposure of the workers, the public and the environment to pathogens. The safety of the workers, public and the environment could be improved by greater enforcement of health and safety protocols, and a training manual for pit workers on disease transmission, hygiene and work practices.

Cost: R1 200 000 Term: 2012–2015

Characterisation of on-site sanitation material and products: VIP latrines and pour-flush toilets

University of Kwazulu-Natal (Westville Campus); eThekwini Municipality; Partners in Development (Pty) Ltd

No. 2137

This research provided an understanding of two emerging waste streams that are expected to be important in the future. These are (i) the characterisation of the nature and transformation processes of ultra low water consuming pedestal type pour-flush toilets, and (ii) the further development of the LaDePa process for transforming VIP sludge into sterile pellets which may be suitable for horticulture. The results from the pour-flush latrine sludge characterisation study

revealed the chemical composition of the sludge to be similar to that of VIP latrines. However, physically, the pour-flush sludge is more homogeneous with small amounts of non-faecal material in the pits. This means filling rates are slower as there is less non-degradable material in the sludge. Also, mechanical pit emptying is easier (provided the sludge is wet enough) without the presence of non-faecal material, which is often the cause of blockage or damage of pit-emptying equipment. For the LaDePa study, a laboratory-scale prototype was installed in the Pollution Research Group (PRG) laboratory, University of KwaZulu-Natal, Durban. The performance of the prototype was assessed by evaluating drying rates at different heating intensities, residence times and pellet sizes. At high MIR emitter intensity (temperature measured superior to 200°C), the drying and pasteurization is faster, but there is a considerable risk of undesirable thermal degradation and burning of the pellets while drying. At medium MIR emitter intensity (temperatures measured around 150°C), the risk of thermal degradation is avoided but the drying and pasteurization takes longer. Under these conditions, around 20 minutes of residence time is necessary to reduce the moisture content to 20% and to ensure complete pasteurization. At low MIR emitter conditions (temperatures measured inferior to 100°C), pasteurization can be achieved before 20 minutes of residence time but drying is too slow. The research team passed on some of the experimental results the developers of the technology; plans are underway to re-configure the process to make it more efficient.

Cost: R1 281 500 Term: 2012–2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Industrial brine minimization: determining the physical–chemical parameters that affect evaporation rates on multi-component hyper-saline effluents

University of the Western Cape; University of KwaZulu-Natal (Pietermaritzburg); Wroclaw University of Technology; University of Venda; CSIR

No. 2100

This report has summarised the issues relating to industrial brine generation and disposal in South Africa and has reviewed the literature on brines with particular emphasis on the water treatment processes that produce brines as a waste, the chemistry of brines and the factors which influence evaporation and determine brine evolution. The present study focused on the brine produced at the eMalahleni water treatment plant. Analysis of the Stage 3 reject brine collected from the plant revealed that it is a Na-SO_4 type water although it does contain significant concentrations of other major ions, namely Ca, Mg, K and Cl. Seventy-one per cent of the cation molar charge is accounted for by Na^+, and the remainder by Ca^{2+} (15%) K^+ (9%) and Mg^{2+} (4%). In the case of anion charge, SO_4^{2-} accounts for 88% and Cl^- (10%) and HCO^{3-} (1%) for the remainder. The brine has a near-neutral pH. Small-scale evaporation experiments confirmed that an effect of salt type (single, binary and ternary solutions of Na_2SO_4, NaCl, KCl, $CaSO_4$, and $MgSO_4$ were studied) was sometimes discernible but not statistically significant, probably in part because while the effect of salt is generally to reduce evaporation the presence of salt also gives rise to greater heating of the solution by absorbing radiant energy. There also seemed to be a solution heating effect leading to a higher evaporation rate (again not significant) in the case of those solutions dominated by divalent as opposed to monovalent cations. Despite these uncertainties the overall effect of salts on evaporation rate was confirmed in both the small-scale study as well as the subsequent pilot-scale study to be essentially one of concentration, inhibiting evaporation as expected. The novel high surface area materials developed, namely composite nanofibres comprised of PAN loaded with Zeolite Y nanoparticulates, were shown to significantly remove divalent cations from model brine solutions, allowing for brine simplification. The PAN TiO_2 nanofibres showed a high Na cation adsorption. This study has been concluded successfully in terms of construction and testing to demonstrate a sensitive response of evaporation to parameters such as salt concentration, wind and irradiance. It also points to the greater potential of generating products of value from the brine.

Cost: R1 500 000 Term: 2011–2014

Application of mineral carbonation processes for brine remediation

University of the Western Cape; University of Venda; Council for Geoscience

No. 2128

Co-disposal of brine wastes with fly-ash is favoured by coal-fired power stations in South Africa but questions remain about the salt/ash/water balance and leaching potential to surface and underground water sources. The potential to recover and reuse the process water after the carbonation treatment was studied by performing detailed chemical analysis of all process waters and doing comparisons of the waters before and after treatment, to determine if treatment is successful and what further treatment to potable standards may be desirable. This report presents a comparative study of the natural carbon sink potential of the fly ash dams, versus optimised accelerated ex-situ mineral carbonation of FA/brine as well as the CO_2 adsorption capacity of hydrotalcite (HT) minerals and zeolites synthesised from made from fly ash (FA). The zeolites and hydrotalcites made from the waste fly ash are also shown to have significant carbon capture potential. Ex-situ carbonation of fly ash via accelerated optimised mineral carbonation is shown to be a potent brine remediation process, with the resulting brine being cleaner with respect to major, minor and trace elements, and the contaminants being bound as mineral carbonates in the fly ash such as calcite, aragonite and dolomite. However, after removal of brine contaminants from brine with fly ash and CO_2, carbonation solids should be stored away from water and potential acidity as this may lead to dissolution of the neoformed carbonates and release of captured CO_2.

Cost: R1 362 750 Term: 2012–2015

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

Long-term forecasts of water usage for electricity generation: South Africa 2030

Quantitative Evidence Research Consultancy Services cc; University of Pretoria

No. 2383

This research aimed to (i) forecast water usage patterns associated with coal-based electricity generation, both in L/kWh and total water consumption (in megalitres), (ii) assess scenarios of water usage patterns based on cooling technology and power plant type, and (iii) propose projected water-saving measures within distressed water management areas. The methodology used was built on work done by the National Energy Technology Laboratory, USA. The guideline study estimates water usage based on water withdrawal and consumption factors. The mathematical technique used to forecast total water consumption and water consumption factors is based on a long-term moving average approach. Historical data of South African power plants was supplied by Eskom from archival records. The investigation derived six key findings:

- Water consumption factor forecasts of dry-cooled power plants (ranging from 0.1 L/kWh to 0.15 L/kWh) are expected to be one order of a magnitude lower than wet-cooled power plants (ranging from 2.2 L/kWh to 2.4 L/kWh)
- Water consumption factor for the return to service (RTS) fleet (used during peak demand) is expected to reach 3 L/kWh by the year 2020
- Water requirements are expected to increase from roughly 360 gigalitres now to just above 370 gigalitres in 2021
- Depending on the retirement of the RTS fleet, total water requirements could be reduced (by 12% to 15%) to 320 gigalitres
- RTS power plants are located within water-constrained water management areas Olifants and Inkomati
- Based on the projection the total base-load water consumption will increase from 332 gigalitres in 2013 to roughly 370.5 gigalitres during 2035

These six findings are based on a forecast electricity output from the coal power plant fleet of 260 TWh by the year 2035, and on an expected installed capacity of 36 900 MW being operated at 80% capacity. Gradual retirement of the RTS fleet could result in savings of 15% of the forecast shortfall of 234 gigalitres by the year 2025. The deficit in electricity generation output caused by the retirement of the RTS fleet will have to be compensated by the simultaneous commissioning and operation of new build power plants.

Cost: R306 000 Term: 2014–2015

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

Adapting constructed wetlands for real-world applications

Cape Peninsula University of Technology; University of the Western Cape; University of Pretoria

No. 2104

This project built on the experience gained from K5/1936 and focused on the treatment of winery effluent, which is a critical to the wine industry in the Cape, through the use of wetlands. Based on the realisation that several of the natural wetlands treating winery effluent do not support plants/vegetation, it was decided to exclude plants from the systems because of the cumulative phytotoxic nature of the phenolics and salts found in winery wastewater. The term used for the wetlands in this project was biological sand filters. After running several unplanted constructed wetlands (BSF) for 3 years the following conclusions were reached:

- Reproducibility between replicates containing the same batch of sand was good, but the magnitude of differences were enough to warrant the use of duplicate systems for future studies.
- Phillipi sand is a good candidate for use in biological sand filters treating winery wastewater from small cellars in the Cape Town environment.
- To optimize organic removal, including removal of acetate, it is recommended that winery wastewater is subjected to alternating redox environments. A polishing aeration step using gravity-fed trickling filters provides a simple, low-cost, low-energy example of how this may be achieved.
- Degradation gradients caused by plug flow of influent ensure that the most 'treated' wastewater exits the biological sand filters first. If a polishing step to remove acetate is incorporated, a nominal hydraulic retention time of 2 hours may be sufficient.
- The results showed that trickling filters may indeed present a feasible option to 'polish' wastewater containing short-chain volatile fatty acids. Currently, experimental columns have been filled with either aggregate, clay balls or open-cell polyurethane foam, in an effort to determine which of these substrates would be best for acetate removal.
- Finally, it was concluded that biological sand filters (unplanted CW's) are promising systems for the treatment of winery wastewater with variable qualitative and quantitative flows

Cost: R1 100 000 Term: 2011–2015

Integrated photo-catalytic and anaerobic treatment of industrial wastewater for biogas production
Vaal University of Technology; Tshwane University of Technology
No. 2105

The aim of the project was to analyse the performance of the AD and AOP systems separately in degrading high-strength wastes and to develop an integrated AD-AOP system to improve biogas production rate and methane yield. The treatment of high-strength wastes such as molasses, textile, heavy metals and pharmaceuticals was investigated under different experimental conditions. An Integrated AD and AOP using South African zeolite was applied in the treatment of methylene blue dye in an up-flow fixed bed bioreactor and UV photoreactor. The optimal operating conditions obtained in the separate AOP and AD were applied. Results showed that, compared to the separate systems, the integrated AOP-AD system achieved better degradation with colour and COD reductions of 81% and 80%, respectively. Moreover, it was found that UV photodegradation pre-treatment improved the biodegradability of the MB dye 3-fold after an irradiation time of 60 minutes. Thus integration of the two processes in such a way that UV photodegradation precedes the AD process led to higher biogas production than that of the stand-alone AD process.

Cost: R700 000 Term: 2011–2014

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Toxicity evaluation of metal and metal oxide nanoparticles to aquatic invertebrates and algae
CSIR; Stellenbosch University; University of Pretoria
No. 2107

Growth in the production and use of engineered nanomaterials (ENMs) has raised concerns with regard to their potential impact on the environment, and aquatic media in particular. This project investigated the potential impact of ENMs on aquatic invertebrates using both experimental approaches (bioassays) and modelling methods. Extensive data cleaning, variable consolidation and dealing with missing variables or data were required to establish the databases from publically available scientific reports. With the neural network models, data from different sources could be combined to generalize the behaviour and toxicity of $nTiO_2$ using reported scientific data. This facilitated the identification

of complex relationships involving many variables that would otherwise not have been possible with deterministic models. In principle, the models could be applied to pilot-scale or full-scale scenarios, e.g. water bodies, to predict response patterns without requiring extensive analytical work. Output from the regression models derived from laboratory data provides generic first-tier risk assessment. Finally, the neural network models could be integrated as management tools to predict the dynamics of $nTiO_2$ after release into aquatic systems and interrogation of the models could be used to explain the effects of the $nTiO_2$ on the environment. For example, adsorption and aggregation processes may have both negative and positive impacts on aquatic systems. An understanding of the aftermath, e.g., enhanced flocculation and removal, deposition, accumulation, etc., may influence mitigation planning. The model is flexible and can be improved by adapting it to new data to generalize risk-based outcomes in diverse aquatic systems, as and when new data are obtained.

Cost: R495 000 Term: 2011–2015

Feasibility study on the use of irrigation as part of a long-term neutralised acid mine drainage management strategy in the Vaal Basin

University of Pretoria
No. 2233

Protecting the environment from contaminated mine water decanting in increasing volumes from the goldfields presents an enormous challenge, probably greater than that of coal-mine water because the decant points are in urban areas. The main limitation of the water is an undesirable concentration of sulphate salts and metals, chiefly iron, and to a lesser extent manganese, aluminium and various trace elements. This project addressed some of the possibilities of irrigating land and producing crops with the mine-water, primarily after it has been neutralised with lime but also as a form of land treatment in which the raw mine-water is applied to soils or mine tailings that have been preconditioned with slaked lime or limestone to achieve in-situ neutralisation and sequestration of many of the contaminants. Supplementary treatments were also explored using aluminium sulphate and locally-mined ferromanganese wad, currently used for uranium recovery in the gold mines. The project found it highly probable that goldfield mine-water can be used cost-effectively to irrigate vegetation on mine tailings or salt-tolerant crops such as wheat or soybean on agricultural land. Clay soils and mine tailings have further capacity to retain many of the other salts present in the water. Results from this study indicate that 75–90% of salts can be removed when raw mine water is applied to mine tailings or clay soils. The use of aluminium sulphate – which works synergistically with lime – as part of the pre-treatment process potentially has several benefits, including smaller, more economical treatment plants. Reverse osmosis has been proposed for treating mine water in the Vaal Basin but is expensive, energy intensive and, like other processes, leaves a saline residue which requires disposal. By contrast, irrigating with chemically treated water will enable its immediate productive use. A Life Cycle Assessment comparing conventional reverse osmosis with the irrigation option together with reverse osmosis of the smaller volumes of irrigation return flows demonstrated significantly lower impacts for the latter option for global warming potential, non-renewable resource (fossil fuel) depletion and acidification potential. Following these positive results further research has been recommended, including the establishment of a pilot plant irrigating with actual purpose-treated mine water, exploring optimal geo-hydrological settings for land/irrigation treatment schemes and a thorough cost comparison with the conventional reverse osmosis option. The favourable implementation of this technology can have far-reaching consequences, not only in the Witwatersrand goldfields, but also the Mpumalanga coalfields and many other regions around the world with a legacy of intensive mining.

Cost: R600 000 Term: 2013–2015

Programme 2: Regulatory, management and institutional arrangements

Development of risk criteria for water management aspects of mine closure

Golder Associates Africa; Department of Water and Sanitation
No. 2127

A stalemate situation currently exists, in which mines are unable to obtain mine closure certificates because of perceived unmanageable post-closure risks to the water resource. This is a complex problem with causative factors originating from both the mining industry and the regulator. While it seems intuitively correct for

regulators and potentially impacted stakeholders to insist that mine closure should not be approved unless it can be demonstrated that there is zero risk that there will be long-term residual impacts on the water resource, this logic is flawed because zero risk can never be demonstrated and proved in advance. In consequence, mine owners are convinced that mine closure will never be approved no matter what measures they implement, so the perceived best course of action has become to do the minimum, and wait. The result is a catastrophic situation: mine owners do not develop and submit rigorous closure plans with regard to water management issues, where regulators do not approve mine closure plans, and mines that have ceased operations only implement minimum-level care and maintenance measures until such time as financial resources are exhausted and the mine reverts to an abandoned and ownerless status. This study has produced a guidance document defining the technical aspects and procedures that need to be followed in order for mines to be able to manage and minimise their long-term risks and liabilities and to provide the regulator with the requisite information to be able to review and approve a post-closure water management plan. The risk criteria are aligned with the revised GN704 regulations and were developed based on extensive stakeholder engagement with the DWS Best Practice Guideline G4:Impact Prediction (BPG G4) and Best Practice Guideline G5: Water Management Aspects for Mine Closure (BPG G5), international practice, and the application of sound scientific principles. By following the processes and methodology described in this report and the BPGs G4 and G5, the mine will have undertaken the appropriate risk management process to understand, manage and minimise its long-term exposure to risk and liability associated with post-closure water impacts. If the questions defined in this guidance document are answered using the methodology set out in the relevant BPGs then there is no technical or scientific reason for the regulator to not approve the post-closure water management plan at the end of mine life.

Cost: R535 000 Term: 2012–2015

Programme 3: Minimising waste production

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation

University of Cape Town; Walter Sisulu University

No. 2108

The purpose of this research was to further the understanding of metal sulphide precipitation in the treatment of acid mine drainage and metal ion impregnated industrial wastewater. During the process of metal sulphide precipitation the physicochemical properties of the precipitant material had a significant effect on the overall viability of the metal removal process. The aim of the work was to ascertain the conditions necessary for optimal metal ion removal. The work showed that metal sulphide precipitation has shown potential as a method for the removal of metals from industrial pollutant streams. Although its relatively low-solubility products and fast-reaction kinetics mean that the process has a number of challenges, it is still a superior choice to that of metal hydroxide precipitation. The findings of the work were, firstly, that metal sulphide particles obey the DLVO theory. However, the reported threshold value for the promotion of aggregation of about -38 mV is difficult to achieve under viable operational conditions. The pH during precipitation either has to be very high, resulting in the need for a high dosage of pH modifiers, or the colloidal suspension has to be treated with significant amounts of coagulants. This reduces the viability of sulphide precipitation as a precipitation method. This work has also shown that other mechanisms of inducing settling, such as partial oxidation of precipitant material, are effective, but only in synthetic mono-component streams. The consequence of using such a technique for typical industrial multicomponent streams and acid mine drainage is that altering the solution redox not only affects the target material, but may induce catalytic reactions that may transform the precipitant material into an undesired product. Further studies with multicomponent systems would be required. The last major finding of this work is that using FeS as a slow sulphide release source for the precipitation of lower solubility product metal sulphides suffers from limitations that render it not viable for industrial use. The encapsulation of FeS by ZnS that was observed in the current process inhibited further dissolution of the sulphide source, thus stopping the precipitation process.

Cost: R1 211 320 Term: 2011–2014

Development of a toolkit to enable quantitative microbial ecology studies of sulphate reducing and sulphide oxidising systems

University of Cape Town; Bangor University; Golder Associates Africa

No. 2109

Treatment systems for acid mine/rock drainage based on biological sulphate reduction offer an alternative to conventional physical and chemical processes. Stable performance of sulphate-reducing systems depends on the maintenance of a stable, robust microbial community. The development of tools to rapidly assess the structure of sulphate-reducing communities would be valuable in the management of such remediation systems. The aims of the project were achieved to varying degrees of success. Comprehensive clone libraries were constructed to reflect the diversity in both the sulphate-reducing and sulphide-oxidising systems. The libraries represent a useful repository of data for ongoing development. The development of specific tools to quantify individual species within the mixed community was less successful, although success was achieved in quantifying total sulphate reducers and members of the *Desulfomicrobium*. Valuable lessons have been learned with regard to probe and primer design and progress toward achieving all the goals is continuing. Other significant conclusions are:

- FISH probes and qPCR primer sets to quantify total sulphate-reducing bacteria and the *Desulfomicrobium* group have been designed and tested.
- The qPCR primer sets have been used to illustrate changes in the relative proportion of sulphate reducing to non-sulphate reducing bacteria in stirred tank reactors, as a function of reducing hydraulic residence time.

Cost: R487 500 Term: 2011–2014

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; Metago Environmental Engineers (Pty) Ltd

No. 2110

Biological treatment of acid rock drainage (ARD) is centred on the activity of sulphate-reducing bacteria (SRB), which reduce sulphate to sulphide, coupled to the oxidation of an electron donor, typically an organic carbon molecule. Commercial processes based on biological sulphate reduction have been constrained by the cost of the electron donor, the relatively slow growth of sulphate reducers and the associated kinetic constraints, and the management of the sulphide product. This report addresses the first two constraints by assessing the potential of whole and partially digested microalgae as the electron donor and investigating novel reactor configurations aimed at biomass retention and recycling. The most important conclusions that can be drawn from the research are:

- While the CSTR with suspended culture is a useful research tool to provide excellent kinetic data, operating conditions are constrained by the maximum specific growth rate of the community members and washout occurs when the dilution rate exceeds this. This may be overcome by retaining or recycling biomass.
- Biomass retention, by attachment to carbon microfibres, or recycling, using the cross-flow microfiltration system, resulted in significantly higher volumetric sulphate reduction rates at low (12 h) HRT. The maximum values, 47.5 and 65 mg/L·h respectively, were 20% and 50% higher than that achieved in a CSTR with no biomass retention.
- The LFCR required no mixing or external energy input and is suitable for incorporation into a passive or semi-passive treatment system. The development of a floating sulphur biofilm at the air-water interface suggests the reactor could be optimised to integrate sulphate reduction and partial sulphide oxidation into a single unit.
- The effluent from the anaerobic digestion of microalgae contained sufficient residual COD, primarily in the form of acetate and butyrate, to sustain efficient sulphate reduction. Blending the digestate and simulated AMD to maintain the desired COD to sulphate ratio of 0.7 resulted in sulphate reduction efficiencies similar to those achieved using defined media. In addition, the absence of fermentable fatty acids, such as lactate, in the digestate eliminated the competition for substrate observed when lactate was used as the electron donor.
- Decoupling the algal hydrolysis and acidogenesis stage from the sulphate reduction allowed a degree of control over the composition of the feed to the sulphate reducing reactor. In these systems an increased efficiency in sulphate reduction was observed.
- Mechanical pre-treatment to rupture the algal cells enhanced the hydrolysis and acidogenesis during anaerobic digestion of biomass with cellulosic cell walls, but was not necessary in the case of *Spirulina*.
- It was possible to cultivate certain algal species on simulated AMD that had been through the biological treatment process. The productivities were lower than on defined media, but could be improved by blending the effluent with fresh water or nutrient supplementation.

Cost: R1 070 000 Term: 2011–2014

A detailed acid-base accounting study of the Karoo formations in the Waterberg coalfield

University of the Free State (IGS)
No. 2142

The large resource base coal zones of the Waterberg Coalfield, located in the Limpopo Province, will enable the mining of coal in this area which will continue into the future. As the demand for energy in South Africa increases in the coming years, the coal produced from this area will prove essential. The main aim of the study was to identify the potential of acid generation from the overburden, interburden and plant discard that will be removed and placed on the discard dumps, and possibly used as backfill material. Acid Base Accounting (ABA) is used as a prediction tool to determine the acid potential of the lithological units. The ABA analyses of overburden indicated a dominantly neutralising potential, as well as an acidic potential for the shale units on top of the coal. The samples indicated non-acid producing potentials and some with neutralising potentials. The cumulative mass of sulphate produced, indicated that the overburden samples do not continue to produce sulphate, but rather reach a constant rate where sulphide is produced. During the kinetic tests, the results for calcium and alkalinity were relatively high. The relatively low calcium values indicate that carbonates are immediately available and demonstrate the balance between the released alkalinity and the acidity generated. If the balance between the alkalinity and the acidity stays positive, the system will not acidify. The interburden contained both acidic and neutralising potentials. Mudstone, shale and calcrete layers indicated a neutralising potential, while sandstone had a relatively high acid-generating potential. With prolonged exposure the system would acidify as sulphate is released into the system. Calcium and alkalinity results showed high calcium values, with relatively low alkalinity for the interburden. The high calcium values indicate the availability of carbonates; whereas in this case the carbonates are not immediately available. The plant discards consist of unwanted material that remains after coal separation, also known as composite samples. The different density composite samples were analysed and indicated that they all have a high potential to produce acid. The report presents management options for overburden, interburden, ash, spoils, and plant discards.

Cost: R1 775 000 Term: 2012–2014

THRUST 6: WATERSMART FUND

Programme 1: Watersmart Fund

Amanzi Quiz

Overstrand Conservation Foundation
No. 2290

The objective of the project was to stimulate children to learn spontaneously about the value, sources, conservation and sustainable use of water resources, as well as threats to water security, by developing an Amanzi (water) resource library and a quiz that runs on computers and cell phones accessible to learners. The project has resulted in a web based education quiz called AmanziQuiz available at: http://www.whalecoastconservation.org.za/news/31/17/Amanzi_Quiz. Amongst the strengths of the Amanzi Library and Quiz system is the alignment of its Library and Quiz questions with the National Curriculum Assessment and Policy Statement (CAPS) for water topics required by the CAPS in all learning streams from grade R to grade 12. Another key strength is that educators adopting the system as a learning aid can present lessons directly from the Library content and test that learning has occurred by utilising the quiz system to get an instant report on how well learners have understood the topic and what aspects may require revisiting with the learners.

Cost: R500 000 Term: 2013–2014

Water wise hotels

Jeffares & Green (Pty) Ltd
No. 2292

The AquaSmart Hotels tool was developed to create awareness regarding water conservation within the hospitality industry by assisting members and owners of hotels, lodges, B&Bs, etc., to determine where and how water is being used within their establishment and providing alternative options which could reduce their water consumption. The AquaSmart Hotels tool consists of two Microsoft Excel workbooks. The first workbook is the tool and the second workbook is a database where water consumption information for the hotel can be stored. This guide provides detailed instructions on how to use the tool and database as well as general information on water conservation within the hospitality industry.

Cost: R313 531 Term: 2013–2014

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Development of innovative institutional management scenarios for water services in rural areas

PDG
No. 2209

Rural water supply challenges continue to prevent South Africa from achieving basic service provision to all. While many of the challenges are technical (topography, geography, technology), the dominant obstacle to successful rural water service delivery is finding an institutional model(s) that complements local government as Water Services Authorities and can (i) overcome these technical challenges, (ii) manage scarce resources in an efficient manner, and (iii) provide a continuous and sustainable service. This project seeks to review the available institutional management options for rural water services, as well as introduce possible alternative and innovative management solutions. While many of these models have been debated and assessed before, there has been limited success with these models in South Africa. The study also seeks to go beyond regulatory and technical aspects, and cover a spectrum of socio-political dynamics, economics, and culture, as well as investigate a wider range of potential institutional partners (Water User Associations, mines, etc.). This is particularly relevant given that the DWA Institutional Reform and Re-Alignment process has highlighted the institutional gap around the management of local water resources.

Estimated cost: R1 620 113 Expected term: 2013–2015

Programme 2: Institutional and management issues – Water services

Constraints on providing sewerage in South African informal settlements: A study of social and institutional management concerns

University of Cape Town; City of Cape Town
No. 2120

This study presents evidence, based on ethnographic research focused on the provision of janitorial services in three informal settlements (two in Cape Town and one in Overstrand). The specific aims of the study were to interrogate the introduction and/or provision of janitorial services in public flush toilet facilities in three Western Cape informal settlements, which meant documenting, analysing and understanding imperatives for and obstacles to providing and managing public flush toilets in informal settlements. Key findings from the research indicated that all role-players involved in using and/or providing informal settlement municipally-provided sanitation services:

- Experience health and safety risks which led to their being fearful and which affected their access (i.e. having the right to enter, get near, or make use of something) to toilets/sites
- Experience difficulty reliably coordinating the various interests/processes associated with cleaning/managing sanitation services
- Have diverse and thus different expectations of what constitutes a free basic sanitation service, and of what should comprise the associated responsibilities of users and of various kinds of service providers
- Influence municipal policy through practice
- Experience lack of guidance from national policymakers when providing services for informal settlements

In addition:

- Municipal incapacity and inflexible institutional processes that impede effective service delivery
- Residents' alternative sanitation practices negate the aims of the state's Free Basic Sanitation strategy
- Officials tended to set-up, in preference, centrally-administered and standardized systems, whilst janitors and residents preferred to have initiatives that were tailored especially to their particular situations
- Municipal authorities and contracted workers (e.g. service providers and janitors) are held legally accountable/responsible for delegated tasks, whereas resident users cannot be legally bound to fulfill O&M responsibilities.
- 'Public' janitorial services are generally more effective/reliable than 'community' systems in informal settlements because:

- Officials and residents had similar expectations of who could access the facilities and who is responsible for the services
- Despite being under-resourced, municipalities seemed better equipped than residents to manage cleaning services

Cost: R1 000 000 Term: 2012–2014

An investigation into the social, institutional and economic implications of reusing reclaimed wastewater for domestic application in South Africa

Cape Peninsula University of Technology
No. 2208

This study is situated in the context of the social and environmental problems South Africa will be facing over the next five years. With the effects of climate change and depletion of the current water resources, alternative water supply such as reuse is becoming common. Experience at Windhoek demonstrates that a direct wastewater reclamation system can be a practical, responsible way of augmenting potable water supplies in arid regions, but requires comprehensive planning, training and ongoing commitment for its continued success. National and local policies should support reuse of wastewater, taking the constraints of the region as well as the potential threats of wastewater reuse into consideration. Active participation through educational programmes is needed to encourage planners and engineers to design systems that cater for reuse or that can at any time be changed to a reuse scheme. Despite people's acknowledgement of the water scarcity of their countries, it is found that the general public in most communities has little knowledge of its water and wastewater treatment and distribution systems. To gain public acceptance of direct reuse of reclaimed wastewater, experts (including engineers, scientists and physicians) should agree that reclaimed wastewater is safe to use from a public health standpoint. In addition to this, the list of promoting factors such as water shortage, gradual introduction of water reuse, and agreement amongst experts should be brought forward. Current literature, with the exception of work on Australia, seems to be almost silent on community awareness and/or engagement on the issue of using wastewater for reclamation. This need to engage communities is a principle enshrined within the South African Constitution and is reiterated in the water service regulation strategy, which emphasises the need for a citizens' voice. The lack of understanding or underestimation of this need cannot be more vividly illustrated than by the numerous service delivery protests riddling South Africa, stemming from community experiences and perceptions of unsatisfactory, inefficient service delivery, with drinking water quality being no exception. The results of this project will assist the government and its various services with an understanding of the implications of using treating wastewater effluent for drinking and its consequences from social, economic and institutional perspectives.

Estimated cost: R1 180 000 Expected term: 2013–2016

An investigation into the barriers to implementation of effective wastewater charges by municipalities in South Africa

Prime Africa Consultants (previously CIC International)
No. 2210

There is a lack of understanding, at a municipal level, of the core principles underlying the setting of wastewater treatment charges (some municipalities also refer to these charges in their bylaws as sanitation tariffs). Wastewater treatment charge structures currently used by many municipalities are outdated and are, with a few exceptions, minimally related to the realities on the ground. Green Drop results over the past few years have shown that most municipalities treat water ineffectively, and anecdotal evidence lays some of the blame for this state of affairs at the insufficient budgets available for water treatment. Although many other problems hamper effective wastewater treatment, including an absence of ring-fencing of income from wastewater rates, the most basic point of departure for a sustainable wastewater treatment sector, is to get the price right, i.e., the wastewater charge. The wastewater charge is not only informed by the costs of wastewater treatment. Municipalities are also aware that excessive municipal rates may serve as disincentives to investment. Thus arises an interesting competitive phenomenon between municipalities (especially metros). Much excellent work has been conducted in South Africa on informing water-related tariffs, yet, in spite of this, municipalities still seem to face barriers in implementing these tariffs. This is to the detriment of an effective wastewater treatment sector in South Africa. The aims of this research are to investigate these barriers, to recommend corrective actions, and to raise awareness among municipalities around the development and implementation of effective wastewater treatment tariffs.

Estimated cost: R600 000 Expected term: 2013–2016

Monitoring, management and communication of water quality and public acceptance in the direct reclamation of municipal wastewater for drinking purposes

Chris Swartz Water Utilisation Engineers

No. 2212

There has been a lot of interest recently in direct water reclamation (direct potable reuse). Being an arid region, southern Africa faces serious challenges with availability of conventional water sources. The shortage of available water in the region is leading to large-scale interest in, and application of, water reclamation and reuse of wastewater as alternative water supply sources to sustain development and economic growth in the region. Water reclamation plants have been constructed and are in operation in Beaufort West (direct potable reuse), George (indirect potable reuse) and Mossel Bay (reuse for industrial purposes), while direct potable reuse in Durban (eThekwini Municipality) and Hermanus are at an advanced planning stage. Water reclamation and reuse has been studied in the region since the 1960s, which led to the first direct water reclamation plant being built in Windhoek, Namibia. Ongoing research and development at the Windhoek plant has led to this plant currently being internationally considered as an effective multi-barrier treatment system from a health perspective. However, no guidelines exist locally for water supply authorities (municipalities) currently managing or planning for direct potable reuse (DPR) projects, in terms of what the specific health-based targets are, what to monitor for (microbiological, chemical, organic micropollutants, EDCs and chemicals of emerging concern (CECs)), and how to undertake the process of ensuring public (social) acceptance. While considerable work has been done overseas on providing a (regulatory) framework for DPR projects, which includes monitoring requirements and guidelines for ensuring wide public acceptance, very little has been done locally. The main concerns are health risks associated with the consumption of direct reclaimed wastewater. The main outcome of this project will be the development of a framework for direct potable reuse in southern Africa, consisting of public acceptance, health-based monitoring programmes (for compliance and operational barriers, including engineered buffers), funding sources and regulatory approval. The main impacts of implementation of the potable water reuse framework will be: improved sustainability of supplementary and alternative drinking water supply to towns and cities in Southern Africa to alleviate water scarcity; to empower communities to take part in the decision-making processes; to improve health; and to stimulate economic development.

Estimated cost: R547 400 Expected term: 2013–2015

Adaptive climate change technologies and approaches for local governments: water sector response

Development Bank of Southern Africa; Department of Environmental Affairs and Tourism; SALGA; Department of Cooperative Governance and Traditional Affairs; University of Cape Town; CSIR; University of Pretoria; Hydrosoft Institute; Department of Water and Sanitation

No. 2283

Project aims:

- To develop a water sector guide of the most relevant adaptation technologies and approaches to climate change over the short-, medium- and long-term for local governments in South Africa
- Identify which local municipalities will need to consider adaptation technologies and approaches to climate change
- Develop a set of criteria to classify adaptive technologies and approaches
- Identify which water distribution and wastewater options are appropriate as adaptive technologies or approaches to climate change at a local government, community and household level
- Map these technologies for near-, medium- and long-term planning and preparation for climate change for the different types of local municipalities (rural, urban and metros)
- Ascertain the institutional and capacity requirements of local government to roll out a climate change adaptation strategy
- Define the practical implementation steps and planning horizons that will be required
- Provide a comprehensive review and way forward for current research (inclusive of all WRC studies) that could provide future solutions for the gaps in the sector, and to meet climate-change projected needs

Estimated cost: R1 500 000 Expected term: 2013–2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Investigation into the cost and water quality aspects of South African desalination and reuse plants

SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2121

Desalination and wastewater reuse by various membrane processes ranging from micro-, ultra-, and nanofiltration to reverse osmosis, in combination with other advanced technologies, can be used in different configurations to augment water supplies. With known feed-water and target product-water qualities the basic plants are relatively standard and consistent in price. However, the infrastructures in front of (intakes, pre-treatment, etc.) and following (waste discharge, product water pumping systems) the basic plant building block (membrane system) are major variables in determining the capital and operating costs of the selected solutions. Each location and situation has different advantages and challenges to be evaluated in making the best decisions for implementation. This project will compare and document actual cost and water quality data from various South African projects to establish a first-order knowledge base for desalination and reuse for the augmentation of water supply in a South African context.

Estimated cost: R1 000 000 Expected term: 2012–2015

Advanced oxidative treatment process for water disinfection using an electrohydraulic discharge reactor and TiO_2 immobilised on nanofibres

University of the Western Cape
No. 2132

In this project, the design and methods for applying electrical energy to multiple electrodes will be explored and described. An assembly having at least more than two electrodes may be configured such that the high voltage electrodes are submerged in the inner tubes, positioned at parallel relative to one another, and the grounded electrode is directly submerged into the wastewater setup, resulting inproduction of a cocktail of chemical species, such as OH radicals, ozone and hydrogen peroxide, which can target and attack the pollutants in the water without the addition of chemicals. Electrohydraulic discharges have been studied for several years; however, the integration of innovations in nano-science and nano-photocatalytis has been incorporated into this area of research on a very limited scale. The new system will be designed so as to generate plasma directly in water, which will produce radicals from water ionisation. Furthermore, in this multifunctional reactor multiple electrodes across the water flow path, in combination with TiO_2 electrospun nano-fibre consolidated photocatalysts, are applied that can promote and enhance the formation of oxidants.

Estimated cost: R1 392 800 Expected term: 2012–2015

Programme 3: Drinking water quality

An investigation into the presence and impact of free-living amoebae and amoeba-resistant bacteria on drinking water production, storage and distribution to health care institutions in greater Johannesburg, South Africa

National Institute of Occupational Health
No. 2138

Free-living amoebae (FLA) are ubiquitous in groundwater and surface waters used for drinking water production. They feed on smaller micro-organisms like bacteria, fungi and algae. Although mostly non-pathogenic, some FLA, particularly *Acanthamoeba* and *Balamuthia* species and *Naegleria fowlerii* are known human pathogens which may cause life-threatening disease in both healthy and immunocompromised individuals. They can survive in this dormant stage for long periods of time, only to excyst and become active again when conditions return to normal. International studies continue to highlight the potential of FLA containing amoeba-resistant bacteria (ARB) to survive routine drinking water production and treatment processes. The overall aim of the study is to establish whether the occurrence of FLA and ARB in drinking water production plants has an impact on the quality of the water supplied to health care institutions in greater Johannesburg, to use this information to assist the drinking water production industry to improve the quality of water supplied to these institutions and to assist the institutions to establish appropriate water management programmes in areas where the patients and personnel are most at risk of infection.

Estimated cost: R423 500 Expected term: 2012–2015

Water safety and security: emergency response plans

Emanti Management

No. 2213

Protecting public health is the primary goal of community drinking water systems, and having an up-to-date and workable ERP helps achieve this goal in any crisis situation. The ERP must include plans, procedures, and identification of equipment that can be implemented or utilized in the event of an intentional attack on the CWS or in the event of a natural disaster. The ERP must also include actions, procedures, and identification of equipment which can obviate or significantly lessen the impact of attacks or disasters on the public health and the safety and supply of drinking water provided to communities and individuals. The purpose of this project is to provide guidance on developing or revising Emergency Response Plans (ERPs) for small- and medium-sized community drinking water systems. An ERP is a documented plan that describes the actions that a Community Water System (CWS) would take in response to various major events. A major event refers to: (i) credible threats, indications of terrorism, or acts of terrorism; (ii) major disasters or emergencies such as hurricanes, tornadoes, storms, earthquakes, fires, flood, or explosion regardless of cause; and (iii) catastrophic incidents that leave extraordinary levels of mass casualties, damage, and disruption severely affecting the population, infrastructure, environment, economy, and government functions. Community Water System characteristics vary greatly, so CWSs should be able to apply the information contained in this document to meet their particular needs and circumstances. The output of the project, i.e., the guidance document, should be able to be used as a flexible template.

Estimated cost: R1 500 000 Expected term: 2013–2015

An assessment of incentivising community engagement in drinking water supply monitoring

University of Cape Town

No. 2214

One of the key challenges we have identified in previous research projects is that reporting of faults in water supplies from rural communities is limited or non-existent. There are many reasons for this, from a simple 'not knowing who to contact', to complex social relationships within rural communities that result in citizens wanting to avoid blaming or pointing out non-performance of government or municipal officials (particularly relevant in smaller communities where everyone knows everyone else). Information communication technologies (ICTs), such as mobile phones, have over the past 10 years been used to mobilise communities, increase public activism, and allow and encourage anonymous reporting. Whilst this has been met with great enthusiasm as a possible method to increase public awareness and government accountability, there have been equally many examples of failed uses or projects with unintended consequences. ICT applications have also seen an increase of use in the WASH sector, but experiences from the health sector (which has been using these technologies for significantly longer) have shown that, whilst projects are often successful when run within the context of an organisation with trained staff or volunteers using the tools, the perception that the general public will similarly embrace and use mobile tools to report problems or to collect information is generally incorrect, and projects in this context have been shown to fail or to be unsustainable. Anecdotal evidence suggests that the communities will only engage if there is a direct benefit to them, despite the tools and data submission being free. Some ICT projects have therefore started incentivizing reporting by communities. The incentives offered vary from airtime, to stipend, to winning a prize and so on. However, the reasons for success are unclear and currently there is no formal research on this topic; much of the evidence is anecdotal and based on best guesses. There are some direct incentives to reporting a problem, such as the report directly leading to the fault being resolved, but it is uncertain if even this is enough to adequately ensure the long-term success of a project. In order to assess if and in what ways rural communities would use such tools, and what the appropriate incentives for the usage would be, this research project proposes not only to assess the use of cellphones but to investigate the use of incentives in the reporting of water supply faults.

Estimated cost: R1 170 000 Expected term: 2013–2016

Detection and quantification of emerging organic pollutants in Durban waterways, and remediation options integrating nanostructured materials and advanced oxidation processes

University of KwaZulu-Natal (Westville Campus)

No. 2215

Anthropogenic organic compounds or problem organics are emerging contaminants of concern because their environmental significance is not fully understood. They have been detected in water systems in many parts of the world but there is limited

information regarding their characterization and quantification in the Durban water ways; yet they are associated with population and practices in specific locations. Previous studies carried out on South African water systems have focused on heavy metals, biological contamination and, to some extent, priority organic pollutants, such as PCBs. Research carried out specifically on Durban and KwaZulu-Natal's water systems is mostly limited to heavy metals and pathogenic pollutants rather than chemical contaminants, and any research that was carried out is now outdated having been done more than 25 years ago; thus it needs updating with new contaminants. Prior work in other parts of the world has shown that such compounds are usually in the nanogram/L range, are continuously discharged into the environment, and not only pose a threat to the environment, and human population centres, but also require new and sensitive techniques for their detection. The current water regulatory monitoring does not emphasize monitoring of these micro-organics, probably because knowledge about their existence in local waterways is limited and their detection requires new and sensitive methods of quantification. The coexistence of chemicals with various chemistries in water bodies also poses a challenge as it requires development of multi-residue detection techniques, one of the challenges that this research will address. This project will determine the presence of emerging organic contaminants in Durban waterways. It will investigate those organic contaminants that are not routinely monitored but may have ecotoxicological effects, as well as those persistent organics whose presence and effects are being re-evaluated. The work will include a crucial screening analysis that will provide a fundamental baseline in terms of class of compounds, local variations and risk factors associated with the various emerging pollutants. In addition, the project team will focus on three major classes of emerging pollutants; specifically, pharmaceutical products and drugs of abuse, pesticides, and personal care products.

Estimated cost: R750 000 Expected term: 2013–2017

Extending EDC Toolbox I to include thyroid and androgenic bioassays

University of Pretoria; Griffith University
No. 2303

Project aims:

- To participate in the Global Water Research Coalition EDC Toolbox
- Inter-laboratory study to establish the suitability and application of the thyroid and androgenic bioassays for the detection of EDC activity in water samples

Estimated cost: R430 000 Expected term: 2014–2016

Programme 4: Water distribution and distribution systems

Determination of the change in hydraulic capacity in pipelines

University of Pretoria
No. 2140

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 is 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. This research, which builds on previously-completed work, will broaden the database, maintain the current momentum of the original research and will provide improved understanding of the hydraulic behaviour of pipelines to be able to improve the design philosophy. The preliminary finding was that the presence of biofilm significantly reduces the hydraulic capacity. In this study emphasis will be placed on the review of newly-installed pipelines (sewage, raw and clear water), but existing pipelines will also be included in the field work. A roughness database reflecting the hydraulic capacity time history will provide a sound basis for the design of new pipelines as well as assist in the operation and refurbishment of existing pipelines.

Estimated cost: R1 125 000 Expected term: 2012–2015

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

Urban effluent treatment in a rhizofiltration system

Durban University of Technology; Stellenbosch University; 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

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

Performance and efficacy of integrated algae ponding systems in wastewater treatment for water reuse and cost recovery through biomass valorization

Rhodes University
No. 2123

A rapid implementation of robust, easy to deploy and operate, sustainable wastewater treatment technology is urgently required. Furthermore, climate change, together with reduced water availability, has major food security implications for South Africa, its neighbours, and other arid, water-poor countries. These two factors alone have profound management implications for both government and business. Correct implementation and management of integrated algae pond systems (IAPS) developed for South African conditions can produce clean water for recycling and reuse, provide energy, and generate a biomass suitable as a broadcast or liquid fertilizer in organic row crop agriculture and high-value horticulture. Even so, and as with any near market-ready technology, there is an element of risk and/or failure to comply. Performance of the IAPS needs to be closely monitored and its efficacy in routinely producing a final effluent that meets the standard (i.e. <75 mg/L COD and <25 mg/L SS) thoroughly elaborated. Furthermore, an evaluation of all factors contributing to final COD and SS must be carried out and included: design and re-design of the algae settling tanks, introduction of more robust separation/filtration technologies for removal of biomass and/or water, and full characterisation of the residual COD and SS in the final effluent. Armed with this information a document emphasising the merits of IAPS and addressing questions and concerns about its implementation will be available to facilitate informed decision making.

Estimated cost: R1 500 000 Expected term: 2012–2015

Development and demonstration of a woven fabric immersed membrane bioreactor package plant for decentralised sanitation

Stellenbosch University
No. 2287

South Africa faces a challenge in providing sanitation for all of its people. Decentralised, small-scale 'package' sanitation plants have great potential to overcome some of the logistical challenges and could make a significant contribution to the roll-out of sanitation in peri-urban and rural areas. Internationally, there has been a major swing towards immersed membrane bioreactor (IMBR) technology for wastewater treatment due to the advantages that IMBRs offer over conventional biological wastewater treatment. IMBR package sanitation plants could have a significant impact on addressing the sanitation backlog. However a major barrier to the application of IMBRs is the cost and lack of robustness of current IMBR membranes. Generally, current commercial IMBR membranes are expensive and cannot withstand rough handling. Further, there is a perception that IMBR technology is 'first-world', complicated, and requires highly skilled operators, and hence cannot be applied for decentralized sanitation in developing regions. To enable South Africa to benefit from IMBR technology this project will demonstrate to wastewater practitioners, vendors of package plants, etc., that IMBR technology can be simple, robust, easy to operate and cost effective.

Estimated cost: R793 875 Expected term: 2013–2015

Integrating agriculture in designing low-cost sanitation technologies in social housing schemes: a case study of Kwadinabakubo, eThekwini Municipality

University of KwaZulu-Natal (Pietermaritzburg)
No. 2220

The disposal of effluent generated from low-cost sanitation technologies such as the decentralized wastewater treatment systems (DEWATS) still poses challenges to the environment. Such effluent has been shown to contain high concentrations of essential nutrients necessary for crop production. WRC Project K5/2002 demonstrated the capacity of different soils to retain these nutrients from the effluent. Integrating agriculture in the planning and design of low-cost sanitation technologies could provide safe and sustainable mechanisms for disposing of such effluent by retaining the nutrients for crop production and releasing water into hydrological systems. There is no information or any guidelines that could inform town planners and policy makers in designing new social housing developments that can integrate agriculture in the design of low-cost sanitation technologies. This project aims to build on previous work by the Soil Science department at UKZN to generate information on recycling of nutrients from DEWATS technology, which will inform policy makers and town planners in the design of new social housing developments that integrate agriculture.

Estimated cost: R1 880 000 Expected term: 2013–2016

Programme 2: Application of appropriate technologies and tools

Nutrient and energy recovery from sewage: demo-researching an integrated approach

University of Cape Town
No. 2218

Humans produce a significant amount of sewage, containing large quantities of nutrients (phosphates, nitrates and micro-nutrients). For example, humans typically excrete 1.6 to 1.7 g phosphorus per day, most of which (approximately 60%) is found in urine. Considering that natural phosphorus reserves are on the decline and are expected to be depleted by 2033, the use of sewage waste has the potential to be a major source of new phosphorus. An alternative technology that utilises seeded electrochemical precipitation (SEP) has the potential to increase the yield and process efficiency of struvite recovery. The use of SEP has been investigated for the removal of calcium carbonate by Hasson and co-workers. This technique has not yet been applied to struvite precipitation, thus providing the opportunity for a novel nutrient-recovery technique. The first aim will be to investigate current nutrient- and energy-recovery technologies based on a systems approach to technology sustainability assessment, which will focus specifically on situation analysis and technology review, in which the analysis of nutrient flows, expected nutrient supply limitations and emerging organic food production will be examined. The second aim will be achieved by investigating the use of seeded electrochemical precipitation as a means to produce struvite crystals of a similar or better quality and size when compared to conventional precipitation techniques.

Estimated cost: R1 400 000 Expected term: 2013–2016

WWTP modelling to support the Green Drop programme

University of KwaZulu-Natal (Howard College Campus)
No. 2221

Simulation of wastewater treatment processes is a rapidly developing technology, increasingly used to achieve better designs of new plants and improved operation of existing ones. The use of modelling offers the possibility of supplementing this relativistic approach by providing performance criteria which have an absolute basis. Furthermore, process models reflect a deeper understanding of the process than is needed for routine operation and compliance monitoring, and the discipline of constructing a model almost always reveals aspects of the process which were not previously understood. Both eThekwini Water and Sanitation (EWS) and Umgeni Water experience considerable difficulties at some of their WWTPs arising from the presence of significant loads of industrial effluents, and there are frequently questions as to whether poor treated water quality is due to industrial components in the wastewater or to deficiencies in the treatment processes. A series of WRC projects has led to the development of steady-state and dynamic WWTP models at UCT and, more recently, with the collaboration of UKZN. However, these models have up to now been based on data from laboratory equipment, and have not yet been applied to full-scale plants. Thus this project aims to:

- To set up and evaluate wastewater treatment plant models for a number of representative WWTPs in the eThekwini/uMsunduzi region
- To use the models to monitor plant performance over extended periods
- To establish norms of expected WWTP performance, based on its configuration and the characteristics of the incoming wastewater
- To establish methodologies for identifying critical barriers to improved performance

Estimated cost: R700 000 Expected term: 2013–2016

Programme 4: Wastewater sludge and faecal sludge management

Development of the Anaerobic Digestion and Pasteurisation Treatment (ADAPT) concept for the safe disposal and beneficiation of faecal sludge

Rhodes University
No. 2306

Project aims:

- Establish the functional components of an ADAPT unit (anaerobic digester and pasteuriser) at a sewage works to demonstrate the practicality of this system to treat faecal sludge and generate a pathogen-free effluent

- Understand the biological processes that take place in the anaerobic digester and how it affects the operation of the ADAPT unit
- Test the effectiveness of pasteurisation to generate a pathogen-free effluent suitable for use as a fertiliser for horticulture and crop plants

Estimated cost: R1 180 000 Expected term: 2013–2015

Towards integrated sanitation and organic waste management – improving faecal sludge management on municipal level by upgrading local wastewater treatment plant with value-added processes (example: Tlokwe Local Municipality)

North-West University (Potchefstroom)
No. 2307

The proposed study aims to apply some of the lessons from the iPit study and apply it to peri-urban settlements in Tklowe. In particular, the project teams intends to use anaerobic technology to treat faecal sludge with and without additional organic substrates and by upgrading the current digester at the local wastewater plant to treat faecal sludge – the current digester is being operated without a lid with no biogas harvesting. Laboratory-scale studies will also be conducted using faecal sludge as the main feedstock and the performance evaluated at different loading rates for process optimisation. The project team will draw upon previous experiences in the iPit project to optimise digester performance for faecal sludge (SRT – 20 h). The iPit toilet design will not be field tested in this study but could be at later stage should the proposed project be up-scaled. The Tlokwe Municipality is eager to improve the performance of the local wastewater treatment plant. Their outstanding achievements within the Green Drop assessment and long-standing collaboration with NWU prove their commitment to continuously advance technology and skills at their facilities. Therefore this project aims to implement a best-practice example at Tlokwe WWTP, making the treatment plant a valuable asset to the community: a resource source instead of a waste disposal plant. This will result in direct economic and environmental and health benefits. The plant's energy-efficiency will increase and methane emissions will be reduced, sources for water pollution contained and an additional renewable energy resource (biogas) will be utilized.

Estimated cost: R1 050 000 Expected term: 2013–2015

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

Demonstration and scaled-up implementation of pour-flush sanitation in South Africa

Partners in Development
No. 2203

While many South Africans aspire to full waterborne sanitation, this is not an achievable goal given the many demands on limited resources. The alternative has been limited to VIP's. However, these are not without their shortcomings including health and safety, environmental and operational issues. In 2009 the WRC commissioned a project to develop and test a prototype for pour-flush sanitation in South Africa. This was done successfully and 20 units have now been in operation for between 7 and 22 months. Funding was received from Irish Aid to demonstrate, on the strength of lessons learned, a large scale

pour-flush sanitation pilot and to share the experiences from this pilot with appropriate audiences. Thus the objective of this study is to implement 275 pour-flush units in a rural community.

Estimated cost: R1 475 175 Expected term: 2012–2013

Energy generation using low-head hydro technologies

University of Pretoria
No. 2219

Energy is the lifeblood of worldwide economic and social development. When considering the current status of global energy shortages, the emphasis to reduce CO_2 emissions, development of alternative energy generation methods and growing energy consumption, it is clear that there is a need to change the way energy is created and used. Energy experts say South Africa has moderate hydroelectric potential, and that the establishment of small hydroelectric projects around the country could help provide a sustainable future energy supply. The US Department of Energy estimates that there are 6 000 to 8 000 potential sites in South Africa suitable for small hydro-utilisation below 100 megawatts, with the provinces of KwaZulu-Natal and the Eastern Cape offering the best prospects. This project therefore aims to:

- Review the feasibility of generating energy in low-head systems
- Develop guidelines to identify locations where low-head hydropower generation systems can be installed
- Develop an assessment model including a cost–benefit tool
- Demonstrate the technology by means of pilot-plant installations, testing different turbine technologies
- Provision of educational material to illustrate and describe the process.

Estimated cost: R500 000 Expected term: 2013–2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

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

Integrated bioremediation and beneficiation of bio-based waste streams

Rhodes University
No. 2225

An integrated approach (ReBenFruWaste) for the remediation of fruit waste streams with high organic loadings with simultaneous beneficiation through the production of valuable products is proposed. The integrated approach will be evaluated on existing food waste streams, but could lay the foundation for the treatment and beneficiation of biorefinery waste streams when bioeconomies come to fruition. This project has four main aims:

- Analysis of existing food waste streams (fruit and olive mill waste streams) for sugar, lipid, phenolic and lignocellulosic content
- Bench-scale fermentations to evaluate (i) conversion of high sugar streams to ethanol (renewable fuel) and (ii) utilization of high streams with high lipid, phenolic and lignocellulosic content as feedstock for high-value enzyme production by *Aspergillus niger* strains
- Characterization of enzyme production and bench-scale demonstration of enzyme applications in different bioconversion processes, from lignocellulose conversion, treatment of resilient phenolic waste streams to the production of valuable fine chemicals, such as antioxidants
- Final cleaning of remaining waste streams through anaerobic digestion (can be combined with municipal waste treatment)

Estimated cost: R750 000 Expected term: 2013–2016

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

Water management efficiency: The development and testing of an optimisation model at selected Eskom sites for an integrated water solution

University of Pretoria

No. 2289

Pinch analysis is a process integration tool, which was first developed for the design of heat recovery systems during the late 1970s. This work formed the basis for the design of water-using systems, with a design objective of minimising water consumption by maximising the reuse of water, using a graphical technique which was termed Water Pinch Analysis. Water Pinch Analysis thus involves a set of systematic formal techniques to handle the complex problem of hierarchical water allocation to a system consisting of a number of processes, and choosing the best combination of strategies. The WRC has funded several projects (1241/1/06; 1158/1/05; 851/1/01) in the past to test the applicability of the technique for water management in both the industrial and water resource fields. The industry-based studies investigated the applicability for three large water users to varying degrees of success and were valuable in gaining insights into its application, limitations and theory. Water Pinch Analysis exposed the water sector to a new technique and developed new capacity in the research domain. These studies also showed that pinch analysis could be used as a neutral tool to set targets and to indicate their environmental performance to the public and authorities. Thus, this study aims to build on the knowledge gained and to develop, test and apply an optimization model for cooling water systems at selected Eskom sites. This project also aims to build capacity for optimization models for water management efficiency.

Estimated cost: R1 500 000 Expected term: 2013–2016

Using membrane distillation crystallization for the treatment of industrial wastewater

University of Cape Town

No. 2223

The sustainable treatment of acid mine drainage and industrial wastewaters is necessary if sustainable growth and responsible management of water is to be achieved in South Africa. Membrane distillation crystallization offers a sustainable wastewater treatment process because it can utilise excess heat from processes, and produce pure water as well as salt(s) products, thus converting waste material into something of value. Membrane distillation crystallization is also an attractive wastewater treatment technique because it requires low operating temperatures (40–60°C); the hydrostatic pressure encountered in the process is lower than in reverse osmosis and less expensive material such as plastics can be used in the process. Another major advantage of MDC to the application of AMD is that the process is able to operate in very acidic or basic streams and thus the AMD streams would not need to be pre-treated or neutralized beforehand. This project therefore aims to investigate the applicability of MDC for the treatment of industrial wastewater, with a specific focus on the treatment of mine wastewater. The project also aims to contribute to the field by investigating concentration polarisation and its effect on the process, while at the same time developing better crystallizer control strategies. Ultimately, this project could offer a more energy-efficient and sustainable industrial wastewater treatment process that reduces wastewater production.

Estimated cost: R1 400 000 Expected term: 2013–2016

Revision of Natsurv 2: Water and Wastewater Management in the Metal Finishing Industry (Edition 2)

Stellenbosch University

No. 2224

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However, South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 2: Water and Wastewater Management in the Metal Finishing Industry' and documents water and wastewater management within the metal-finishing industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Estimated cost: R700 000 Expected term: 2013–2015

Revision of Natsurv 4: Water and Wastewater Management in the Dairy Industry (Edition 2)

University of KwaZulu-Natal (Pietermaritzburg)
No. 2226

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However, South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 4: Water and Wastewater Management in the Dairy Industry' and documents water and wastewater management within the dairy industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Estimated cost: R700 000 Expected term: 2013–2015

Revision of Natsurv 1: Water and Wastewater Management in the Malt Brewing Industry (edition 2)

CSIR; Tshwane University of Technology
No. 2285

Project aims:

- Provide a general overview of the malt-brewing industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes
- Determine the water consumption and specific water intake
- Determine the wastewater generation and typical pollutant loads
- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14 000 (among others)
- Provide recommendations for best practice

Estimated cost: R700 000 Expected term: 2013–2015

Revision of Natsurv 3: Water and Wastewater Management in the Soft Drink Industry (edition 2)

Dube Ngeleza Wiechers Environmental Consultancy Pty (Ltd); University of KwaZulu-Natal (Howard College)
No. 2286

This project aims to obtain an overview of the soft drink sector within South Africa and changes since 1980s:

- To evaluate and document the generic industry process
- To determine the water consumption and specific water intake
- To determine wastewater generation and typical pollutant loads
- To determine the local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14000 (among others)
- Provide recommendations for best practice

Estimated cost: R700 000 Expected term: 2013–2015

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

Micro-nutrient requirements for anaerobic digestion of concentrated industrial effluents: Development of a speciation/precipitation model to optimise micro-nutrient dose for methane production from industrial waste streams

University of KwaZulu-Natal (Howard College Campus)
No. 2228

Anaerobic digestion of industrial effluents is used to convert organic material at concentrations that are too low for economic recovery to methane gas. Balanced anaerobic digestion requires inorganic micronutrients to proceed. In many industries, including hydrocarbon and certain chemical industries, effluent streams may contain a number of the micronutrients required for balanced growth, but there may be several micro- (and macro-) nutrients that are not

present in the stream. To date, research in the field has been predominantly experimental and empirical; there are no studies which provide guidelines for predicting the micronutrient requirements for a particular application beyond the general micronutrient-to-COD ratios. Therefore, this study will test the hypothesis that a model describing the partitioning of micronutrients between soluble, precipitate and potentially bound and adsorbed phases can be used to determine the amount of the micronutrient available for anaerobic digestion, and can therefore be used to predict the microbial response to different micronutrient dosing strategies.

Estimated cost: R400 000 Expected term: 2013–2016

Phase 2: Recovery and beneficiation of nutrients and water from brewery effluent by means of unique combination of algal assimilation, constructed wetlands, hydroponics and aquaculture

University of Cape Town; Rhodes University

No. 2284

Project aims:

- Develop a better understanding of (i) the changes that take place in HRAP algal community structure at different times of year and/or at different flow rates, and (ii) the underlying mechanisms responsible for some of the results obtained in the HRAP during Project K5/2008, such as the mechanism/s responsible for majority of the ammonia and phosphate removal.
- Develop technology to convert brewery effluent grown algal biomass into fish biomass without mechanically harvesting the algae and allowing filter-feeding fish to bioconvert algal biomass into fish biomass

Estimated cost: R850 000 Expected term: 2013–2016

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Limiting and mitigating the impact of coal mines on wetlands

CSIR

No. 2230

By virtue of their positions in the landscape and relationship to drainage networks, wetlands are frequently impacted by coal-mining activities, especially opencast methods. These impacts will be ongoing, since coal is a strategic resource and will continue to be mined extensively to support the country's development. At the same time, however, regulatory authorities and the public now have an improved understanding of the range of economic, social, ecological and hydrological costs of wetland loss and degradation. The rules of the game have changed, with regulators increasingly insisting that mines avoid, minimise and mitigate their impacts on wetlands, and internalise the true costs of wetland loss into their balance sheets. Many mining proposals entailing large-scale wetland loss have encountered delays in licence approvals, unrealistic rehabilitation commitments and unwelcome public and media attention. As a result, the coal-mining sector has realised that it needs to proactively and systematically address the business risk posed by its impact on wetlands. Thus, in 2011 the CSIR and SANBI embarked on a three-year cooperative applied research project, funded by the Coaltech Research Association. Supplementary funding is also being provided by the SANBI Grasslands Programme and Working for Wetlands, for particular components of the work. The project's focus is on developing mechanisms for limiting and mitigating the impact of coal mining on wetlands, and providing guidelines to the coal-mining industry and regulators in this regard. Based on interest expressed by the WRC in supporting this project to expand on its original scope and thereby improve its impact, this project proposal was prepared. It highlights areas where DMR and WRC resources can add further value to the work already underway, by allowing further work to be undertaken that was not part of the original scope of the funding. The project aims to compile an atlas to guide both mining companies and regulators with regard to high-risk wetland identification and offsite mitigation principles and methods. The sensitive wetlands atlas will identify key wetlands or subcatchments in the grassland biome of Mpumalanga that are particularly important or irreplaceable in terms of biodiversity, water resource management and other ecosystem services. The atlas that will be produced will guide both mining companies and regulators in their planning and decision-making. The project will pilot the mainstreaming, into the coal-mining sector, of information generated through the National Freshwater Ecosystem Priority Areas (NFEPA) project. The aims of the project are fourfold:

- To improve planning and decision-making around coal mining by developing products, for both regulators and mining companies, that highlight high-risk wetlands and ecosystem services
- To improve the science and practice of wetland rehabilitation in a coal-mining context, by improving current wetland rehabilitation guidelines with particular focus on post-mining landscapes and mitigating mining pollutants
- To enhance the quality of planning and regulatory processes by providing improved data on resource economics and risk assessment with respect to wetlands and coal mining
- To compensate for unavoidable residual loss of wetlands due to coal mining by developing and testing a systematic framework for wetland offsite mitigation, as well as identifying wetland offset receiving areas

Estimated cost: R1 056 000 Expected term: 2013–2015

An industrial ecology approach to sulphide-containing mineral wastes to minimise ARD formation: characterising potential for ARD, design for disposal and extraction of products with value

University of Cape Town

No. 2231

Project aims:

- Develop a method for characterizing the long-term ARD generation potential that takes into account the likely impact of microbial colonization and the relative time frame of acidification and neutralization, building on the proposed concept of the biokinetic test (Hesketh et al., 2010)
- Provide an expanded techno-economic assessment and holistic environmental assessment of the sulphide separation step for removal of risk of ARD formation
- Develop appropriate uses for the benign tailings generated in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden
- Develop appropriate uses for the sulphide-rich tailings resulting from the separations in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden

Estimated cost: R2 565 000 Expected term: 2013–2017

The BioSURE Process: a sustainable, long term treatment option for acid mine drainage treatment

VitaOne8 (Pty) Ltd

No. 2232

The BioSURE Process was identified as one of few treatment options suitable for the treatment of AMD in the Witwatersrand and elsewhere. However, it has been rejected by Aurecon, in their feasibility study for the Witwatersrand, as a viable option for the long-term treatment of AMD, the reason cited being a lack of full or demonstration-scale operating data. The full-scale operation undertaken by the East Rand Water Care Company (ERWAT) has in fact demonstrated that the BioSURE Process can be used as a cost-effective treatment technology for AMD. The process is attractive because it makes use of primary sewage sludge or other sources of organic wastes as substrate and produces a good quality effluent. Since it converts permanent hardness into temporary hardness, conventional cold-lime softening processes can be used to desalinate the water while valuable by-products may be recovered. The effluent quality after desalination is suitable for consumption in various industries as a substitute for high-quality potable water. ERWAT, in its role as a service provider, is very well positioned with its access to sources of primary sewage sludge and biodegradable organic waste. As an operating company and with the past experience of operating a 10ML/day plant, it can play a significant role in the treatment of AMD. A survey of the industries indicated that there are reliable and consistent sources of waste, other than primary sewage sludge, from various industries to treat approximately 20–30 ML/day of AMD in the Central and Eastern Basins. This waste is currently being disposed of in landfill sites at high cost. Considering the quantity of primary sewage sludge generated by ERWAT and Johannesburg Water's wastewater treatment plants that can practically be used, a significant volume of AMD can be treated in the Witwatersrand. Co-treatment with industrial waste and recovering costs for treatment of industrial waste will reduce the overall treatment cost of AMD. It is therefore important that more aspects should be considered than only the need to treat AMD. These aspects include the requirements to treat and dispose of sewage sludge and the urgent need to provide additional capacity to process biodegradable organic solids. This project is required in order to improve the BioSURE Process and to properly document its operating philosophy and limits to

applicability, in order to make it truly available for implementation. It is planned to:

- Compare the performance of the biological sulphate-reducing reactors using primary sewage sludge and carbohydrates such as silage and combinations thereof
- Test the performance of the process using a feed of high acidity, low pH AMD
- Investigate the removal of hydrogen sulphide using a process to regenerate iron hydroxide with a biological iron-oxidising process integrated with the recovery of valuable magnesium sulphate using a eutectic freeze unit
- Investigate the integration of the effluent treatment process with the so-called SANI process for COD and nitrogen removal

Estimated cost: R1 557 600 Expected term: 2013–2015

Mine water atlas of South Africa

Golder Associates Africa (Pty) Ltd (Midrand)
No. 2234

Large volumes of water are used by the mining and other industrial sectors for extraction and concentration of metals and non-metallic minerals, and generation of the electricity required for crushing ore, on-site processing, smelting, refining and other aspects of treating resources to improve their properties. Demand for water by the mining industry is limited and localized but becomes high when associated refining, smelting and manufacturing operations are considered. Mining has been an integral part of South Africa's history and economy. In 2007, the South African mining industry employed 493 000 workers and represented 18% of South Africa's 588 billion USD gross domestic product. Mines are most heavily concentrated in the eastern half of the country. While most mines are designed as closed systems, water pollution can result from problems in the mining or milling processes and aquatic ecosystems can be affected. In discussions with mining and/or water stakeholders in South Africa, it has emerged that a national mine-water atlas would be extremely valuable as a tool for water management planners and as an educational resource for water users, legislators, and the public. The Mine Water Atlas of South Africa is thus intended to be a comprehensive reference of the extent of the influence of acid rock drainage (ARD) on the country's surface and groundwater resources: summarizing the location, geography, geology, water quality and hydrologic characteristics. The information shall be presented in a graphical format supported by descriptive narratives and tables to better facilitate the reader's understanding of the material. The information, maps, and tables in the Atlas will portray general, regional conditions. The Atlas will be a significant and timely contribution that can inform the implementation of commitments made in the past two years. Decision makers can also look to the Atlas for background information and tools to assist in fulfilling commitments made in other recent events and declarations.

Estimated cost: R2 700 000 Expected term: 2013–2015

Programme 3: Minimising waste production

Treatment of mine water using a combination of coal fly ash and flocculants in a jetloop reactor system

University of the Western Cape
No. 2129

The generation of contaminated high-sulphate mine-water and waste coal fly ash are undesired by-products in coal mining and coal-fired power stations, respectively. Mine-water is contaminated by contact with oxygen and pyrite-bearing rock, or leaches from mine tailings due to infiltrating rain. Mine-water produced in coal mines could be acidic, neutral or alkaline depending on the geology of the mines. Acidic mine-water, often termed acid mine drainage (AMD) is produced when rock that contains more acid-producing minerals than acid-neutralizing minerals was disturbed during mining. Prior work has been done on the fly ash neutralization process and stability of solid residues formed during neutralization, as is recorded under the 'general information' section. This study will optimize the jetloop reactor system which will make this system using fly ash for remediation viable in an industrial environment, and thus a serious contender for low cost mine-water treatment and recovery.

Estimated cost: R1 033 000 Expected term: 2012–2015

Continuous eutectic freeze crystallization

University of Cape Town
No. 2229

While treating coal mining–impacted waters using reverse osmosis, facilities such as the Emalahleni Water Reclamation Plant and the Optimum Water Reclamation Plant produce large volumes of hypersaline brines. These brines are disposed of in evaporation ponds, and thus are lost to the usable water pool. With increasing use of desalination, and hence brine production, the loss of water is predicted to increase exponentially. The total combined brine production rates for the coal and gold mining industries in South Africa are projected to be ±17 000 m^3/day in the next 20 years from current values of ±3 000 m^3/day. Conventional treatment methods, such as concentration in evaporation ponds, have many disadvantages including extensive land use and low productivity. In addition, evaporation ponds recover neither the water nor the salt. Eutectic freeze crystallisation (EFC) is able to reduce the volume of brines by as much as 97% and concurrently produce pure salts as well as potable water. For example, pure calcium sulphate, pure sodium sulphate and potable water, in the form of ice, can be produced. Eutectic freeze crystallisation works on the principle that when brine is cooled to the eutectic temperature, both ice and salt crystallise out of solution. The ice, being less dense than water, will float, and the salt, because it is denser than water, will sink, thus effecting gravity separation. There is a major misconception that any freezing process is expensive but, thermodynamically, it is cheaper to freeze one kilogram of water (333 kJ) than to evaporate one (2 300 kJ). Energy savings of 85% have been reported when comparing EFC to evaporative crystallisation. An extensive experimental programme focussing on the use of EFC has been undertaken over the past 6 years and proven the concept of EFC as a feasible treatment for multi-component hypersaline brines. Firstly, it was shown that thermodynamic modelling can accurately predict the identities of the recovered salts, as well as their recovery temperatures. Secondly, it was shown that EFC can be used for the treatment of hypersaline brines and inorganic effluents produced by major South African industries. Thirdly, it was shown that EFC can be used to recover multiple salts from multicomponent brines. Lastly, it was shown that EFC can produce almost pure salts and ice. However, all of the work so far has been done in batch mode, an essential mode for testing proof of concept and initial feasibility. Although the batch mode has provided crucial information, it has not been sufficient to showcase the potential of the technology. The next challenge is to develop EFC to the point that it can be used in continuous mode. In this project, important knowledge about operational considerations for continuous EFC, including residence time, degree of undercooling, crystalliser solids content and operating limits, will be generated. This knowledge is crucial for making the transition between batch and continuous, as well as to be able to design an EFC plant on both a pilot and industrial scale. This is the essential focus of this project.

Estimated cost: R2 276 600 Expected term: 2013–2018

THRUST 6: WATERSMART FUND

Programme 1: Watersmart Fund

Development of the micro-flush toilet

Maluti GSM

No. 2291

Project aims:

- Develop a two-stage flush mechanism which has a 'trickle flush' to clean the pan and a 'gush flush' to simulate the pour-flush action than enables low-volume flushing
- Develop a fully operational prototype of the micro-flush toilet
- Trial the prototype at different applications to evaluate performance
- Refine design with feedback from users
- Develop a marketing strategy to raise awareness of the micro-flush concept and create demand for the product in homes, schools and clinics throughout South Africa
- Demonstrate the effective performance of the micro-flush toilet for a range of downstream treatment systems
- Establish links with a ceramics manufacturer with a view to taking the project forwards into full-scale production (additional investment required for production)

Estimated cost: R480 000 Expected term: 2013–2015

NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Revising the DWA guidelines on municipal tariffs for water services

Nelson Mandela Metropolitan University
No. 2356

In their capacity as the policy leader for Water Services Authorities and Providers (WSAs and WSPs) in South Africa, the South African Department of Water Affairs (DWA, now the Department of Water and Sanitation, DWS) have issued guidelines for financial and water services managers involved in setting retail water and sanitation tariffs for standardised piped water service packages; the most recent of which were issued in 2011 (DWA, 2011). The guidelines favour a homogeneity in water service delivery package (a similar quality of piped water service for rich and poor), retail tariff setting to recover the on-going capital and operating costs, a distinction between potable water provision and waste water management (sanitation) services, and retail tariff structures comprised of one or two parts, customised to several different categories of user demand. One part of the tariff structure is related to usage and another to access (and is fixed). The guidelines recommend that the part of tariffs related to usage should rise in incremental steps as household demand does, that is, an increasing (and therefore also non-linear) block tariff (IBT) structure. Not only is a water service tariff structure the key element in raising revenue to offset the costs incurred in provision, it also is a key element in allocating water services provided, and influences a wide range of choices and decisions, many of which are closely linked to local and regional economic development. South African water tariffs are not set endogenously through the interaction of demand and supply, so automatically taking into account a whole range market influences, but within a constitutionally mandated monopoly market setting. As a result setting water service tariffs has largely become a municipal discretion. It is a discretion that requires some negotiation, but also permits a wide range of options, e.g., choosing a water service provider (or composite of firms that will supply), choosing what water service packages will be offered and choosing the revenue-raising mechanisms that will be employed to recover costs. It is also a discretion that can benefit by more informed guidance. This research will provide a context and framework for this discretion to be exercised.

Estimated cost: R1 600 000 Expected term: 2014–2017

Programme 2: Institutional and management issues – Water services

Loss aversion and water conservation

University of Cape Town
No. 2357

As a water-scarce country, South Africa must apply its available water resources in the most efficient and equitable manner possible. In its Water for Growth and Development Plan, identifying water scarcity in major urban centres, the Department of Water and Sanitation has highlighted the importance of water conservation and demand management and, specifically, 'nurturing attitudinal and behavioural changes towards the value of water' Through low-cost and non-pecuniary measures, this project aims to make the 'value of water' salient (explicit) to residential consumers, thereby shifting behaviour towards greater water efficiency. To do so, this study proposes to use insights from behavioural economics to incentivize a reduction in residential water consumption. The study will examine whether the behavioural insight that people are loss averse can be exploited by simple gain/loss framing variations. The behavioural literature shows that individuals are very susceptible to framing and that changing the way we frame options and outcomes can affect individuals' decisions. An outcome of the project will be a clearer understanding of what type of framing most effectively facilitates a behavioural shift towards more efficient water usage and whether it is helpful to make the link between metrics like 'litres used and not used' and 'financial cost and saving' very explicit. Given that these are low-cost interventions, the results from this proposed experiment (for example how to frame messages to consumers) can be incorporated in existing and future information-provision and environmental-awareness campaigns.

Estimated cost: R642 537 Expected term: 2014–2017

Assessing the impacts and achievements of the Strategic Framework for Water Services (SFWS)

Prime Africa Consultants, CSIR

No. 2415

Aims:

- To conduct an assessment of and, where possible, quantify the achievements/failures in implementation and the positive/negative impacts (social, technical, economic, biophysical) of the SFWS
- To assess and identify the gaps, critical challenges, and areas required for improvement of the SFWS to address the current water sector context in the country
- To determine the factors affecting success/failure of the SFWS and provide recommendations on how to address these gaps, challenges, and areas required for improvement in a reviewed SFWS
- To provide recommendations on how to align the reviewed SFWS with new developments, including policy and legislation, in the water sector

Estimated cost: R1 600 000 Expected term: 2014–2016

Risk governance in the South African water sector: business

University of Cape Town

No. 2416

Aims:

- Through a combination of literature reviews and stakeholder engagement, develop a comprehensive understanding of how risk is managed in a wide range of local and international water utilities and institutions
- Through a combination of qualitative and quantitative methods, undertake a high-level benchmarking activity of stakeholders to understand how mature their risk management is
- Understand and identify what strategic and local interventions can be implemented to improve the way risk is managed; interventions need to be specifically designed for the context
- Identify business value-creation benefits and strategic opportunities of integrating risk governance with other business processes

Estimated cost: R800 000 Expected term: 2014–2017

Best practices in sustainable water and wastewater management: a road map to Green Drop and Blue Drop for small- to medium-sized municipalities in SA

Sarah Slabbert and Associates

No. 2420

Aim:

- To research and report best-practice sustainable water and wastewater management in small- to medium-size municipalities and produce a fourth WIN-SA lesson series

Estimated cost: R500 000 Expected term: 2014–2015

Programme 3: Innovative management arrangements – Rural water supply

Dealing with land tenure and tenancy challenges in water and sanitation services delivery in South Africa: Policy options and opportunities

University of the Western Cape

No. 2358

Amid rapid urbanization in South Africa, the challenges of tenure and tenancy seem to detract from the efficacy of on-going efforts to improve access to urban water and sanitation services for the urban poor and marginalized. The proportion of people without sustainable access to safe drinking water and basic sanitation, a significant proportion of people living under complex mixes of formal and informal tenure arrangements in low- and middle-income areas, continue to cope with water insecurity or express dissatisfaction about water and sanitation service. Although there is a paucity of reliable data on the burgeoning of populations in urban informal economies and, therefore, achievements in access to water and sanitation, it is plausible that this growth may have exacerbated service delivery backlogs and probably reversed some of the gains made towards progressive realization of the access right to water and sanitation. Challenges such as these underscore the need for in-depth review, empirical and action research to develop clear understanding of the ways in which tenure and tenancy affect access to water and sanitation services, particularly for the urban poor, informal tenants and informal settlement dwellers, whose needs for improved services tend to be greater than those of other groups of people living in urban areas. Some

of the pertinent research questions are: How is the mix of land tenure and tenancy arrangements within and/or outside the ambit of the formal land registry system characterised, and what is its effect on access to and provision of water and sanitation services. To what extent do current pro-poor service provision strategies take differences in tenure and tenancy profiles into account? How do tenure security and tenancy arrangements affect patterns of access to and investments in water and sanitation services? What are the appropriate service models for different tenure and tenancy profiles? What is the role of formal and informal service providers in this regard, and how can stakeholders, such as the state, non-governmental organizations (NGOs), civil society organisations (CSOs) and the private sector, support this? In the context of rapid urbanization, clear understanding of complexities associated with the mix of formal and informal tenure and tenancy challenges will contribute to enhancing institutional preparedness and mechanisms to improve access to water and sanitation by the urban poor, marginalized and vulnerable living in low- and middle-income areas. Ultimately, the impacts of this should be social integration, as opposed to fragmentation, as well as better quality of life, dignity, affirmation, enhanced social capacity and well-being.

Estimated cost: R1 890 000 Expected term: 2014–2017

Programme 4: Regulation of water services

Extending performance monitoring and analysis in South Africa

Nelson Mandela Metropolitan University
No. 2359

There is much that has been achieved in the monitoring of municipal service performance through Blue Drop and Green Drop ratings. It is also being demonstrated in WRC Project K5/2118 (ongoing) that relative efficiency can also readily be monitored and cost-efficiency indices calculated by applying stochastic frontier analysis (SFA) and data envelopment analysis (DEA). The initial findings of relative efficiency analysis for a significant sample of South African municipalities were presented for the first time at a WRC-SALGA National Seminar. At this seminar a number of challenges were raised about the relative efficiency monitoring. This proposal motivates addressing selected challenges as well as adding in to overall performance assessment a measure for rating consumer satisfaction. Many have expressed concerns with all forms of performance monitoring in South Africa on the grounds that the data is unreliable. Specifically with respect to relative efficiency benchmarking the concern is that the water service outputs reported were less than what was really being delivered, for instance, that large chunks of the service were, in fact, not operational for substantial periods and that this inflated efficiency ratings. In order to address this concern and preserve the integrity of the results, some form of data audit is required. All of the current performance ratings applied or proposed are supply-side ones. The demand-side ratings are missing in South African municipal water service performance assessment. This shortcoming can be addressed through a consumer satisfaction rating, capable of assessing different components/attributes of the service and likely to be relatively immune to strategic bias and political and bureaucratic manipulation.

Estimated cost: R850 000 Expected term: 2014–2016

Programme 5: Water services education and awareness

Islamic jurisprudence and conditions for acceptability of reclamation of wastewater for portable use by Muslim users – case study of eThekwini Municipality

University of Cape Town
No. 2360

Recycling of water – desalination, reclamation of wastewater and reuse of grey-water are the key approaches being advocated to deal with the growing constraints of freshwater. None, however, is as controversial as the reclamation of wastewater for portable use, especially amongst the followers of Islam. A recent announcement by a Metro on its intentions to reclaim wastewater for potable use, resulted in huge opposition and rejection from members of the community of the Islamic or Muslim faith. Yet the reality is that many places in South Africa have very little choice and out of need/survival have opted for reclamation. Last year the George and Mossel Bay regions suffered major water shortages and opted for desalination as an option to augment their water supply. The objections are based on the notion that the water does not comply with religious requirements. The questions arise as to whether these sentiments are based on perceptions created by myth or

whether they are factual. What do Islamic jurisprudence, the Quran and the Sunnah mention? More interesting is, should the facts from an Islamic perspective be supportive or accept the reclamation, would that fact in itself be sufficient to shift the mindset or perceptions and attitudes of Muslims towards acceptance of reclamation of wastewater for potable use, including drinking? This is what this study aims to explore.

Estimated cost: R360 000 Expected term: 2014–2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Establishing the current practice and prospective management strategies for water treatment residues handling, disposal and reuse in South Africa

Umgeni Water

No. 2361

The increasing demand for potable water has led to increased sludge production, which has led to WTRs becoming of increasing environmental and financial concern. Historically, there have been numerous WTR management practices utilised internationally including disposal through discharge to sanitary sewers, streams or similar bodies of water, landfill (onsite or off-site) and land application (agriculture, forestry and land reclamation), which is the practice most utilised in South Africa. These management methods have recently been questioned due to possible risks to both public health and aquatic life. With continuous WTR production it has become apparent that there is a need for the development of new and improved WTR utilization and disposal technologies that will be sustainable in the long term. Thus the aim of this study is to investigate alternate options for WTR recycling/reuse under South African conditions as well as to determine the changes needed to optimise and secure recycling opportunities. This study will provide guidance on the cost and economy of scale applicable to specific WTR management practices as well as suitability for recycling/reuse. It will also provide recommended actions and changes needed to optimise and secure WTR recycling opportunities. The most cost-effective method of management for the different WTRs will be suggested, potentially saving water treatment plants costs and bringing down the production cost of potable water.

Estimated cost: R1 000 000 Expected term: 2014–2016

Green synthesis and demonstration of a low-pressure low-fouling mixed matrix nanofiltration system for drinking water treatment

University of Johannesburg

No. 2362

The fabrication of novel nanoporous polymers and membranes from polymer nanostructures (e.g. cyclodextrins, polysulfone, polyvinylidene fluoride, and cellulose acetate) has been extensively explored. Most of the studies involved exploring mixed matrices (composites) of the polymers that contained nanomaterials (e.g. carbon nanotubes, silver nanoparticles, iron-nickel nanoparticles, etc), which sought to improve the mechanical strength, hydrophilicity, anti-fouling properties and pollutant rejection capacities of the nanocomposites. In this proposed study, an integrated nanofiltration membrane/composite system that has the complementary strength of ceramics and polymeric membranes, i.e., a membrane material with the high thermal, chemical, and mechanical stability observed with ceramic membranes, while retaining the ease of manufacturing, high packing density, and favourable economics of polymer-based membranes, will be synthesized. Such systems can play a crucial role in purifying water in rural settlements in South Africa, wherein hundreds of thousands of households still rely on river and borehole water for drinking and cooking purposes. The proposed integrated (mixed matrix) membrane/composite nanofiltration system will be synthesized by applying the 12 principles of green chemistry and engineering.

Estimated cost: R915 000 Expected term: 2014–2017

Development and testing of novel metal-modified natural clay-based adsorbents for groundwater defluoridation

University of Venda

No. 2363

Groundwater is the most appropriate and widely used source of drinking water for many rural communities in South Africa. However, the presence of fluoride concentrations above the

recommended limits for drinking water requires defluoridation. A number of methods for removing fluoride from groundwater have been developed, including chemical precipitation, membrane processes, adsorption and ion exchange. Of all these technologies developed so far, adsorption has been considered as the most efficient and applicable technology for fluoride removal from ground and surface water in rural areas. In this study, the development and testing of new or modified adsorbents using locally-available adsorbents with improved fluoride uptake properties, to meet the stringent legislative requirements of 1.5 mg/L of fluoride in drinking water, is explored. The use of locally-available adsorbents for evaluation and application as adsorbents for point-of-use water defluoridation systems for rural areas is a sustainable solution. The potential application of bentonite clay and diatomaceous earth modified with selected high charge density cations such as Fe^{3+}, Al^{3+} and Mn^{2+}, introduced as metal cations, metal hydroxides/oxy-hydroxides or metal oxides will be tested.

Estimated cost: R690 000 Expected term: 2014–2017

Degradation of emerging micropollutants by combined advanced oxidation with immobilized plasmon titanium dioxide nanocomposites in an electrohydraulic discharge reactor

University of the Western Cape

No. 2364

The pharmaceuticals and hormones which are generally produced to accelerate physiological responses in humans are now regarded as a potential threat due to their inherent lipophilic nature and potential to harm human health. Human exposure to PPCPs/EDCs equally has been shown to result in testicular, breast and ovarian cancers, low sperm count and retarded fertility. Electrohydraulic plasma discharge is a novel water-cleaning technology which has recently gained research interest, mainly due to its high efficiency, high speed, and zero or less chemicals needed. This technology involves chemical-free degradation and mineralization of emerging micro-pollutants and microbes which is essential to maintaining public health. Recent studies supported by the WRC at UWC have proved the concept of the advanced oxidation process coupled with a photocatalyst and several patents have been filed. Hence, the aim of this study is to further develop the understanding and application of this new emerging technology to tackle the problem of PPCPs/EDCs in our aquatic environment and water systems, in order to preserve the natural aquatic environment and maintain sound human health. The present study investigates outstanding issues with regards to the novel integration of the plasmonic photocatalyst into the advanced oxidation system. Combining plasmon-enhanced photocatalytic material such as semiconductor TiO_2 with electrohydraulic discharge reactor in an advanced oxidation system, as is proposed in this study, would enhance the photocatalytic oxidation efficiency of PPCPs/EDCs/antiscalants because the reaction would be accelerated by both the high-energy plasma species and the UV emission as well as the plasmon-enhanced photocatalyst.

Estimated cost: R787 400 Expected term: 2014–2017

Functionalized electrospun and cast nanocomposites for the removal of organic matter and bacteria from surface water

University of Johannesburg

No. 2365

Water pollution is a persistent global problem that emanates from increased anthropogenic effects. Polluted water usually contains bacteria, viruses, protozoa, minerals, organic matter and many pollutants in quantities beyond the acceptable limits of water quality standards, therefore requiring treatment before use. Water may be treated using different approaches, depending on the quality of the raw water which enters the plant. Traditionally, adsorbents are used; however, the majority of these suffer drawbacks such as poor pollutant binding capacity as well as weak mechanical strength. In addition, some of these sorbent materials are prone to degradation by chlorine. This study is aimed at the development and evaluation of the potential of fabricated filters for removing organics, metals and micro-organisms from contaminated water. The proposed filters will have functional multi-layers of electrospun fibers impregnated with nanoparticle catalysts to form nanocomposite filters or membranes. The nanocomposites will be cast onto membranes to produce strong support materials with tailor-made porosity to ensure no passage of water contaminants. This is necessary as the small contaminant moieties that normally resist conventional treatment can be effectively removed because of the functional groups that act as binding sites for contaminants. Owing to their small diameters, high surface area to volume ratio and low porosity, these nanocomposite filters are very efficient in

removing most of the water contaminants. The significance of this study will be the ease of use of the multi-layered nanocomposites as well as the disinfection of water without addition of harmful chemicals such as chlorine or labile aluminium.

Estimated cost: R650 000 Expected term: 2014–2017

A longevity study into the purification capacity of home water treatment devices (HWTDs) supplied in South Africa

University of Johannesburg
No. 2366

In a recent WRC study (Project number K5/1994//3) the purification capacity of small-scale water purification units manufactured in South Africa was investigated. However this study only established the microbiological, chemical and physio-chemical testing regimes of counter-top and faucet-mounted point of-use (POU) devices within a laboratory environment, over a 3-day period, and did not investigate the longevity or sustainability of the HWTDs filter cartridges within a household environment with municipal tap water, over an extended period of time. Most manufacturers of these devices recommend a HWTD cartridge lifespan of, for example, over 3 months or 1 000 L. Thus this study is an extension of the previous study, and is aimed at further assessing counter-top and faucet-mounted POU HWTDs sold in South Africa in terms of their product approval and regulatory certification standards to produce potable water that meets SANS 241:2006 water quality standards, as well as the criteria set out by the NSF (P231, 42, 44, 53, 58) for drinking water purification units, over an extended period of time. The HWTD device cartridges that were assayed within the previous study will be exposed to a testing regime within a household environment using municipally-treated tap water over the manufacturing recommended lifespan of the device, in order to determine their durability and endurance to produce purified water in regulation with SANS 241:2006 and NSF standards and so fully assess their capacity to provide safe drinking water for domestic, public and occupational use over an acclaimed time frame. Results obtained will provide guidance to local governing authorities on improving legislation by-laws in relation to POU small-scale water purification device approval and distribution in South Africa, as well as educate the general public on the safe and proper usage of HWTDs.

Estimated cost: R632 320 Expected term: 2014–2016

Evaluation and selection of an appropriate automatic coagulant dose control system for conventional water treatment plants

Umgeni Water
No. 2396

The water industry is currently facing increased pressure to produce higher quality treated water at a lower cost. The coagulation-flocculation process is a major step in the production of potable water which allows the removal of colloidal particles. The main complexity is to determine the optimum coagulant dosage related to the incoming quality of raw water. Currently both manual and automatic methods are available to predict optimum coagulant dosage rate. Automatic coagulant control is ensured mainly by streaming current detectors (SCD), which measures the residual charge on colloidal colour and turbidity particles in the water. As these particles have a negative charge and the coagulant ions have a positive charge, the amount of coagulant added dictates the magnitude and sign of the net electrical charge. The system controls this net charge at a set point which has been shown by jar testing to provide close to optimum coagulation under a certain range of raw water conditions. Thus the current study is aimed at evaluating and selection of appropriate dosing control equipment and development of a mathematically-based algorithm to predict the relationship between incoming raw water quality and coagulant dose. Preliminary investigations have shown that there is a non-linear relationship between the coagulant dose and ion charge analyser readings. The project will address the applicability of the streaming current detector principles, various types of raw water quality, and mathematically-based models to achieve optimum coagulant dosages. Other types of coagulants will be tested as well; these are the polymeric organic (aluminium sulphate) and inorganic coagulants (ferric chloride). Investigations will be conducted on a laboratory scale where the control system will be applied and possibly on a full-scale plant.

Estimated cost: R450 000 Expected term: 2014–2016

Programme 2: Water treatment for rural communities

Application of high-throughput green liver systems for sustainable water purification using endemic aquatic macrophytes

Nelson Mandela Metropolitan University
No. 2367

This study investigates the development and use of a low-technology, low-maintenance and low-cost biological system based on the 'green liver system' for the treatment of xenobiotics in raw waters, either at source or prior to abstraction. The green liver system is not a new concept; it has been successfully implemented in China and Brazil. In this study selected endemic aquatic macrophytes will be evaluated, in various combinations and ratios, in a sequential exposure model, for their ability to bioaccumulate and/or biotransform environmental toxins and xenobiotics, and selected as components of the green liver consortium. The optimized model system will be further evaluated for tolerance to physico-chemical and flow rate variation, and pollutant load. The proposed system should also be suitable for purification of an impoundment in situ. The use of this system has several advantages: it prevents damage to the biological component from grazing or other land use, the biological consortium can be purpose designed for the particular pollutants, and the addition of a fuel pellet production component encourages harvesting and maintenance of the green liver system. Such benefits do not exist in traditional ponding or wetland systems. The limited successes of wetland systems is largely due to the very large footprint, limited flow, inability to easily manipulate populations for specific desired xenobiotics, and the eventual bioaccumulation of the xenobiotics within the system.

Estimated cost: R450 000 Expected term: 2014–2017

Design, construction and monitoring of a sustainable domestic rainwater harvesting multi- tank treatment station at a central location in Enkanini informal settlement, Stellenbosch

Stellenbosch University

No. 2368

The provision of a continuous and sustainable water source to rural and informal communities is a priority identified by the Department of Water and Sanitation (DWS). Domestic rainwater harvesting (DRWH) can be promoted as a core adaptation strategy and has been earmarked as a short-term intervention to provide water, especially to dispersed settlement areas. Numerous DRWH tanks have been implemented by the DWS, in eight provinces, as an alternative water supply and for food production. However, a previous WRC study has shown that possible health risks associated with the consumption of harvested rainwater can hamper the large-scale implementation of DRWH, as microbial and chemical contaminants have previously been detected in rainwater tanks. Thus in this study it envisaged that the design, construction and monitoring of a sustainable domestic rainwater harvesting multi-tank station, with on-site treatment systems (based on the results obtained from the pilot scale deliverable for the WRC research project K5 2124 3) will not only alleviate stress placed on the standpipe municipal systems, but will also produce water for domestic and potable purposes, based on the level of treatment provided per respective tank. Furthermore, a pamphlet (Xhosa, English and Afrikaans) containing general information on domestic rainwater harvesting, the identified primary uses per tank and advice on water storage will be developed for the users. Community members will also be trained on major and continuous maintenance and repair of the DRWH tanks and treatment systems using a compiled manual. The operational sustainability and the capacity of the tanks to service numerous households' daily water needs will also be monitored.

Estimated cost: R900 000 Expected term: 2014–2017

Programme 3: Drinking water quality

Emerging contaminants in wastewater treated for direct potable re-use: the human health risk priorities in South Africa

Chris Swartz Water Utilisation Engineers

No. 2369

The use of treated wastewater for direct potable applications can play an integral role in meeting future water demands. However, the possible presence of emerging contaminants in reclaimed municipal wastewater is of critical concern because of potential adverse impacts to human health. Specific health effects criteria in the evaluation of water recycling for human consumption include (i) primary health concerns of wastewater reuse that are the long-term health outcomes of ingesting chemical contaminants found in recycled water, (ii) health risks of using recycled water as a potable water supply compared to similar risk for conventional water supplies, and (iii) the need for extensive toxicity monitoring programmes. Much research has been done in Southern Africa and overseas on water reuse. However, to date there are no guidelines on reuse for the South African water sector. This project will therefore be limited to identifying emerging contaminants

of concern in reclaimed potable water, their sources, pathways and receptors, potential risk from exposure to these chemicals, performance of water reclamation treatment systems and risks for potable water reuse in South Africa. Assessment of direct potable reuse systems in South Africa for the removal of contaminants that may have negative health impacts will provide a good basis for the development of South African guidelines for implementation of barriers, monitoring programmes and assessment programmes to eliminate or minimise risks and which can improve public acceptance of reclaimed water.

Estimated cost: R1 500 000 Expected term: 2014–2017

Programme 4: Water distribution and distribution systems

State-of-the-art in advanced metering technology and application

University of Cape Town
No. 2370

The water meter industry has seen substantial developments in the last two decades, with many new capabilities added to water meters. These advanced water meters (also called intelligent or smart meters) can be used for much more than just consumption metering. Advanced meters have several significant advantages, such as saving costs by eliminating conventional meter reading, billing and debt management systems; providing simultaneous readings for multiple users allowing more accurate water balance calculations to be done; assisting poor users to manage their free basic allowance; and enhancing water demand management and water loss control. However, advanced metering systems also have important disadvantages, such as a higher failure rates (due to electronics, batteries and more components) than conventional meters; higher supply and maintenance costs; susceptibility to tampering and vandalism; and concern regarding rights of access to water. It is also a new industry with many teething problems that will still have to be addressed. The aim of this project will be to determine the state-of-the art in developments and application of advanced water metering to allow municipalities to understand the available technology and how best to utilise it. The project is focused on how to use advanced water metering in a sustainable way for providing communities with water supply within the bounds of cost of service provision and limited water resources. A major aim of the project is to assist municipalities with information on decision making regarding advanced water metering.

Estimated cost: R1 280 000 Expected term: 2014–2017

The impact of leak–soil interaction on leak development and detection in water distribution systems

University of Cape Town
No. 2371

Leakage from water distribution systems is a worldwide problem, which is likely to intensify as systems age and available water resources are stretched to their limits. Leaks form in all pipe materials, and thus municipalities must have processes to identify and repair new leaks as they form. The simplest way to find a leak is when it is observed or reported after becoming visible above ground. Other leak detection methods include the monitoring of district metering area flow patterns, analysis of the noise emitted by leaks and inspection of the internal pipe surface. A question that hasn't received much research attention is under what conditions a leak will become visible above the ground. Water distribution pipes are typically buried below meters of graded sandy soils that may facilitate water draining away from the surface. In a recent experimental study it was found that even jets directed vertically upward did not penetrate about 30 cm of an ideal soil, while sustaining a pressure of 25 m in the pipe. The work showed that a fluidised zone of soil and water is created on the outside of a leak that is responsible for dissipating the vast majority of the energy of the water jet, thus substantially limiting the leak's ability to reach the soil surface. Another implication of the fluidised zone is that the high velocities of the soil particles may cause scouring of the outer pipe surface, especially in pipe materials that don't have much abrasion resistance, such as PVC. Evidence of such scouring has emerged from failed pipe samples taken from the field, showing that the pipe material is removed by the soil action, eventually increasing the size of the leak. This may cause even small leaks in PVC pipes to eventually become major problems; however, very little research has been done on this phenomenon. Thus this study will develop an understanding of the fluidisation phenomenon outside leaks in water distribution pipes, and its implications for the development and discoverability of leaks. While the longer-term goal of this work is to develop a theoretical model for the fluidisation phenomenon based on the fundamentals

of fluid mechanics, the aim of this project will be to investigate the direct impact on leakage in water distribution systems.

Estimated cost: R700 000 Expected term: 2014–2017

The effect of age on the friction of large-diameter potable water cement mortar-lined pipelines

University of KwaZulu-Natal (Howard College Campus)
No. 2372

Most of Umgeni Water's large diameter potable water pipelines are constructed from steel with a cement mortar lining. Potable water which passes through these pipelines is, in some instances, treated with chlorine and in others with chloramine. In undertaking designs of new pipelines an estimate of the pipeline friction factor is used to determine the pressure along pipe routes through the development of hydraulic grade lines. This information is further used to determine appropriate pipeline wall thicknesses and pumping heads. The friction factor used, therefore, has a direct influence on the cost of the infrastructure that will be implemented. Studies have been undertaken internationally as well as in South Africa to predict how friction of pipelines changes with age. There seems, however, to be limited information relating to friction in cement mortar lined potable water pipelines and how this changes with age. Studies show that biofilm growth on the pipe wall also affects the friction factor. Some researchers have shown a linear relationship between pipe age and roughness. Other studies contradict this because the biofilm processes such as attachment, growth and detachment are non-linear. The rate at which biofilm grows/detaches are dependent on the concentrations of chlorine and chloramines, thickness, flow velocity and other factors. Studies also demonstrate that if the biomass is algae, then the disinfectant plays a very small role in controlling it. So, it is important in this study to do a detailed analysis of the relationship with disinfectant, biomass growth, and water and pipe age. Accounting for sustainability in pipeline design requires a means to determine the correlation between age and friction in potable water cement mortar lined pipelines which transport either chlorine- or chloramines-treated water. This study will provide support for decision makers to decide pipe sizes to deliver the required quantity of treated water to end users. Appropriate pipe size considerably reduces the cost of a pipeline during the planning and construction phase. Analysis of the factors that influence the pipe roughness will be used to select suitable water supply/treatment practices which directly and/or indirectly minimize head losses for reducing running costs. This analysis also provides knowledge about pipeline maintenance that has economic impact.

Estimated cost: R354 000 Expected term: 2014–2016

Updating WRC water demand management software for latest operating systems

WRP Consulting Engineers (Pty) Ltd
No. 2373

Since the early 1990s, the WRC has been providing support to municipalities throughout South Africa to address leakage and wastage from reticulation systems. South Africa was one of the first countries outside of the UK to embrace the Burst and Background Estimate (BABE) methodology which was initially developed by a number of experts from various UK water companies. The BENCHLEAK model developed in South Africa was created to ensure that South African water utilities had free access to software which would encourage the use of the standard IWA water balance. Once again this was the first model of its type and led to the development of many similar models which were used throughout the world. The BENCHLEAK model also helped to promote the concept of the Infrastructure Leakage Index (ILI) throughout southern Africa and in turn led to a large-scale study of ILI values for almost 100 systems countrywide. BABE models developed through the WRC include the original BENCHLEAK water balance model which was initially developed as a simple Excel spreadsheet and has now been superseded by the AquaLite Model. The SANFLOW model used to analyse minimum night flows was one of the WRC's most popular downloads due to its ease of use and simple design. The various models continue to operate properly on some Windows operating systems but not on some of the later systems. It is proposed that the software is re-designed where necessary to accommodate the latest Windows operating systems; the possibility of creating an iPad version should also be investigated. The aims are therefore to upgrade the existing models to ensure that they are fully operational on all current platforms and operating systems. In addition, it is proposed to convert SANFLOW, PRESMAC and AquaLite to run on an iPad and create an app so that they can be downloaded worldwide.

Estimated cost: R520 000 Expected term: 2014–2015

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Understanding the mechanistic interactions of engineered nanomaterials (ENMs) with biological treatment systems during wastewater treatment – a case of metal and metal oxide ENMs

CSIR (Pretoria)

No. 2374

To protect human health and promote environmental integrity, research towards understanding ENM interactions with WWTP biological treatment systems is crucial. Such knowledge will be useful in developing treatment technologies suitable for ENM removal from wastewater systems. This study is a continuation of a previous WRC project titled 'Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems (K3/2122/3)'. Whilst the previous project mainly focused on the general fate and behaviour of ENMs in wastewater, this work seeks to generate data and knowledge that elucidates the nature of interactions between the ENMs and the biological treatment system as well as understanding plausible elimination mechanisms for ENMs in WWTPs. The results will constitute critical knowledge necessary in the development of wastewater treatment technologies to deal with contaminants with nanoscale dimensions, so as to protect South African ecosystems. This study will investigate the metal and metal oxide ENMs behaviour in wastewater to evaluate their removal over long-term exposure to wastewater, dissolution behaviour, and bio-sorption behaviour on non-viable and viable aerobic biomass.

Estimated cost: R1 200 000 Expected term: 2014–2015

A feasibility study to evaluate the potential of using WSD design principles to strengthen planning for water-sensitive cities of the future

City of Cape Town; University of the Western Cape

No. 2412

Aims:

- Conduct a scoping exercise to evaluate suitable sites for a feasibility assessment study. This exercise will also evaluate the vision, strategy, organisational structure (i.e. planning divisions), resources, budgets and implementation strength of the institutions that may be involved in adopting WSUD
- Engage and share the water-sensitive urban design concept, framework and guidelines with relevant stakeholders and ensure buy-in of stakeholders throughout the project cycle
- Provide a baseline assessment of the selected catchment/s with relevant implementation partner/s
- Set specific WSUD objectives for the selected catchment with realistic design and performance objectives – including a comparative analysis between conventional design and WSUD objectives
- Screen and evaluate the feasibility of the WSUD options within current best planning and management practices, including the selection of appropriate technology options to meet design, cost and performance objectives
- Where possible, develop suitable templates for the various activities and recommend development of new tools or guidelines where gaps in knowledge exist
- Present options to key stakeholders and evaluate the feasibility of the options and the barriers to implementation and document opportunities for future potential demonstration partnerships
- Link knowledge and partnerships to the WRC Community of Practice Programme

Estimated cost: R2 000 000 Expected term: 2014–2017

Development and management of a Water Sensitive Design Community of Practice programme

City of Cape Town; University of the Western Cape

No. 2413

Aims:

- Scope potential and current water sensitive design (WSD) project opportunities
- Establish project priorities and their potential to be implemented as WSD research projects
- Develop and maintain 'Learning Alliances'
- Scope institutional challenges associated with implementing WSD in the planning and implementing environment
- Strengthen and broaden the WSD researcher base for South Africa
- Develop a WSD project database and website

- Facilitate and coordinate partnerships with relevant sector players to convert potential WSD projects to demonstration projects for consideration by the WRC
- Consolidate WSD project information from additional research projects

Estimated cost: R2 500 000 Expected term: 2014–2019

Programme 2: Application of appropriate technologies and tools

The Activated Sludge Bios – a real-time tool to evaluate activated sludge process performance

Durban University of Technology

No. 2376

The activated sludge (AS) process is an internationally acclaimed method for wastewater treatment, due to its environmental friendliness and economic feasibility. This biologically driven process could only be realised through the advent of engineered systems, which are designed to exploit naturally occurring biological activities. In these systems, notable interactions are apparent between functional microbial organisms, process configurations and overall operational control, all of which ultimately affect the absolute performance and efficiency of the AS process. For effective management and optimization of the activated sludge process, it is imperative to have a thorough understanding of the possible interactions between the functional microbial organisms and process operations. To date, very little research has been conducted on correlating the dynamics of all functional microbial populations with the works operational conditions and process configurations, worldwide. From previous observations, it was clearly noted that a gap exists in the promulgation of knowledge between various groups in the wastewater community, which subsequently negates a thorough, holistic evaluation of works process performances and thus consistencies. The invaluable information and data generated in the previous project could therefore be used as a basis to expand the current research and to create an easily accessible information source. This study will focus on evaluating a greater number of works including both domestic and industrial WWTW. The overall aim is therefore to develop an interactive web-based tool. This new tool is envisaged to incorporate the current troubleshooting guide and complement it with an interactive, online information hub that establishes a self-sustaining network between wastewater engineers, microbiologists, works operators and the wastewater community at large.

Estimated cost: R1 600 000 Expected term: 2014–2015

Energy use reduction at biological nutrient removal activated sludge plants: application of mathematical modelling to find optimum operating and control strategies

TrueSense Consulting Services

No. 2377

Most WWTPs in South Africa are nitrifying activated sludge plants because of the requirement to at least comply with the DWA's General Standard for final effluent discharge. Therefore most owners face huge electricity costs which continue to increase yearly. In addition, although not yet legislated, the wastewater sector will in the future be required to contribute to the reduction in greenhouse gas emissions. The outcomes from this project, carried out a local ERWAT wastewater treatment plant, will contribute the following to ERWAT as well as municipalities and other utilities in the country:

- Sustainable solutions to reduce operating costs at WWTPs as well as greenhouse gas emissions
- Human capital development through knowledge transfer to wastewater treatment plant operators who will be trained to implement the recommended changes at ERWAT. In addition, the results from the plant will be used by other plant owners to benchmark energy consumption at similar plants thus enabling them to make informed decisions regarding improving energy efficiency.

Estimated cost: R700 000 Expected term: 2014–2015

Programme 3: Stormwater and sewerage systems

A functional description of urban effluent treatment in a rhizofiltration system

Stellenbosch University

No. 2378

The design of the rhizofiltration system potentially offers a sustainable, energy-efficient solution to prevent pollution in South

African rivers. Once proven to be successful at a pilot scale, the results may influence policy and decision makers on water boards and in local governments to suggest the construction of full-scale rhizofiltration systems at strategic locations. Also, the design is such that once proved to be successful at a pilot scale, the construction and upkeep of full-scale rhizofiltration systems can be conducted by unschooled workers from informal settlements along river banks. These communities could therefore be empowered to reduce pollution in their rivers. It is envisaged that the project will ultimately lead to the development of a conceptual model that can be used to guide experimental work and eventually the design of full-scale rhizofiltration systems, as well as better understanding of microbial, physical and chemical interactions within a rhizofiltration system.

Estimated cost: R749 200 Expected term: 2014–2015

Sanitation technology assessment and evaluation

Partners in Development (Pty) Ltd, University of KwaZulu-Natal (Howard College Campus), Sustainability Institute
No. 2414

Aims:

- Develop a sanitation technology assessment & evaluation tool
- Produce a collection of informative sanitation technology dossiers
- Produce a dialogue report to inform future sanitation policy
- Host knowledge dissemination workshops to present the assessment tool to key stakeholders

Estimated cost: R1 315 600 Expected term: 2014–2015

Programme 4: Wastewater sludge and faecal sludge management

Investigating the practice of open defecation post sanitation provision and the practice and implications of ingesting soil which may be contaminated

Partners in Development (Pty) Ltd
No. 2379

The assumption that open defecation ends where toilets begin is faulty. The provision of toilets – as basic sanitation – is a top priority on national and international agendas, and the reason for this is that without toilets people defecate in the open and the faecal contamination of the environment that results is responsible for tragic and preventable death and disease. While the diarrhoeal diseases responsible for a high number of deaths among young children and vulnerable persons receive the most attention, open defecation is also a virtually sure route for the spread of helminthic infections which interfere with growth and cognitive development and impede educational and vocational aspirations. However, while the focus on the provision of toilets to all is an important strategy in the fight to eradicate open defecation, the flawed assumption can be found in many of the campaigns and reports produced by organisations promoting improved sanitation that the provision of toilets can be more or less equated with the eradication of open defecation. Literature investigating open defecation as a preference over using a toilet is scanty. The few reports that do explore this are not specific to the South African context and cultural factors which drive the practice do not always carry from one context to another. This study will investigate the extent to which open defecation continues to occur after the provision of sanitation and document the knowledge, beliefs, motivations, behaviours and attitudes around it in order to obtain the information needed to inform sanitation, health, education and housing interventions.

Estimated cost: R750 000 Expected term: 2014–2015

Programme 5: Sanitation technology and innovations

Towards wastewater biorefineries: integrated bioreactor and process design for combined water treatment and resource productivity

University of Cape Town
No. 2380

This project is focused on development of sustainable process solutions for water-sensitive systems in which water treatment is coupled to value creation – for improved bioresource productivity and a reduced environmental footprint. The project drives towards the integration of production of the clean-water product and that of the C, N and P-based products, by conversion of the organic fractions and salts from the wastewater treated. Specifically this integrated biorefinery system requires effective design of its reactor components to ensure simple and energy-efficient

processes. To achieve this requires a cross-cutting and interdisciplinary approach. Further it requires the research approach to be sensitive to the 'big picture' informed by industrial metabolism, while delivering the detailed technical knowledge of individual unit operations, requiring an integrated team approach. The project has potential to contribute towards the empowerment of communities.

Estimated cost: R600 000 Expected term: 2014–2015

Evaluating the design of existing rural school sanitation infrastructure and developing a model and guidelines for optimal design

Partners in Development (Pty) Ltd
No. 2381

A particularly important aspect of sanitation design which is not yet well understood is the rate at which sludge accumulates and the implications for eventual pit emptying. If the collection chambers in on-site sanitation systems have not been designed with careful thought for the number of learners, rate of accumulation of sludge, adequate drainage and method of desludging, schools can find themselves in a crisis when the pits become full: a situation where they have no functional toilets at all. Knowledge of household pit-filling rates can be applied to school sanitation only to a very limited extent. In contrast to household toilets, school toilets may only be used during the mornings and not at all on weekends. The majority of high school users may defecate only at home, with the result that sludge in school pits has a far higher ratio of urine to faeces. Younger learners may defecate at school more regularly, but still not as often as they do at home. On the other hand, if toilets for males have urinals and these have separate drainage, the sludge in the pit may contain even less urine than typical household toilets. At some schools, toilets may have to cater regularly to large numbers of users during sporting events, while other schools do not host any events. While most school toilets in South Africa are VIPs, some are full-flush toilets connected to a sewerage system, others flush into a septic tank and others may use a low-flush leading to a soak-away. The amount of flush water entering the system will impact the rate of accumulation and the type of degradation, depending on whether conditions are primarily aerobic or anaerobic in the pit. While flush toilets may have the benefit of learners not being able to dispose of rubbish in the toilets, rubbish disposed of in VIPs may contribute to the rate of accumulation. Anal cleansing material at schools could range from toilet paper, in cases where it is supplied by the school, to chip packets, sticks and pages of exercise books, with a different impact on filling rates. In the typical scenario where bins are not provided in loos, it can be assumed that sanitary pads and tampons will be disposed of in toilets as well. Fundamental to better school sanitation design is a better understanding of sludge accumulation at school toilets. The many different forms which school sanitation infrastructure has taken in South Africa have never been evaluated against a single set of criteria. By gleaning the learnings from both the successes and failures across the different designs, an improved model could be developed and guidelines established to ensure that common pitfalls are avoided and best practice is followed. The model and system design guidelines produced during this study will inform policy and decision making in the Department of Education, as well as local government which may get involved in the delivery of sanitation to schools.

Estimated cost: R1 500 000 Expected term: 2014–2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Strategic assessment and mapping of opportunities for water desalination and water-use optimisation of concentrated solar power generation in South Africa

Escience Associates (Pty) Ltd
No. 2382

South Africa has a high resource potential for the use of concentrated solar power plants (CSPs), but it has limited water resources. An integrated CSP cost efficiency and water usage model will be developed for the three major CSP technologies incorporating air cooling, hybrid cooling and evaporative cooling (evaporative cooling will be used as benchmark and will consider freshwater and saline water options) and will be used to identify areas most suitable for CSP development from a cost and water usage point of view. This model will then give an accurate indication of the cost per MWh produced on an hourly basis for locations

within South Africa with suitable solar resources. Distance from existing and planned transmission infrastructure and distance from transport infrastructure will be included, to give an indication of infrastructure-related costs for each location. In considering water availability, freshwater, brackish water, and produced water from other industries will be included. In this way the optimal locations can be chosen for future CSPs so that electricity can be produced by CSPs as cost- and water-efficiently as possible.

Estimated cost: R600 000 Expected term: 2014–2016

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

Long-term forecasts of water usage for electricity generation: South Africa 2030

Quantitative Evidence Research cc

No. 2383

Water and energy are key resources required for social and economic wellbeing and both are increasingly scarce. Extracting, delivering and disposing of water requires energy and extracting and refining fuels and producing electricity requires water. This water–energy nexus is becoming increasingly important due to increasing energy demands and decreasing freshwater supplies. While it is estimated that power plants account for approximately half the global industrial water withdrawal, limited studies have investigated the water–energy nexus in South Africa. The aspect of water usage becomes critical when taking into account the state of water scarcity. The objective of this project is to fill this knowledge gap and identify current water requirements for electricity production currently, and, based on future electricity demand projections, to develop conditional forecasts for the demand on water supplies. This work will be important for water and energy policy development.

Estimated cost: R306 000 Expected term: 2014–2015

Revision of Natsurv 5: Water and Wastewater Management in the Sorghum and Beer Industry (Edition 2)

CSIR

No. 2384

The Natsurv reports of the different industries have been well used by the sector. However, South African industrial sectors have either grown or in some cases shrunk considerably since the first editions were published, in the 1980s. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. This project will review Natsurv 5: Water and Wastewater Management in the Malt Brewing Industry, since industrial production of sorghum beer has increased over the last 20 years, and, malting sorghum for traditional beer brewing has developed significantly into a large-scale commercial industry.

Estimated cost: R700 000 Expected term: 2014–2015

Revision of Natsurv 7: Water and Wastewater Management in the Red Meat Industry (Edition 2)

JR Muller & Associates

No. 2385

The Natsurv reports of the different industries have been well used by the sector. However, South African industrial sectors have either grown or in some cases shrunk considerably since the first editions were published, in the 1980s. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. This project will review Natsurv 7: Water and Wastewater Management in the Red Meat Industry, published in 1989, since which date the meat industry has been deregulated (resulting in a proliferation of small abattoirs), and meat-processing technology has improved.

Estimated cost: R700 000 Expected term: 2014–2015

Revision of Natsurv 6: Water and Wastewater Management in the Edible Oil Industry (Edition 2)

Chris Swartz Water Utilisation Engineers

No. 2404

Aims:

- To review and document water and wastewater management within the edible oil industry as part of the first stage of revisions of the Natsurv series 1 to 16
- Provide a general overview of the edible oil industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes

- Determine the water consumption and specific water intake (local and global targets and benchmarks)
- Determine the wastewater generation and typical pollutant loads
- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14 000 to name a few
- Provide recommendations for best practice

Estimated cost: R750 000 Expected term: 2014–2016

Revision of Natsurv 8: Water and Wastewater Management in the Laundry Industry (Edition 2)

Cape Peninsula University of Technology
No. 2405

Aims:

- To review and document water and wastewater management within the laundry industry
- Provide a general overview of the laundry industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes
- Determine the water consumption and specific water intake (local and global targets; benchmarks).
- Determine the wastewater generation and typical pollutant loads
- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life-cycle assessments, water footprints, and ISO 14 000, to name a few
- Provide recommendations for best practice

Estimated cost: R700 000 Expected term: 2014–2016

Revision of Natsurv 12: Water and Wastewater Management in the Pulp and Paper Industry (Edition 2)

Prodomos Technologies (Pty) Ltd
No. 2421

Aims:

- Provide a detailed overview of the pulp and paper industry in South Africa, its changes since 1980 and its projected change(s). Representative samples of the respective industries will be used as case studies.
- Critically evaluate and document the 'generic' industrial processes of the pulp and paper industry in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critically evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name a few. Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution.
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000 Expected term: 2014–2016

Revision of Natsurv 17: Water and Wastewater Management in the Steel Industry (edition 1)

Prodomos Technologies (Pty) Ltd
No. 2422

Aims:

- Provide a detailed overview of the steel industry in South Africa, its changes since 1980 and its projected change(s).

Representative samples of the respective industries will be used as case studies.

- Critically evaluate and document the 'generic' industrial processes in terms of current practice, best practice and cleaner production.
- Determine the water consumption and specific water consumption (local and global indicators, targets; benchmarks, diurnal trends) and recommend targets for use, reuse, recycling and technology adoption.
- Determine wastewater generation, and typical pollutant loads (diurnal trends) and best practice technology adoption.
- Determine local electricity, water, and effluent prices and by-laws within which these industries function and critical evaluate if the trends and indicators are in line with water conservation demand management and environmental imperatives.
- Critically evaluate the specific industry water (including wastewater) management processes adopted and recommend fundamental principles and guidelines that are important for the water users.
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, wastewater treatment and reuse, best available technology and ISO 14 000, to name a few. Provide and outline the manner in which industries may prevent, minimize and mitigate possible water pollution
- Provide recommendations on the best practice for this industry with the aim of developing a comprehensive guide to the industrial sector to meet the Department of Water and Sanitation's regulatory requirements.

Estimated cost: R850 000 Expected term: 2014–2016

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

Nanoparticles for the treatment of industrial scale effluents – particularly the removal of organic contaminants from textile effluents using nano-TiO_2

Cape Peninsula University of Technology
No. 2386

Textile production is a water-intensive and potentially highly-polluting activity, and the treatment of textile industry wastewaters is a topic of considerable research. At the same time, engineered nanomaterials for wastewater treatment, immobilized in robust industrial-scale systems, are emerging technologies currently receiving international attention. The aim of this project is to assess some of the emerging nanotechnologies for wastewater treatment to contribute to water and energy savings in the textile industry for sustainable economic development in Southern Africa.

Estimated cost: R1 250 000 Expected term: 2014–2016

The use of modified multi-walled carbon nanotubes for the selective extraction of Cr(VI) and mercury from industrial effluents

University of Johannesburg
No. 2387

Hexavalent chromium) and mercury (both inorganic and organic forms) are two priority pollutants, and although treatment methods such as ion exchange, chemical precipitation and reverse osmosis have been used, adsorption has been identified as a key process in metal ion removal due to its efficiency. Adsorption by activated carbons has been popular for both pollutants. However, activated carbon suffers from disadvantages, such as lack of selectivity for a specific pollutant. Carbon nanotubes are a new form of nanomaterials which have been gaining increasing recognition for their applications in environmental remediation, due to their superior adsorption capabilities to conventional adsorbents like activated carbon. This project therefore aims to investigate the use of carbon nanotubes as selective sorbents for the two metals of interest. The emphasis is on multi-walled carbon nanotubes, since these are cheaper, more easy to synthesise and more readily available than single-walled carbon nanotubes.

Estimated cost: R1 000 000 Expected term: 2014–2017

Anaerobic and photocatalytic treatment of textile and distillery wastewater in integrated fluidized bed reactors

Vaal University of Technology
No. 2388

The treatment of many industrial wastes requires the application of robust and costly techniques, which is a major deterrent. It is for this reason that biological methods have proved to be very attractive to both industries and local authorities. However, these systems, used

as stand-alone techniques, are not efficient in treating some high-strength industrial wastewater. Generally, biological wastewater treatment, especially anaerobic digestion (AD), has been the technique of choice for many years due to its simplicity and low cost, but AD is challenged by the presence of xenobiotic and recalcitrant compounds. Process efficiency and robustness may be improved by integration with another process, such as ion exchange, membrane processes, or advanced oxidation processes. This study will investigate the development of a combined bioreactor/photoreactor and its applicability to common South African industrial wastewaters.

Estimated cost: R1 200 000 Expected term: 2014–2017

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Prevention of acid rock drainage (ARD) formation from fine coal and tailings fractions by sulphide removal: the role of bioflotation reagents

University of Cape Town
No. 2389

UCT has developed an approach to attaining benign tailings and waste materials for disposal from sulphur-containing fine coal fractions, base metal and gold tailings, either at the point of generation or through the re-processing of waste deposits. The separation is based on flotation with the potential for improved resource productivity in addition to acid rock drainage (ARD) prevention. There is a growing body of literature on the use of biological agents as flotation reagents. In this project, we will investigate the use of bioflotation for both the recovery of coal from coal fines and the recovery of pyrite from both coal fines and base metal tailings fractions. Our aim is that, should successful flotation processes be defined, the flotation reagents would be such that they could be manufactured cost effectively on site using waste organic resources in the vicinity of the site of application, thereby removing the transport requirements. Secondly, such reagents would need to meet the specifications of being non-toxic and completely biodegradable.

Estimated cost: R1 247 513 Expected term: 2014–2018

Programme 3: Minimising waste production

Improving evaporation rates of mining wastewaters

University of the Western Cape
No. 2390

Coal-mining activities generate wastewater, and the minimization of wastewater, through its reuse, or safe re-entry into the hydrological cycle, is a critical part of water management and integral in tackling water scarcity issues. The resulting wastewater brines are complex liquid mixtures of different salts with a composition that varies depending on the water process system used to produce the final saline effluent. As a result of the large quantities produced and due to its chemical composition, there is a need to properly and safely dispose of the brine solution. Evaporation ponds evolved years ago, and they are still considered the most effective brine management option due to several advantages which include easy construction, low maintenance and little operator attention. Predicting the evaporation rate of the pond is critical in effective management of the brine disposal holding area. This is a concern with increasing salinity due to the large amount of dissolved salts in the ponds, as this results in a decreased rate of evaporation. The consequence of this is the need to build additional ponds, which requires large areas of land. The objective of this study, therefore, is to investigate methods to improve the evaporation rate of brine in ponds using chemical and halophilic biological colouring agents to increase the absorption of insolation.

Estimated cost: R1 795 960 Expected term: 2014–2018

The synthesis of highly selective immobilized ligands for extraction of toxic metal ions from waste water

University of the Western Cape
No. 2391

It was reported by Madzivire et al. (2012) that the concentration of radionuclides in Rand Uranium mine-water was above the target water quality range (TWQR) for potable water set by the Department of Water and Sanitation by a factor of 12. Generally, discharges of radioactive elements such as uranium, thorium and strontium to surface and groundwater originate from anthropogenic sources. Although there are a number of conventional extraction methods that remove radionuclides from water using ligands, in most cases the ligands are destroyed and the metal ions cannot be recovered for re-use. This means new ligands must be produced

for each treatment cycle, and the spent ligands carrying the radioactive ions must be disposed of responsibly. The purpose of this project is to develop a method which will enable the recovery of both the ligands and the metal ions so that both can be reused.

Estimated cost: R765 362 Expected term: 2014–2018

An integrated bioprocess for AMD remediation and renewable energy generation

University of Cape Town
No. 2392

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa and is already having a negative impact on the quality of several important water resources. There are two main sources of ARD in South Africa: firstly the rebound of groundwater through underground workings, which typically has a high volume, low pH, high metal and sulphate load and tends to be restricted to a single discharge point, and is suited to active treatment. The second source of ARD is diffuse, such as spoil heaps, waste rock dumps and open pits, whose waters vary substantially in volume and composition, and are more amenable to passive or semi-passive treatment. This research will result in a design for an integrated, sustainable biological process with the ability to treat low to medium volume ARD streams. The potential for energy recovery, both as biogas and electricity, will be assessed.

Estimated cost: R2 372 862 Expected term: 2014–2019

Application of next generation sequencing and metagenomic analysis to characterise mixed microbial communities involved in sulphur metabolism

University of Cape Town
No. 2393

Acid rock drainage (ARD) remains one of the biggest environmental threats facing South Africa. Biological desalination of ARD has been implemented to some extent, but due to a lack of a detailed understanding of the micro-organisms responsible for the process (mainly due to inadequate methods for identifying and quantifying the microbial ecology within the process unit), it has been applied as a 'grey box'. The advent of culture-independent molecular biology techniques has facilitated a more complete assessment of the microbial ecology, and the most recent advances in metagenomics, combined with either transcriptomics or proteomics have opened the way for deep, genomically-resolved analyses of the metabolic potential of microbial consortia. Genome resolution enables a far more complete view of metabolic capacity and functional roles, as well as evolutionary processes, than is possible using datasets with minimal or no assembly and provides the foundation for community proteomic and transcriptomic measurements. Genome reconstruction-based metagenomics analyses will be applied here to biological ARD desalination. Important information on the metabolic potential of component species and the interactions between community members will be derived.

Estimated cost: R1 754 440 Expected term: 2014–2018

Biogeochemical cycle of mercury in natural and manmade wetland ecosystems affected by gold mining and industrial activities in the Witwatersrand Basin – modelling and remediation

University of the Witwatersrand
No. 2394

Wetlands are essential habitats in the environment since they fulfil a variety of ecological functions. One of the major characteristics of wetlands is their ability to act as chemical sinks. Due to this, they tend to accumulate pollutants that are introduced into the environment such as lead, copper, zinc, chromium and mercury. The nature, the level and the impact of mercury in the environment has not been extensively studied in South Africa, particularly in areas that have been significantly affected by mining activities. The reports are mainly from coal combustion and chlor-alkali plants. No seasonal changes and bioaccessibility have been reported. There is therefore a need to carry out a detailed assessment and evaluation of the impact of mercury in Gauteng, an area very densely populated and with intensive water use.

Estimated cost: R950 000 Expected term: 2014–2018

Programme 4: Mining in the 21st century

Mine water treatment technology selection support methodology and tool

Golder Associates Africa
No. 2395

Mine-affected water and specifically acid mine drainage (AMD) treatment facilities are planned and implemented by the mining industry, using one or more of a selection of available unit operations such as chemical neutralisation, membrane processes, and ion exchange. However, there is a lack of full-scale experience to draw on, which fosters conservatism in the sector and promotes copycat installations which simply repeat other processes that have already been operated at full scale, despite the fact that the process train which is appropriate in one situation is probably not the appropriate process train in another situation. This project will develop a methodology and provide a tool to assess the alternative treatment technologies for a variety of mine waters based on their suitability. This tool can be used by industry to rate and rank alternative embryonic and emerging treatment technologies from the perspective of supporting technology research and development as well as from the perspective of good mine-water treatment practices.

Estimated cost: R500 000 Expected term: 2014–2016

THRUST 6: WATERSMART FUND

Programme 1: Watersmart Fund

WaterSmart app: Testing the impact of a mobile application in consumer-led demand management

University of Cape Town
No. 2408

Aims:

- Develop and test the impact of a mobile application in consumer-led demand management
- Understand which interventions motivate customers, and which do not
- Measure the impact of the app on perceptions and knowledge of water use efficiency
- Measure any actual changes in total monthly water use before, during, and after the project
- Analyse the types of interactions with the app: what was most viewed; what was least viewed
- Capture lessons learnt by the consumers, including recommendations for what they would like to see in the app
- Understand whether this is a viable future method for consumer-led demand management

Estimated cost: R475 000 Expected term: 2014–2016

An investigation of the treatment efficacy of permeable pavements with a view to harvesting stormwater for use in South Africa

City of Cape Town
No. 2409

Aims:

- Undertake an investigation of the treatment efficacy of permeable pavements in South Africa with a view to harvesting stormwater for use
- Assess the design and maintenance of existing permeable pavements and make recommendations for improvements where necessary
- Fine-tune the assessment methodology for South African conditions to test the treatment efficacy of other stormwater management technologies / sustainable drainage system (SuDS) technologies in the future
- Develop a database for collecting performance data for different SuDS technologies operating under varying conditions

Estimated cost: R500 000 Expected term: 2014–2016

Water harvesting toolkit for the climate information portal

University of Cape Town
No. 2410

The project aims to provide a free, accessible (easy-to-use) interactive, web-based toolkit allowing the use of location-specific up-to-date climate data for design of and learning about small-scale rain-water harvesting systems – rooftop, or small headwater dams. In the general case – for example, in the school classroom – the toolkit would provide a practical, interactive illustration of water harvesting principles that would facilitate education around water harvesting and conservation of water. In the more specific case – for example, a rural clinic wishing to catch runoff from roof space – the toolkit would allow design choices to be explored leading to better understanding of the available water resources and better allocation of budget in the design. Specific objectives:

- Establish the data pipeline and application programming interface to allow the toolkit to access climate data in the CIP back-end
- Define the regionally relevant algorithms for (a) calculating water availability for a rooftop case, and (b) automated water balance calculations for a small headwater catchment, based on topography and soil/vegetation parameters
- Develop the interactive user interface
- Develop the explanatory text and graphics for each step
- Integrate the components into a functional user interface for exploring rainwater harvesting
- Present the system at a suitable forum, and refine it to reflect feedback of potential users

Estimated cost: R438 580 Expected term: 2014–2016

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KSA 4

WATER UTILISATION IN AGRICULTURE

SCOPE

The strategic focus in this KSA is on increasing the efficiency and productivity of water use for production of food, forage, fibre, and fuel crops; improving food security; reducing poverty and increasing the wealth of people dependent on water-based agriculture; and ensuring sustainable water resource use. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers is addressed through creation and application of water-efficient production technologies, models and information systems within the following interrelated sub-sectors of agriculture, namely:

- Irrigated agriculture
- Rain-fed agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

The challenge for applied research is contributing to finding sustainable solutions for water use in agriculture, with priority given to innovative new

Gerhard Backeberg:
Executive Manager

products which support economic development and inform decision-making for private business and public policies. In the process of undertaking these research projects, the composition of research teams endeavours to broaden representativeness of Black and female researchers; post-graduate students are trained to improve the expertise of human capital, with research empowering individuals and groups in rural communities.

OBJECTIVES

The strategic objectives of KSA 4 are as follows:

- To increase the biological, technical and economic efficiency and productivity of water use
- To reduce poverty through water-based agricultural activities
- To increase profitability of water-based farming systems
- To ensure sustainable water resource use through protection, restoration and reclamation activities

THRUSTS AND PROGRAMMES

Thrust 1: Water utilisation for food, forage and fibre production

***Scope**:* The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture	***Scope:*** Water productivity can be increased by producing more with the same use of water or by producing the same with less use of water. This requires understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.
Programme 2: Fitness-for-use of water for crop production, livestock watering and aquaculture	***Scope:*** Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in assessment of the fitness-for-use of surface and underground water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

Thrust 2: Water utilisation for fuel-wood and timber production

***Scope**:* The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations	***Scope:*** In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship of water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

Thrust 3: Water utilisation for poverty reduction and wealth creation in agriculture

***Scope**:* The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Programme 1: Sustainable water-based agricultural activities in rural communities	***Scope:*** Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A wide-ranging programme is required to support the sustainable development of rangeland livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities.
Programme 2: Integrated water management for profitable farming systems	***Scope:*** Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

Thrust 4: Water resource protection, restoration and reclamation in agriculture

***Scope**:* The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and people-induced impacts of resource use

Programme 1: Sustainable water resource use on irrigation schemes and within river catchments	***Scope:*** With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and prevent water resource degradation.
Programme 2: Impact assessment and environmental management of agricultural production	***Scope:*** Agricultural decisions to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, have wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

RESEARCH PORTFOLIO FOR 2014/15

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

Water use of fruit tree orchards
CSIR; University of Pretoria; Citrus Research International; University of KwaZulu-Natal (Pietermaritzburg)
No. 1770

The terms of reference for this project required the measurement of the unstressed water use and ancillary variables of at least 4 types of fruit-tree/orchard crops at selected sites to enable modelling using available South African or international models. Furthermore, the conditions stipulated that the selection should be representative of sub-tropical and deciduous fruit trees/orchard crops in winter and summer rainfall areas. Consequently, the decisions of (1) what species to measure, and (2) where to measure them, needed to ensure that the fruit-tree/orchard species and cultivars that were eventually selected met the criteria of at least 4 different species or cultivars; which included both subtropical and deciduous species; and that monitoring sites were located in both summer and winter

rainfall regions, respectively. A ranking procedure was developed to characterize individual crops. The subsequent monitoring of Valencia and navel oranges, apples, nectarines, peaches, pecans and macadamias ensured that the chosen species/cultivars covered summer and winter rainfall zones, evergreen, deciduous and subtropical crops, that included both fruits and nuts. Project activities moved from an initial planning, review and 'desktop-type' stage to a field measurement and modelling phase. Intensive measurements of a range of relevant variables at the various sites were conducted, modelling exercises were undertaken at the respective sites once sufficient field data had been collected, and findings from the respective tasks described above were consolidated. The range and extent of the project was ambitious, with monitoring sites across South Africa. The composition of the multi-disciplinary and well-distributed project team ensured the collection and comparison of fruit-tree water-use data from a wide range of climatic zones and species/cultivars. This has yielded a unique and extensive data set that provides comprehensive knowledge of water-use characteristics and the actual water use of selected fruit-tree/orchard crops under South African conditions.

Cost: R5 567 500 (incl. leverage) Term: 2007–2014

Water use efficiency of irrigated agricultural crops determined with satellite imagery

University of KwaZulu-Natal (Pietermaritzburg); South African Sugarcane Research Institute; Stellenbosch University; WaterWatch; University of Pretoria; University of the Free State; Delft University of Technology

No. 2079

The accuracy of the Surface Energy Balance Algorithm for Land (SEBAL) data products, ET, biomass production and biomass water use efficiency (WUE), was tested extensively (for two important agricultural crops: sugarcane and maize, representing a range of climatic, soils and agronomic conditions, over a period of 26 months, and against field observation and accepted South African crop growth and water balance models) and found to be acceptable. The SEBAL data products were further developed for sugarcane yield estimation and yield forecasting. It can be concluded that these yield estimates and the forecasted cane yield is an improvement on the current method used. It is also important to note that the yield estimates and forecasting can be further improved with frequent and consistent updates with the SEBAL data. The SEBAL yield estimates can be improved for maize with the identification of the exact point of flowering. Also, the integration of SEBAL data sets into a crop forecasting system for maize can prove to be very beneficial. The SEBAL data provided through this project is quantitative and has a spatial dimension. It can be provided over an extensive area, e.g., the entire Lowveld sugarcane production area, but with detail at a 30 m spatial resolution. The quantitative spatial data has many uses for both the sugarcane and maize industry, specifically related to water management and yield estimation. General farming practices can be evaluated in terms of ET, ETdeficit and WUE and recommendations derived, as was done by TSB as part of this project. The spatial SEBAL data has been further developed, to the point of operational application. The integration of the spatial SEBAL data into a simplified version of the CaneSim model for yield estimation and into the existing model for cane crop forecasting, proved that the accuracy and value of the spatial data was recognized by researchers and that the integration process improved the yield estimates and forecasts. It can therefore be concluded that this project was successful in confirming that the degree of accuracy of data products from the Surface Energy Balance Algorithm for Land (SEBAL) model is acceptable for application in South Africa.

Cost: R4 000 000 (incl. leverage) Term: 2011–2014

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

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

Baseline and scoping study on the development and sustainable use of storage dams for inland fisheries and their contribution to rural livelihoods

Rhodes University; University of the Western Cape; SA Institute for Aquatic Biodiversity

No. 1957

South Africa's inland fishery resource endowment has been overlooked as a means of supporting sustainable livelihoods in the

democratic era, lacking a guiding policy and legislation aligned with the country's rights-based Constitution. The absence of an equitable inland fishing governance framework with defined use rights has resulted in growing unmanaged and unsustainable fishing practices, conflicts between resource users, and the perpetuation of Colonial- and Apartheid-era exclusion of rural communities from livelihood and economic opportunities linked to aquatic natural resources. This project aimed to provide a knowledge base to inform the development of policy and institutional arrangements for inland fishery governance. The research approach consisted of a combination of literature reviews, community-based surveys, fishery productivity modelling and stakeholder consultation. Access rights arrangements and legislation were analysed to derive recommendations for reform, and the production potential of South African impoundments was estimated using morpho-edaphic models. Selected fishing communities were surveyed to evaluate the role of indigenous and local knowledge in inland fishery utilisation, and to characterise the role of inland fisheries in rural livelihoods. A series of consultations and workshops were conducted with rural fishing communities, mandated government department representatives, and recreational angling bodies. The results of the reviews and surveys were discussed with government departments to determine options for institutional and organisational arrangements. The organised recreational angling sector was presented with the project findings, and their views on inland fishery governance solicited. The institutional and organisational requirements for inland fisheries governance were then analysed based on the project research results, South African development and environmental policies, and internationally accepted fishery; good governance' norms. Recommendations for institutional and organisational arrangements were presented to the relevant government departments and feedback incorporated into the research reports.

Cost: R4 000 000 (incl. leverage) Term: 2010–2014

Programme 2: Integrated water management for profitable farming systems

Analysis of food value chains in rain-fed and irrigated agriculture to include emerging farmers in the mainstream of the economy

Institute of Natural Resources NPC; University of Fort Hare; Lima Rural Development Foundation; University of KwaZulu-Natal (Pietermaritzburg)

No. 1879

South African agriculture is characterised by a dual economy, with large-scale commercial farmers dominating the current food value chains and emerging, smallholder farmers being faced by a range of constraints, which prevent them from participating effectively in these same value chains. The purpose of this research was to develop a better understanding of the environment in which emerging farmers operate, and their goals and aspirations for entering food value chains, as well as to ascertain the value chains in which they either currently participate, or could potentially participate. The project aimed to analyse a number of key irrigated and rain-fed food value chains, with specific attention to water use, in order to identify mechanisms allowing subsistence and emerging farmers to participate in the mainstream economy, and to understand the current lack of participation. In addition, the study was expected to generate knowledge on the role of water in rural communities, and how it could be better (more efficiently) managed and shared. Generally value chains were very short and there was almost no value adding or processing encountered. Overall, very little use was made of formal markets such as fresh produce markets. These markets were not accessible and the farmers could not compete with large-scale producers. Sometimes farmers' products were not of a standard that allowed them to supply higher paying markets. The study clearly demonstrated a range of opportunities and constraints that small-scale farmers face when accessing various markets. As a result of a general shortage of resources for purchasing inputs coupled with a lack of technical skills and business acumen, many farmers are not able to participate in mainstream markets that have stringent standards (e.g. hygiene, traceability of produce, etc.). The lack of packing facilities, limited scale of production and the lack of access to transport are some factors that constrain the participation of small-scale farmers in mainstream value chains. Despite this, there are some value chains that small-scale farmers have effectively claimed, such as 'green mealie' production. These are value chains where farmers have the skills necessary to produce a good quality product and where systems have developed that have allowed them to market their produce effectively.

Cost: R2 999 989 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; University of Limpopo

No. 1958

The overall objective of the project was to support efficient and sustainable conservation of water as a production input in food value chains following equitable allocation of water resources in irrigated agriculture. The research findings highlight that much still has to be done to align land reform and water allocation reform. This has also been clear from the project's case study area, where water allocation reform has not been nearly as prominent or influential as the land reform process. In fact, water allocation reform has for the most part been non-existent, with the majority of beneficiaries not having any knowledge of water allocation reform processes in their area. The level of knowledge regarding the quantity of water used, licensing and water use authorisation, financial support for resource-poor farmers and efficiency practices has also been found to be extremely low. During the period of research, it became evident that not a single farmer from the irrigation schemes within the scope of the project study area had a water use licence in place. In the case of the community property associations (CPAs), very few farmers knew about water use licensing, and it was only the management structure of the CPAs that was aware of water allocation and water use licensing. This project has resulted in a number of relevant findings and key messages that will be valuable inputs to South Africa's land reform and water allocation reform initiatives. One of the key deliverables of this project is a set of three guidebooks aimed at emerging farmers, agricultural extension officers and policy advisors working in the Department of Rural Development and Land Reform (DRDLR) and Department of Agriculture, Forestry and Fisheries (DAFF). Each of the guidebooks is aimed towards a different audience and targets some of the perceived knowledge needs of that particular audience, as established during the course of the research. The contents of the guidebooks focus on the key themes of the research project: water allocation and land reform, water conservation and food value chains.

Cost: R3 000 000 Term: 2010–2014

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Impact of wastewater irrigation by wineries on soils, crop growth and product quality

ARC; Stellenbosch University
No. 1881

Based on the research project findings, the following criteria should be considered for possible amendments to the General Authorisation for wineries when using augmented wastewater as a resource for irrigation of vineyards:

The COD must be augmented to 3 000 mg/L or less, preferably to less than 2 000 mg/L to avoid unpleasant odours while irrigations are applied-

- The ECiw must be less than 0.75 dS/m
- The SARiw must be less than 10
- It should be a sandy soil with low CEC
- The internal drainage in the root zone must be unrestricted
- The irrigation water must not percolate beyond the root depth
- Only micro-sprinklers should be used, since drippers have narrow flow paths and/or small orifices, and are more susceptible to clogging
- The irrigation must be applied with micro-sprinklers in such a way that the bunches are not wetted
- At least 50% PAW depletion should be allowed between irrigations to allow sufficient aeration for oxidation of organic material applied via the irrigation water
- The irrigation frequency and volumes (schedule) should enhance, rather than negate, wine quality characteristics
- Due to the possibility that direct contact with winery wastewater may cause off-odours in the wine, overhead sprinkler irrigation is not recommended if winery wastewater is re-used for vineyard irrigation
- A summer interception crop, e.g. pearl millet, should be sown in early January to ensure that its growth peaks when the winery wastewater is applied, and that the species does not complete its life cycle too early
- Since a summer interception crop may increase the ET of vineyards substantially if growing conditions are favourable, it could induce competition for water between grapevines and cover crop; however, this can be avoided by timely slashing of the interception crop, which will also minimise possible competition for N and P

Cost: R3 500 000 Term: 2009–2014

Insights into indigenous coping strategies to drought for drought adaptation in agriculture: the Southern Cape scenario

Cape Peninsula University of Technology; Stellenbosch University

No. 2084

In South Africa much attention to drought assessment and adaptation measures in agriculture is placed on scientific solutions (e.g. early warnings, soil moisture and rainfall data, hydrological modelling, dam management, drought resistant crops) and institutional interventions. It was noted that the emphasis can be attributed to the fact that the research and development agenda tends to be dominated by professionals with a scientific background where emphasis is placed on rainfall or soil moisture data and hydrological modelling (for drought studies), and modernization and mechanization of the agricultural sector. From this study it was noted that the most vulnerable people to the impacts of drought, the local or indigenous population, have been living and coping with extreme environmental conditions such as drought for a long time. Their local or indigenous knowledge therefore holds valid, meaningful and relevant answers for coping with current and future droughts; yet there have been limited studies capturing this knowledge. The purpose of this project was to capture local or indigenous knowledge of the impacts, experiences, coping and adaptation strategies of past and current droughts in the Karoo. It was found that some of the strategies adopted by farmers dated back centuries. Migration with animals to better grazing lands was one of the oldest coping mechanisms used by livestock farmers, who were found to be the most resilient to drought. Livestock farmers further highlighted that they have developed methods of conserving water through rainwater harvesting from mountain slopes, construction of stock dams for water storage and use of windmill-pumped boreholes. The identified coping and adaptation strategies adopted by farmers in the Karoo indicate systems that have evolved over a long period of time.

Cost: R812 000 (incl. leverage) Term: 2011–2014

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 cropping systems adapted to bio-climatic regions in South Africa and suitable for biofuel production

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

No. 1874

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

areas and the projected impact of biofuel production on water resources and food supply.

Estimated cost: R7 400 000 (incl. leverage)
Expected term: 2009–2015

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 272 000 Expected term: 2011–2016

Nutritional water productivity of indigenous food crops

ARC (Vegetable and Ornamental Plant Institute)
No. 2171

Many indigenous vegetables (underutilized crops in particular) have high nutritional levels of micro-nutrients and could significantly contribute to nutritional security if eaten as part of the daily diet. A WRC project on nutritional value and water use of eight indigenous vegetables showed that 100 g leafy indigenous food crops (morogo) contain sufficient beta-carotene to supply more than 80% of the recommended daily allowance (RDA) of 4–8 year olds, and more than 40% of the RDA for 19–50 year olds. The eight indigenous food crops studied for their nutritional value were amaranth, cowpea, Chinese cabbage, nightshade, spider flower, Jew's mallow, watermelon and pumpkin leaves. Despite the importance of these vegetables in combating malnutrition and poverty, they are still poorly understood by the South African scientific community. In the abovementioned project, one of the research gaps identified was whether crop nutritional value is closely interlinked to water and nutrients, especially nitrogen (N), potassium (K) and phosphorus (P). This new project will explore the nutritional water productivity of four indigenous food crops, which have the potential to broaden the food basket. The crops are jute mallow, orange-fleshed sweet potatoes, nightshade (or *Amaranthus*) and *Cleome*. These crops are selected based on their popularity, nutritional quality and potential for small-scale and commercial production. The above questions will be investigated through field experiments linked to the ongoing Department of Science and Technology (DST) funded projects at the ARC-Roodeplaat VOPI, particularly the commercial production and breeding programmes of these indigenous food crops. Considering the importance of indigenous vegetables to combat malnutrition and broaden the food base in rural South Africa, the DST has funded ARC with over five million rand per year for the next three years. Rural based universities are targeted for this trial work as a major access point to the rural communities to introduce the technology solution developed at the ARC.

Estimated cost: R1 950 000 Expected term: 2012–2016

Current rain-fed and irrigated production of food crops and its potential to meet year-round nutritional requirements of rural poor people in North West, Limpopo, KwaZulu-Natal and Eastern Cape Provinces

University of Pretoria (Institute for Food, Nutrition and Well-Being)
No. 2172

Renewed attention must be given to agriculture, nutrition and health in adjusting research agendas, and strategies must be directed at early childhood nutrition, particularly of poor households. More research is needed in support of programmes that will improve health through balanced nutrition and the availability of food at reasonable prices. The on-going WRC scoping study (WRC Project No. K5/1954//4) entitled 'A baseline and scoping study on water use and nutrient content of crop and animal food products for improved household food security' identified insufficient data on food intake of poor households in rural areas of South Africa. The study also found that very little information is available on the sources of foods consumed by rural households. This means that, overall, insufficient data are available to make generalisations about the 'basket' of foods and the source of foods of the rural poor in this country, and consequently it is difficult to develop appropriate programmes that will improve the nutritional health of rural communities. Although dietary studies indicate that rural poor people meet very little if any of their nutritional requirements through own food production, this is contradicted by case study evidence from an agricultural perspective. It is therefore necessary to undertake empirical research on food production and intake by poor households. Opportunities exist that some of the foods in a balanced diet can be produced in gardens or field plots, which are currently underutilised. The provinces of North West, Limpopo, KwaZulu-Natal and Eastern Cape have been prioritised because this is where the majority of rural poor people live and produce crops under rain-fed and irrigated conditions, and potential exists to enhance production. It is important to identify the food crops for detailed follow-on research of water use and nutritional productivity for the purpose of reducing under-nourishment and increasing household food security.

Estimated cost: R3 650 000 (incl. leverage)
Expected term: 2012–2016

Water use and crop parameters of pastures for livestock grazing management

University of Pretoria (Plant Production and Soil Science)
No. 2173

The focus of this project will be to integrate irrigation and nitrogen management in order to improve the efficiency of both inputs. In South Africa, returns generated from animal production enterprises make pastures one of the highest value crops produced under irrigation. It is estimated that the total area utilized for irrigated pasture production is approximately 16% of the total area under irrigation. The most common irrigated pastures are ryegrass, kikuyu and lucerne. Irrigated ryegrass and dryland kikuyu with supplemental irrigation are the primary sources of feed in the pasture-based dairy industry and these are mostly grown in the relatively higher rainfall areas. Therefore, in this project, the promising practice of temperate legume with tropical grass or temperate grass mixture and the most commonly practised grazing mixture of kikuyu/ryegrass will be researched. Lucerne is regarded as the most important pasture legume produced in the drier parts of South Africa for its high quality roughage (hay). This roughage is extensively used in many animal production systems, including feedlots, dairy systems, the animal feed industry and the wildlife industry. The studies to be conducted under controlled environments and at representative research stations and commercial farms will aim to: (i) determine water use and irrigation requirements of most common farmers' practices including kikuyu/ryegrass, legume/ryegrass mixtures and lucerne; (ii) evaluate irrigation systems (flood, sprinkler and sub-surface drip) for lucerne production; (iii) conduct detailed physiological studies of lucerne as affected by different water stress treatments, and (iv) parameterise, test and validate selected crop growth/pasture model(s). As end products, databases of irrigation requirements of kikuyu/ryegrass, clover/ryegrass mixtures and pure lucerne under different pasture management practices will be developed. Finally, the validity and practicality of irrigation tools developed will be assessed in conjunction with pasture-producing industries.

Estimated cost: R2 750 000 Expected term: 2012–2016

Water footprint of selected vegetable and fruit crops produced in South Africa

University of Pretoria (Plant Production and Soil Science)
No. 2273

The vegetable and fruit industries are highly dependent on the availability of irrigation water and are clearly responsible for significant freshwater consumption. Numerous studies have evaluated irrigation practices and water use by horticultural crops in the country. Information is lacking on the long-term production and water consumption patterns at regional and industry scales over

the entire agri-food production chain from field to fork. Standard methodology to calculate water footprints was recently published by Hoekstra et al. (2011). According to this methodology, water footprint assessments consider both the direct and indirect water consumption and pollution of a consumer or of a product. Blue-, green- and grey-water footprints make up the total water footprint, and temporal and geographic components are included. Blue water refers to surface and groundwater available to multiple users, green water is water originating from rainfall that is stored in the soil and available for vegetation growth only, and grey water refers to the volume of water required to dilute emitted pollutants to ambient levels. Generally, blue water is scarcer and has higher opportunity costs, meaning that irrigated crops with lower ratios of blue to green water consumption are viewed more favourably. Detailed water footprint assessments using standardized, state-of-the-art methodology for important vegetable and fruit crops is essential to: (i) enable regional-scale integrated water resource management and drive policy formulation, (ii) better understand the water-related risks to the production of vegetables and fruit in the country, and (iii) facilitate the identification of opportunities for reducing water use within the production chain to ensure the sustainability of these industries.

Estimated cost: R2 750 000 Expected term: 2013–2017

Determining water use of indigenous grain and legume food crops

University of KwaZulu-Natal (Crop Science)
No. 2274

Completed and ongoing WRC-funded research work (Projects K5/1579//4 and K5/1771//4) to determine water use has mainly focused on African indigenous vegetable crops. There is, however, recent evidence of knowledge gaps on water use, agronomic practices, etc., of indigenous legume and grain crops. The indigenous grain and legume crops include grain sorghum, maize landraces, cowpeas and Bambara groundnuts. Furthermore, limited research results on water use are available and little crop water use modelling has been done on these crops. There is clearly a need for research-based knowledge on water use which will contribute to higher production, water use productivity and food security. More research is required on these neglected crops to better inform farmers and extension officers of appropriate management practices. Quantifying water use should therefore be done for combinations of indigenous crops (such as grain sorghum, maize landraces, cowpeas and Bambara groundnuts) by means of inter-cropping or crop rotations in comparison with intercropping or crop rotations of conventional crops (such as hybrid maize, dry beans, green peas and groundnuts). This will make it possible to broaden the crops and products in the food basket for consumption in a more balanced diet of starch and protein for rural household members. In addition, this knowledge of water use will provide opportunities to prepare for the challenge of climate change by adapting agronomic practices and cropping systems, thereby preventing detrimental livelihood impacts. Higher production and supply of indigenous grain and legume food crops will enable storage and inter-seasonal transfers, to specifically bridge the gap in nutrition during late winter and early spring. From a perspective of rural development there is also the potential of processing and value-adding in the food value chain of these crops. As a whole it is therefore imperative to better understand the water use of indigenous grain and legume crops in the context of intercropping, to improve the fertility of the soil, and of producing food crops which combine staple grains with legumes as protein sources.

Estimated cost: R2 750 000 Expected term: 2013–2017

Quantifying citrus water use and water stress at tree and orchard scale

Citrus Research International
No. 2275

Citrus is the largest exporter in terms of volume and one of the largest in terms of the earning of foreign exchange, with more than 100 million 15 kg cartons exported annually. The 58 000 hectare citrus industry provides more than 100 000 jobs that support more than 600 000 people, but the whole industry is dependent on irrigation. Citrus is a perennial crop which requires a constant supply of water in order not to limit yields and returns on investment. Due to climate change, established production areas are likely to become drier, which will place increasing pressure on water resources and irrigation management to maintain productivity. An ongoing WRC research project (K5/1770//4) is using a sap-flow technique to quantify water use of mature citrus, deciduous fruit and nut tree cultivars under best management practices. Initial findings indicate results that are contrary to expectations,

specifically for citrus. In addition an external international review recommended more in-depth research to first validate measuring techniques; and secondly to quantify water use for different growth stages for different cultivars. The more detailed research must investigate water use over seasonal growth stages, from planting to mature canopy size, and water stress in relation to fruit yield and quality. In order to provide effective advice to both established and emerging commercial farmers on irrigation methods and scheduling, accurate knowledge is required on water use. The emerging commercial farmers, who comprise approximately 300 of the 2 700 citrus growers and who are supported by the industry through bursaries, mentoring and extension, are especially in need of this information. All citrus fruit producers are faced with a major challenge in maintaining high yields per hectare and fruit quality whilst simultaneously achieving viable returns and ensuring sustainability. Given the increase in competition for water between irrigation agriculture, secondary industry and domestic water use, more knowledge is required on citrus water use for growers to remain competitive and justify future production.

Estimated cost: R2 750 000 Expected term: 2013–2017

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

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 (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

Scoping study on different on-farm treatment options to reduce the high microbial contaminant loads of irrigation water to reduce the related food safety risk

Stellenbosch University (Food Science)
No. 2174

There is an urgent need for research into possible on-farm treatment options to help reduce the high levels of microbial contamination in irrigation waters and thereby reduce the associated food safety risk to consumers. Of primary concern during such treatment is the reduction of pathogens in the irrigation water, and that the treatment process be financially feasible and technically appropriate and robust. Over the past few years it has been established that many of the South African rivers that are drawn from for agricultural irrigation purposes are carrying extraordinarily high pathogenic loads; some of the products irrigated by this water are minimally processed foodstuffs or products that are consumed raw. The WRC projects A quantitative investigation into the link between irrigation water quality and food safety (K5/1773//4)'

and '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 (K5/1875//4)' have clearly demonstrated the extent of the problem in terms of geographic distribution and the high microbial loads in rivers used as irrigation water sources. Several risks have been identified when polluted water is used for crop irrigation. Risks can be short-term and range in seriousness, depending on the potential contact with humans, animals and the environment. No irrigation water contaminated by untreated or poorly-treated faecal waste is risk-free. The purpose of this scoping study is to explore alternative on-farm treatment options that can reduce this risk. Emphasis will be placed on technical and financial feasibility and determining the priorities and scope for further research.

Estimated cost: R2 250 000 (incl. leverage)
Expected term: 2012–2016

Evaluation of the risks associated with the use of rain-water, harvested from roof tops, for domestic use and homestead food gardens; and groundwater for domestic use and livestock watering

University of Pretoria (Microbiology and Plant Pathology)
No. 2175

Harvesting rainwater from rooftops is an ecologically-friendly alternative approach to addressing the country's critical water shortages. Water collected in this manner can address domestic water shortage and provide irrigation water for home gardens. Prior to promoting rooftop water harvesting, it is essential to determine the potential level of microbiological and chemical risks associated with such water collection systems. Water collected in this manner is also commonly stored in large plastic containers using well-known brands such as Jo Jo. The ability of microorganisms to proliferate in such water storage systems has been well documented. The quality of such harvested and stored water is however, not well known. In general, dust, bird droppings, chemical leachates from the roof material, adhesives and coatings, etc., may be washed down from the roofs after heavy rain storms with the result that this water will be collected in the storage water unit posing a potential risk for the consumer. Water quality may thus be compromised by the water collection approach. In addition, biofilms may develop in the storage unit and may further compromise the water quality. This is of particular importance since it is known that waterborne pathogens may survive, proliferate and shed into the waterways thereby contributing to the contamination risk. While the quality of groundwater varies significantly from one area to another, available research results (WRC Report 1175/1/06) to assess the risk of groundwater for use in domestic consumption as well as livestock watering has to be refined and updated. By understanding the risks associated with roof-top harvested rainwater and groundwater, improved usage of these valuable resources can be made. Through improved intervention strategies, guidelines and regulations, basic public health issues can be managed and exposure to contamination prevented.

Estimated cost: R2 750 000 (incl. leverage)
Expected term: 2012–2016

Knowledge transfer on water quality management for improved integrated aquaculture and agriculture systems

Stellenbosch University (Aquaculture)
No. 2276

South Africa has a large number of irrigation dams and networks that can potentially be used for integrated aquaculture–agriculture practices. Many of these water resources have not realised their potential. The challenge remains how Government can provide support to develop the aquaculture sector, particularly in rural and peri-urban areas. The perception is that farmers are not effectively engaged or strategically supported. Research-based knowledge is available on water quality management in farm irrigation dams and extension manuals have been developed. However, it is not fully understood how much of the knowledge is sufficiently interpreted and successfully applied. Access to technology is one of the major constraints for small businesses development in South Africa. It is further elaborated that much of the available knowledge does not reach household and producer level. In order to determine the development agenda, technology transfer from the source to the receiver needs attention. Technology transfer was most successful when conducted at a time when people had a specific need for it in their projects. During this process, engagement with the farmers is a crucial element for success. To achieve successful technology transfer, the following elements must be understood:

- What information is available to aquaculture and agriculture and how it is disseminated

- What media/modes are used by the farmers to access information
- In what ways is accessed information utilised
- What are the constraints to information routes at farmer/producer level
- What thinking/rational processes drive information prioritising
- How much of successful farming practice is based on existing and new knowledge
- What are the cost implications of information dissemination

Estimated cost: R1 950 000 Expected term: 2013–2017

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

Programme 1: Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations

Water use 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

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: R5 100 000 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

Empowerment of women in rural areas through water use security and agricultural skills training for gender equity and poverty reduction in KwaZulu-Natal and North West Province
North-West University (Agricultural Economics and Extension)
No. 2176

In rural areas land is available, and the high unemployment rates, generally ranging from 30 to 40%, suggest the availability of labour to practise agriculture. Whilst financial and infrastructure support for resource-poor farmers in rain-fed and irrigated agriculture is clearly required, investment in social and human capital, i.e., trust among people, clear property rights, the rule of law, education and skills development are equally important. Secure water use entitlements and land tenure are essential to provide incentives for enabling the poor to increase productivity of natural resources. A report to guide policy in Eastern and Southern Africa published by IMAWESA, recognized that meeting the agricultural water management challenge requires five key actions. These include providing secure rights to land and water and developing human capacity. A key feature for sustainable rural productivity will clearly be to develop capacity of the principal users of the land who are women. It has been reported that women constitute 70% of the agricultural labour force and are the main food producers for rural households in South Africa. However, there is sufficient evidence to suggest that poor rural women are considerably more disadvantaged than poor rural men because of an explicit gender bias in land allocation, access to credit, access to rural organisations, marketing channels and agricultural services in general. Women living in traditional rural areas form part of the most economically and socially disempowered groups in South Africa. This project focuses on the skills and training needed by rural women in order to sufficiently equip them to address the challenges of food insecurity and poverty. Although reports on agricultural training and skills development are widely available and have been well documented, very few, if any, are specifically tailored to meet the skills and training requirements of women in rural areas within cultural and traditional realities. The project will identify skills required by women in agriculture (farming and non-farming activities within the food value chain) but will not develop training guidelines.

Estimated cost: R3 000 000 Expected term: 2012–2016

Up-scaling of rainwater harvesting and conservation on communal crop- and rangeland through integrated crop and livestock production for increased water use productivity
Institute of Natural Resources (Sustainable Agriculture and Food Security)
No. 2177

Sustainable crop-livestock systems can support the majority of poor members of rural communities. Rainwater harvesting techniques and practices in these systems have the potential to improve the livelihoods of these communities. Many rainwater harvesting techniques have been tested and are proven to be effective, but their successful application in rural areas for crop-livestock systems is limited. Clearly, correctly designed institutions and organisations are required to support the application of rainwater harvesting techniques by individuals and groups in communities. Conflict that often exists between livestock owners and crop farmers usually leads to low or no production. By clarifying the production potential and rules that determine access to resources, solutions can be found to resolve conflicts. Production systems should be geared towards optimising both crop and livestock production and exploiting the synergies between the two. By up-scaling from the homestead food garden to the croplands and rangelands, opportunities are created to increase production and move from subsistence to profitable levels of farming. In an uncertain environment, interventions such as rainwater harvesting for crop-livestock water use productivity can bring resilience to the system. However, the integrated functioning of the crop- and rangeland system is not well understood. There is also a lack of knowledge of livestock water use productivity in rural areas since livestock have mainly been kept for cultural reasons, whilst demand for livestock products has increased. The challenge for research is therefore to adapt or develop technologies and practices which will improve land productivity whilst enabling water conservation in rain-fed agricultural production on dry-lands and rangelands. Participatory action research should be undertaken to

demonstrate that higher crop and livestock water use productivity at lower risks is achievable.

Estimated cost: R3 070 465 Expected term: 2012–2017

Action-oriented development of a strategy for knowledge dissemination and training for skills development of water use in homestead gardening and rainwater harvesting for cropland food production

'Rhodes University (Environmental Learning Research Centre)
No. 2277

Household food security in South Africa remains a national challenge with an estimated 59% of 13.7 million households being food insecure, with hunger and chronic malnutrition being widespread within this group. Yet, present utilisation of available land and water resources for smallholders (0.5–10 ha), both in home-gardens and fields remain low. As it is women who are responsible in the majority of cases for farming decisions, they are a key group to target in initiatives aiming for increased crop-production and food-security. There is a substantial body of training information in the public domain which responds to the multi-faceted crop-production challenges faced by small growers. Two recent WRC research products are prioritised; one targeting homestead food production and the second water-harvesting and conservation techniques. In addition, there are other potentially useful publications for use in knowledge mediation processes. These include, for example, WRC grey-water re-use guidelines and in-field rainwater harvesting manuals. The challenge of achieving impact from research outputs is a global one; and is related to what is now recognised as inadequate Research-Develop-Disseminate-Adopt (RDDA) assumptions of how knowledge is/ought to be mediated in society. Contemporary theories of learning and change indicate that for knowledge or information to become meaningful, there is a need for the information to be related to the situation and experience of the user; and also to provide new knowledge or information that can expand existing knowledge and/or practice. The choice of strategic approach to achieve effective knowledge dissemination and uptake to transform available knowledge into productive practices will be determined by those opportunities that unfold during the project, including consultations with both learning organisations and mass-media organisations (TV, radio etc.), and feedback with homestead gardeners and smallholder farmers.

Estimated cost: R1 950 000 Expected term: 2013–2017

Programme 2: Integrated water management for profitable farming systems

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Eastern Cape Province

University of Fort Hare (Agricultural Economics and Extension)
No. 2178

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R1 950 000 Expected term: 2012–2016

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in the Limpopo Province

Umhlaba Consulting Group (Pty) Ltd

No. 2179

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued (Sunter, 2011) that, for a balanced economy, both an outward and inward focus is required. The last mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The millennium development goals also require reduction in poverty levels and empowerment of women. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows for negotiating higher prices and improving operating margins. For this purpose ways must be found to enable more productive farming practices, and more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R2 144 000 Expected term: 2012–2016

Water use productivity associated with appropriate entrepreneurial development paths in the transition from homestead food gardening to smallholder irrigation crop farming in KwaZulu-Natal and North West Provinces

University of KwaZulu-Natal (Agriculture Sciences and Agribusiness); African Centre for Food Security

No. 2278

In the programme of action of the Presidency announced during 2010, Outcome 7 envisages vibrant, equitable and sustainable rural communities with food security for all. It is expected that Output 4 will deliver improved employment opportunities and economic livelihoods. This includes a rising percentage of small-scale farmers producing for market sales and an increased number of jobs in agro-processing. Furthermore, it has been argued that, for a balanced economy, both an outward and inward focus is required. The last-mentioned involves support for establishment of new small businesses and related additional job creation. In this regard priority attention should therefore be given to encouraging existing and new small farming businesses to be undertaken on smallholder irrigation schemes. The available evidence indicates that natural and human resources on most if not all smallholder irrigation schemes in South Africa are utilised far below potential. Given the semi-arid circumstances and potential impact of climate change, increasing emphasis must be placed on higher productivity of water use under irrigation. It will involve higher crop production and better product quality, which allows negotiating higher prices and improve operating margins. For this purpose ways must be found to enable more productive farming practices, more competitive and profitable farming on irrigation schemes. This in turn requires that an assessment is made of the goals and aspirations of current and potential farmers, in particular women, to improve the economic performance of farming enterprises. In order to show the way forward, research should be done which is based on real situations on existing irrigation schemes, where solutions are practically achievable. This can be done by involving farmers and potential beneficiaries on irrigation schemes in the research effort.

Estimated cost: R1 950 000 Expected term: 2013–2018

The optimisation of electricity and water use for sustainable management of irrigation farming systems

University of the Free State (Agricultural Economics)
No. 2279

Electricity tariff structures have changed over the years, while electricity rates have recently escalated considerably and are expected to continue increasing in future. This requires a change in design norms and standards as well as a shift in emphasis to life-cycle cost evaluation. This subject was last formally researched more than 10 years ago, with publication of a report in 2002 (WRC Report No 894/1-4/02), followed by technology transfer activities (WRC Report No 274/05). This research output clearly needs to be revised and guidelines must be updated. Over the intervening years, new technologies have become available, such as variable speed drive (VSD) and energy-efficient motors (with a new classification system). Better engineering practices for pumps, including auto-restart and remote control, have led to increased accuracy and energy efficiency. It is therefore essential to evaluate and compare different technologies on the basis of efficient energy/power use and operating cost over the life cycle of the irrigation system. In addition, better automatic weather stations are accessible and convenient irrigation scheduling techniques, such as continuous logging probes with telemetry, can be applied. This enables more efficient use of water, reduced electricity consumption and higher food production. At the same time there are pressures to reduce the carbon and water footprint, especially for export food markets. In so doing, costs must be lowered, profitability and competitiveness increased and water use productivity improved. However, farmers need advice and extension based on user-friendly guidelines, in order to respond to these pressures and incentives by changing irrigation practices. These practices that influence electricity power use include determining water use of crops, soil water monitoring, application rates of water, pumping water from the river or storage dam to the field, installing energy-efficient motors, selecting correct pipe sizes, and regular maintenance of equipment, etc. Measurement and verification therefore requires determining the baseline and implementing an information system for management of reduced energy/electricity consumption and optimisation of water use on irrigation farms.

Estimated cost: R1 950 000 Expected term: 2013–2017

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 run-off and sub-surface drainage are all related and need to be managed as a whole. It is essential to distinguish between requirements and standards for design, installation, operation and maintenance of drainage. The internationally available research results and modelling approaches will be assessed and evaluated for applicability in South Africa. The demand for design and installation of drainage in the field by far exceeds the available capacity. Timing is critical because only a very small group of experts is still active in the field and there is an urgent need to train new practitioners. This report will form the basis for training at tertiary level and for providing guidance to practitioners. The research output will form the basis of informing public policy formulation and strategies for implementing drainage systems on irrigation schemes.

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

Programme 2: Impact assessment and environmental management of agricultural production

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 (School of Biological and Conservation Sciences)
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 (Incl. leverage)
Expected term: 2010–2015

Vulnerability, adaptation to and coping with drought: The case of the commercial and subsistence extensive livestock sector in the Eastern Cape

University of the Free State (DiMTEC)
No. 2280

Dry periods and droughts remain the major meteorological factor with devastating impacts on the livelihoods of most rural people in South Africa. The agricultural sector specifically incurs millions of Rands in losses every year. For example, the direct mean annual loss (MAL) to the extensive livestock sector in the Northern Cape alone is in the excess of R350 million. Little evidence is available of the required adaptations to reduce vulnerability and increase resilience of farming enterprises to natural hazards such as drought. Given the expected increase in these extreme events due to climate change, more research is essential on how vulnerability can be reduced in order to prevent future disasters. The proactive approach towards drought risk management emphasizes the need for coordination and collaboration among all role players. This includes coordination between monitoring agencies in terms of reliable early warning systems, communicated in a comprehensible way to decision-makers, farmers, agricultural businesses and all that have an interest in agriculture. Collaboration at national and provincial level between the Department of Agriculture, Forestry and Fisheries (DAFF) at national level, provincial Departments of Agriculture, National and Provincial Disaster Management Centres (NDMC and PDMC), Department of Water Affairs (DWA), South African Weather Service (SAWS) and others is essential in this regard.

Estimated cost: R2 950 000 (incl. leverage)
Expected term: 2013–2017

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

Determining the water footprints of selected field and forage crops towards the sustainable use of fresh water

University of the Free State (Agricultural Economics)
No. 2397

Significant amounts of water are used in the agricultural sector to produce food, forage and fibre to meet the ever-increasing world-wide demands. According to the Department of Water and Sanitation, 60% of fresh surface water is used by irrigated agriculture, making it the largest single user of water in South Africa. While being the largest user of fresh water, irrigated agriculture is also expected to contribute significantly towards poverty alleviation in South Africa through job creation and increased economic activity in rural areas. The allocation of fresh water to irrigated agriculture thus holds substantial social and economic benefits for South Africa. The establishment of standardised procedures for calculating blue and green water footprints for irrigated field and forage crops in South Africa will contribute towards the setting of accurate benchmarks for fresh water use along the life cycle of the crops. By linking the water footprint applications to economic and social analytical tools, the social and economic impact of proposed changes in water use behaviour will be understood. The analysis of consumer awareness, preference and willingness to pay for water footprint information on product labels will give insight into the scope for incentivising water users through price premiums to use fresh water efficiently. This project will report on standardised procedures for calculating green and blue water footprints of irrigated field and forage crops, which will ensure that water footprints can be compared and will allow for benchmarks to be derived for water use along the life cycle of the crops.

Estimated cost: R3 000 000 Expected term: 2014–2019

Quantifying water use of high-performing commercial apple orchards in the winter rainfall area of South Africa

CSIR (Natural Resources and Environment)
No. 2398

Within the deciduous tree fruit industry, pome fruit (apples and pears) is the biggest fruit group in terms of area, volume, contribution to GDP and earning of foreign exchange. South Africa is the 7th biggest exporter of apples in the world and the main Southern Hemisphere competitor is Chile, which is third in terms of export. South Africa is also the 6th biggest exporter of fresh pears, with Argentina the biggest fresh pear exporter in the world and the main Southern Hemisphere competitor. The deciduous fruit industry (including table grapes) employs 106 000 people with 424 000 dependents. Employment in apple farming consists of 27 800 labourers with 111 200 dependents. Currently there is limited knowledge of water use of young apple orchards up to full-bearing age in South Africa. The focus of water use research should be on Golden Delicious and Cripps' Pink cultivars on M793 rootstock, which is the industry standard. Golden Delicious is the major mid-season cultivar, with 24% of the area planted. Cripps' Pink is a late season highest value cultivar, with 9% of the area planted and experiencing growth potential. Within the winter rainfall area, 28% of apples are produced in the Ceres region, primarily in the Koue Bokkeveld climatic zone, and 42% in the Elgin/Grabouw/Vyeboom/ Villiersdorp region and climatic zone. Within these regions soils vary considerably and will influence site selections. Soils should therefore be selected to effectively quantify the water balance of the orchard and for comparison between climatic zones. Based on results of completed research it is clear that there is still an existing knowledge gap on water use of apple orchards as well as water use efficiency under local conditions. Increase in efficiency of water use will enable expansion of the area under apple production, or alternatively allow water savings that can be transferred to other sectors or improve the resilience to drought. Research is therefore required to quantify the water use and model water use for future extrapolation for different apple cultivars to wider production regions. This research project should provide a baseline for expansion of this type of research to other deciduous fruit types. The research output will inform strategic decisions by the deciduous fruit industry and relevant government departments.

Estimated cost: R3 000 000 Expected term: 2014–2018

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

Revision of the 1996 South African Water Quality Guidelines: Development of risk-based approach using irrigation water use as a case study

University of Pretoria (Plant Production and Soil Science)
No. 2399

The SA water quality guidelines of 1996 comprise one of the most widely-used tools in water quality management. However, they are now significantly out of date. A Phase 1 Department of Water Affairs (now Department of Water and Sanitation – DWS) project was completed in 2008 that performed a needs assessment, developed a general philosophy and described the general specifications of a decision support system (DSS) for revised water quality guidelines for South Africa. An initiative within DWS is under way to secure approval and funding for Phase 2 to revise these guidelines. The new guidelines will be different in a number of fundamental ways. Firstly, they will be risk-based – a fundamental change in philosophy from the 1996 guidelines. Secondly, they will allow for much greater site-specificity – a widely-recognised limitation of the generic 1996 guidelines. Thirdly, they will be made available primarily in a software-based decision support system. The overall DWS initiative aims to develop a DSS for all significant water users. With this project a start is made to revise the guidelines for irrigation water use.

Estimated cost: R2 000 000 Expected term: 2014–2016

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 grasslands after eradication of alien invasive trees

Rhodes University (Institute for Water Research)
No. 2400

Invasive alien plants (IAPs) remain a serious threat to the water supply and to storage reservoirs throughout South Africa. IAPs are known to use a large quantity of water through evapotranspiration (ET), and the clearing and control of IAPs has been a major activity of the Working for Water (WfW) programme. Water saving has been the primary motivation for the programme. Successful clearing of these often aggressive woody trees and shrubs requires careful regeneration of effective indigenous vegetation cover after the physical clear-felling and removal of the IAPs. Application of effective post-clearing management regimes is required in order to improve the grass cover within catchments and this can ensure that there is controlled run-off and groundwater recharge. The research project will address issues in the following areas:

- Sustainable development solutions: applicability of Payment for Ecosystem Services (PES) to sustainable management of grasslands and IAPs on land under communal tenure; improved models that provide better estimates for ET, water use productivity (WUP) and livestock water productivity (LWP)
- Empowerment of communities: sustainable management by rural communities where livestock farming plays a crucial role in livelihood strategies; optimizing the land-use options available to graziers using WUE and LWP concepts
- Informing policy and decision making: providing evidence-based scientific input into the policies of WfW, DWS and the DAFF
- Human capital development in the water sector with training for post-graduate students in ET modelling and hydrology. Improved models for ET estimations in South Africa using earth observation will be a significant contribution to further understanding of the impact of changes in land-use on water supply and encourage sustainable land-use practices.

Estimated cost: R4 300 000 Expected term: 2014–2019

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

Programme 2: Integrated water management for profitable farming systems

Wide-scale modelling of water use and water availability with earth observation/ satellite imagery

Stellenbosch University (Environmental and Geographical Studies)
No. 2401

It is clear that both the land area and water resources available for irrigated crop production is very limited in South Africa. With the added pressures of climate change, population growth and the impact of a decline in water quality, the need for improved assessments of the current water resource uses and land uses is critical. Actions related to improved water use productivity and irrigation expansion or water reallocation can only follow once this information is available. Use of remote-sensing data, together with algorithms developed over the past 20 years to estimate actual evapotranspiration (ET), is an internationally accepted alternative and improves the traditional methods used to estimate or measure actual ET. Remote sensing data is routinely and frequently captured across the world. It is frequently used in deriving land cover–land use maps and hence suitable for estimating the area under irrigated agriculture. Remote-sensing data utilised in energy balance modelling has the potential to provide recent estimates of ET. Combining these remote-sensing based datasets will provide estimates of crop ET and total amount of water utilised by irrigated agriculture. Using remotely-sensed data within a framework for water accounting will be invaluable for water resources planning. A water accounting framework can provide an overview on water resources (per selected area) and facilitate decision making. The consumptive use by various land uses need to be understood prior to new water allocations. Various international initiatives have been developing water accounting systems to support water managers and decision makers. The usefulness of such a framework will be tested and illustrated in this project.

Estimated cost: R4 900 000 Expected term: 2014–2018

THRUST 4: WATER RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

Programme 2: Impact assessment and environmental management of agricultural production

Assessing the impact of erosion and sediment yield from different land uses in farming and forestry systems and their effect on water resources in selected catchments of South Africa

University of KwaZulu-Natal (Centre for Water Resources Research)
No. 2402

Recent soil erosion mapping and modelling studies conducted by DAFF and the ARC-ISCW indicate that large parts of South Africa consist of highly erodible soils with widespread soil erosion evident. Soil erosion not only involves the loss of fertile topsoil, reduction of soil productivity and reduction in crop yield over time, but also causes water management problems, especially in semi-arid regions such as South Africa where water scarcity is frequently experienced. It must be noted that soil erosion cannot be prevented but must be limited. Siltation of storage dams is acknowledged to be a major problem in South Africa and better understanding of erosion and sediment yield is important to limit the cause of siltation. Phosphates are also linked to sediments contributing to eutrophication of dams and estuaries. Sediments in water furthermore increase the wear and tear of nozzles and hydraulic pumps for irrigation. It has also been highlighted in completed studies that better knowledge of limiting erosion will contribute to changing the behaviour of farmers by adopting conservation farming practices. Incorrect land use practices including overgrazing of natural grasslands is one of the major contributing factors to erosion and sediment yield. Completed WRC-funded research recommended that further investigation should focus on the connectivity of sediment delivery pathways and develop precautionary measures to limit the direct discharge of sediment into streams. Attention in this project will be given to quantification of sediment detention, retention or reaction to specific controls in stream networks, including farm dams, wetlands and buffer strips.

Estimated cost: R2 200 000 Expected term: 2014–2018

The modelling of rainy season characteristics and drought in relation to crop production in the Levubu catchment of the Limpopo Province: Climatology and climate change perspective

ARC (Institute for Soil, Climate and Water)
No. 2403

Drought is one of the most disastrous climate-related hazards in the world, which has significant impact on agriculture, environment, infrastructure and socio-economic activities. In semi-arid regions like the Limpopo Province, drought is the climate hazard that has the most detrimental effect on crop production. The most affected

people are the resource-poor farmers whose productivity is threatened by frequent droughts. The quantification and monitoring of drought is of critical importance politically, economically and environmentally in most countries. Agroclimatological information is important to improve agricultural production as well as protecting the agricultural resources from deteriorating. The frequencies, means, extremes, deviations, exceedence of thresholds, spatial variability and trends of agroclimatological parameters are important for assessing and managing agricultural risk. Many practices like the use of irrigation, improved cultivation and improved crop varieties have been developed over the years to adapt agriculture to climate variability and climate change, but agricultural productivity can further be increased, costs of production reduced and crop failures avoided through use of weather and climate information. In this project, analyses of agrometeorological information will support the farming community in better planning, improving preparedness and adaptive capacity, risk assessment, evaluation of current climate and agricultural interactions and simulation of future trends.

Estimated cost: R2 000 000 Expected term: 2014–2018

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KSA 5

BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

SCOPE

KSA 5 provides strategic direction to the international cooperation, business development, communication, marketing and branding goals of the WRC. Additionally, it supports the management of research projects, enhances innovation and provides the tools and processes for protecting technological developments. It also links the WRC's financial processes with technical fund management, while providing the necessary dissemination function to relevant stakeholders of research outputs and impact, and strategically positions the WRC within the local and international water sectors through its marketing and branding initiatives.

The scope of this KSA includes:

- Facilitating, and where appropriate, formalising new partnerships
- Supporting the continuous improvement of the political profile of the WRC by enhancing the credibility and relevance of the WRC through strategic positioning and strengthening stakeholder relations

Inga Jacobs-Mata:
Executive Manager

- Leading the up-scaling and demonstration and commercialisation of water technologies in partnership with the research KSAs and strategic external partners
- Managing the intellectual property and innovation processes within the WRC
- Coordinating the marketing and communication activities of the WRC including the media engagement, parliamentary liaison, strategic communication and marketing
- Providing the instruments to track, measure and report on the impact of the WRC in research and human capital development
- Coordinating local and international dialogues and other stakeholder events/activities led by the WRC
- Supporting knowledge creation by providing appropriate business process management, research management tools and logistic support
- Sharing and disseminating knowledge

OBJECTIVES

The strategic objectives of KSA 5 are as follows:

- To improve knowledge uptake with the aim to increase implementation
- To position the WRC as a premier knowledge resource for all water-related issues, locally and internationally in order to enhance effective uptake of research
- To effectively manage the WRC research cycle for more efficient knowledge management
- To provide strategic research advice related to the water sector, R&D capacity, knowledge flow and ultimate impact

THRUSTS AND PROGRAMMES

Thrust 1: Knowledge dissemination and uptake

Scope: This Thrust aims 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; to build and maintain relationships with stakeholders; and to market the WRC effectively. This thrust also complements the objectives of other Thrusts, utilising public relations, marketing and communication mechanisms. In addition, it ensures that the WRC leads and participates in knowledge-sharing and knowledge-dissemination activities (e.g. workshops, exhibitions). 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 acts as a resource centre to meet the information requirements of the WRC and the water sector in general.

In so doing, its activities are centred on:

- Driving the implementation of the WRC communication strategy
- Improving knowledge uptake with the aim to increase implementation
- Enhancing sector involvement in the WRC research processes
- Strengthening awareness of the mandate and role of the WRC in the South African water sector

Programme 1: Communications works engine	***Scope:*** This programme is the knowledge generation and dissemination hub of the WRC. It aims to package water-centred knowledge for different users. It manages the production of WRC-funded research reports, technology transfer reports, *The Water Wheel*, *Water SA*, WIN-SA, brochures and briefs. It includes the following functions: • Develop and maintain innovative ways to share and disseminate WRC products, e.g. brochures, technical, policy and ministerial briefs, Knowledge Review, media briefings. • Produce and publish *the Water Wheel* • Produce and publish special publications such as books and learning material • Manage the production and publication of *Water SA* • This programme also focuses on the WRC's engagement with the media for enhanced public awareness of WRC-funded research. • Preparing media briefings, media conferences and networking events in order to create and sustain an awareness and appreciation among the media of the WRC's position of leadership within the water sector • Drafting press releases on topic water issues
Programme 2: Marketing	***Scope:*** The focus of this programme is to build and maintain relationships with various stakeholders. This includes: • Drives the WRC's marketing and brand strategies • Establishing working relationships with industry, decision makers and key stakeholders • Delivering multimedia presentations to inform various target groups about the WRC and its accomplishments • Media monitoring of WRC impact
Programme 3: Events and exhibitions	***Scope:*** This programme coordinates institutional events and also provides to KSA-specific events. It includes: Exhibiting at high-profile, water-centred conferences nationally and, if necessary, internationally Knowledge sharing (internal) • Organising knowledge-sharing events such as internal open days, guest lectures and regular research managers' meetings • Supporting the research community through WRC 101 courses • Improving the relationship and interaction with the research community (during and beyond the project) • Promoting the WRC at carefully selected opportunities • Contributing to and/or advertising in selected media or periodicals to coincide with events of special significance for water, e.g. Water Week • Engaging with the youth through science festivals, games and competitions to serve the dual purpose of positioning the WRC and stimulating interest in water-centred science, engineering and technology

Programme 4: Digital records management	***Scope:*** This programme aims to provide an effective printing and distribution service; and to develop mechanisms for effective knowledge sharing, information storage, indexing and transfer. It includes the following functions: • Manage the quality-control process of WRC technical and technology transfer final reports • Manage the process of layout and printing of the WRC reports and other publications • Manage the effective distribution of research reports • Manage effective report distribution facilities (manual and electronic)

Thrust 2: Business development

Scope*:* Recognising the growing demand for the WRC's services in South Africa and the limited resources (human, financial and infrastructure) available, the WRC undertook to develop a strategic business development strategy, which is coordinated under this Thrust. The main purpose of the strategy will be to seek effective ways to improve the impact of the WRC initiatives and expand the resource pool using existing capabilities as leverage. Emphasis will be placed on strengthening collaborative partnerships (local and international) and positioning the WRC as a key player in all water research related activities.

Programme 1: Resource mobilisation	***Scope:*** The main purpose of this programme is to leverage funding (joint funding opportunities, free funding opportunities (consultancy). This will be achieved through: • The facilitation of joint research projects/workshops/conferences • Strategic engagement with key stakeholders(outreach, and participation in the whole innovation value chain)
Programme 2: Impact expansion	***Scope:*** This programme focuses on establishing strategic partnerships, profiling the WRC; and intelligence gathering to support and influence policy.
Programme 3: IP and commercialisation management	***Scope:*** This programme focuses on the WRC footprint i.e. intellectual property management, technology brokerage and development. It also ensures that the WRC promotes the effective transfer of information and technology through up-scaling and demonstration. In the words of the Department of Science and Technology's 10-year innovation plan, it serves as an enabler to address the "innovation chasm" between research results and socioeconomic outcomes.

Programme 4: Partnership development	***Scope:*** The aim of this programme is to enhance the credibility and relevance of the WRC locally and globally; and to coordinate strategic local, continental and international partnerships and facilitate dialogues which position the WRC as a significant international player and a recognised asset to South Africa. To achieve these desired objectives, the WRC will explore the following modalities: • Structured engagements: MoU's with equivalent entities (local and international) • Formal membership in strategic organisations • Strategic resource partnering with key stakeholders, including business (DWA, DEA, DAFF, DST, Parliamentary Portfolio Committee, philanthropic institutions, etc.) • Support institutional collaborations (university-to-university) • Support expert-to-expert collaborations • Interest group engagement (professional bodies, etc.) • Exploit niche areas (e.g. acid mine drainage, etc.)
Programme 5: International cooperation	This programme supports the implementation of the WRC's International Strategy. Acknowledging the potential benefits of international partnerships to South Africa and the African continent, the WRC aims to raise its international profile so that these benefits are more effectively realised. The development of the WRC International Strategy is the first step in raising the WRC's international profile, and in highlighting our already pivotal role in key African initiatives such as the TIGER Initiative and the Sanitation Research Fund for Africa (SRFA). The WRC has developed its international strategy in response to the increasing globalisation of research. The WRC presently undertakes a range of international activities including support of international collaboration, participation in research forums, conferences, and liaison with various international institutions. This international strategy will guide the WRC in developing more strategic partnerships both nationally and internationally, and responding to international trends in research policy and research support. • Strategically developing, promoting and steering South Africa's water research and development (R&D) agenda through bilateral and multilateral cooperation instruments and organisations • Sharing and exchanging information, ideas, best practices and technologies with international partner institutions

Thrust 3: Business systems management

Scope*:* This programme focuses on our way of working, i.e., business process management, portfolio management, web development and content management. In therefore aims to coordinate the research funding cycle and provide effective tools, systems and procedures to support the core business of the WRC. It supports the management of research projects, and links financial processes with technical fund management.

Programme 1: FMS management	***Scope:*** This programme focuses on the following key functions: • Coordinate the annual funding cycle • Increasing the user-friendliness of the WRC Fund Management System (FMS) for both external and internal users • Advance the linkage between financial and technical management of research projects • Provide support to the research KSAs with regard to proposal cycle and project management on FMS • Develop the FMS as a management information tool
Programme 2: FMS compliance support	***Scope:*** This programme provides support to the Compliance unit in terms of quarterly and annual reporting derived from the FMS.
Programme 3: Content management	***Scope:*** This programme oversees the WRC's content management objectives and ensures compliance to existing legislation in this regard.
Programme 4: Relationship management	***Scope:*** This programme provides the logistics required for the flow of research-related information into and out of the WRC. Additionally, it is the support point for all external and internal FMS queries.

Thrust 4: Research coordination support

Scope*:* The primary aim of this Thrust is to provide strategic research advice related to the water sector, R&D capacity, knowledge flow and ultimate impact. The WRC is mandated to lead and co-ordinate water research in South Africa. It is also tasked to promote effective knowledge transfer and enhance knowledge and capacity in the sector. It is therefore important that the WRC understands all of the elements driving the water knowledge cycle in South Africa.

Programme 1: Social research	***Scope:*** There is a growing recognition among South African water researchers, as there is worldwide, of the need to deal with social problems in the water sector through robust social science theories and methodologies, to bring these skills into multi-disciplinary water research teams and to define a strategic social research agenda. This programme explores the potential of social science research in the water sector, by supporting research that develops/applies social research methodologies to understanding complex water challenges. It also promotes the integration of these skills into inter-, multi- or transdisciplinary research projects in the South Africa water sector, and in the WRC. It relies heavily on a consultative approach through workshops and interviews. In 2014/15, this programme will focus on finalising a social research agenda for the WRC, and designing its implementation strategy through KSAs 1 – 4.

Programme 2: Water foresight	***Scope:*** This programme 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. This functional area may also provide advice regarding sector needs and global trends, i.e., foresight and scenario studies. Examples of research/studies to be carried out under the leadership of this functional area are: Assessment of the scope and extent of water research done in South Africa Analysis of research capacity, demographics, current and future needs Impact of research, including methodology for impact assessments Long-term scenario building Assessing knowledge uptake and dissemination and establishing new effective mechanisms
Programme 3: Research coordination support to the WRC's strategic planning process	***Scope:*** This programme provides support to strategic planning process of the WRC, including but not limited to, the consolidation of the WRC Corporate Plan, Annual Report and Consolidated Business Plans.

KNOWLEDGE DISSEMINATION

Enhancing public understanding of water research: *the Water Wheel*

The WRC aims to enhance public understanding of science through the publication of *the Water Wheel*. The magazine currently serves over 8 000 subscribers and is published every two months. The WRC published six issues of *the Water Wheel* in 2014/15.

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 2014/15, the WRC published five issues (four regular issues and one special edition).

Distribution of WRC research and technology transfer reports

Table 1 indicates the number of WRC reports (print copies) distributed to various stakeholder groups in 2014/15. Table 2 lists the most popular reports in 2014/15 in terms of numbers of print copies requested. Table 3 indicates the number of e-reads and downloads of research reports from the WRC website in 2014/15, and Table 4 lists the most popular reports in 2014/15 in terms of number of downloads from the WRC website.

Table 1 Reports distributed in 2014/15

Foundation for Water Research	114
Institutes	2 651
Municipalities	339
Private	17 936
Schools	315
State Library	114
University/University of Technology	2 705
WRC	700
TOTAL (print)	24 874

Table 2 Most popular reports (print copies) distributed in 2014/15

Report no	Title	KSA	Total
TT 565/13	Energy efficiency in the South African water industry: A compendium of best practices and case studies	3	485
TT 595/14	Guidelines for reducing water losses in South African municipalities	3	344
2233/1/14	Feasibility study on the use of irrigation as part of a long-term acid mine water management strategy in the Vaal Basin	3	302
TT 610/14	Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries	2	300
TT 596/14	Conduit hydropower pilot plants	3	245
TT 597/14	Conduit hydropower development guide	3	227
TT 588/14	Water sensitive urban design (WSUD) for South Africa: Framework and guidelines	3	196
TT 589/14	Manual for fish kill investigations in South Africa	2	193
TT 598/14	A manual for cost benefit analysis in South Africa	4	179

Table 3 Downloads and e-reads of research reports from the WRC website in 2014/15

	Downloads	E-reads
WRC research reports	20 444	3 447

Table 4 Most popular reports (downloads from website) in 2014/15

Report title	Downloads
Water purification works design	602
Guideline for the inspection of wastewater treatment works	439
National standards for drinking water treatment chemicals	330
A simple guide to the chemistry, selection and use of chemicals for water and wastewater treatment	293
Guidelines for reducing water losses in South African municipalities	203
Guidelines and training aids for the sustainable operation and maintenance of small water treatment plants	190
The South African guidelines for sustainable drainage systems	156
The state of non-revenue water in South Africa	140
Water sensitive urban design (WSUD) for South Africa: Framework and guidelines	140
Easy identification of some South African wetland plants	136
The effect of water quality variables on aquatic ecosystems review	122
Process design manual for small wastewater works	102
Waste water treatment plants: The financing mechanisms associated with achieving Green Drop rating	97
Hydrogeology of Groundwater Region 10: The Karst Belt	95
Energy generation using low head technologies	92
Theory, design and operation of nutrient removal activated sludge processes	91
Vadose zone hydrology: concepts and techniques	90
State of the art: fracking for shale gas exploration in South Africa and the impact on water resources	89
Introduction to operation and maintenance of water distribution systems	88
Waterborne sanitation design guide	82
WET-EcoServices	81
Water resources of South Africa, 2005 Study (WR2005)–2011 Update: Executive Summary (version 2, 2011)	80

COMPLETED PROJECTS

Integrated Water Sector Skills Intervention Map Based on a Sector Skills Gap Analysis

Rural Water Concepts South Africa cc; ONYXX Human Capital: Eon Consulting: BCON Development Practitioners; Institute of Plumbing of South Africa; independent consultant; Tshwane University of Technology

No. 2113A

This project was commissioned by the WRC on behalf of the Department of Water and Sanitation (DWS) in response to repeated declarations that the water sector in South Africa was lacking (and losing) skills necessary to plan for and maintain supply of services to the public. The project was commissioned in the face of a lack of readily accessible objective data to confirm or refute the declarations. This research project aimed to provide a technologically up-to-date method of arriving at the evidence required to take management decisions on the situation described. It considers both the capacity and skills aspects, where capacity is the number of staff required by job title in an institution and the skills are the competence needed by individuals in the jobs.

With regard to the capacity aspect, the project provides a review of the institution's legal mandate linked to the size of responsibility of the institution, in order to estimate capacity requirements with regard to staff numbers by job title. With regard to the qualitative aspect, the project developed and initiated an online staff skills survey system that provides a 'live' and repeatable process for measuring individual and institutional competence. The final report provides a record of the capacity and skills assessment carried out with five public water sector organisations, namely: DWS, the Breede-Overberg Catchment Management Agency (BOCMA), Umgeni Water and Moses Kotane Local Municipality. The report also provides findings from HR qualitative and qualitative surveys in water sector institutions (WSI) and information on the supply of graduates to the South African water sector.

Cost: R2 294 92 Term: 2011–2014

NEW PROJECTS

Production of 'State of Water Research in South Africa': Report and study on water research and development expenditures in South Africa

Quantitative Evidence Research Consultancy Services cc

No. 2424

Aims:

- To produce for the first time the document the "State of Water Research and Development in South Africa"
- Update bibliometric, patent and human resources indicator
- To measure the R&D expenditures for water related research in South Africa and hence provide the baseline for monitoring future allocation
- Inform policy and decision makers about the state of water R&D in the country

Expected cost: R589 000 Expected term: 2015–2016

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NEW TT REPORTS 2014/15

Effects of urine separation and treatment

JA Wilsenach, M McMillan, A Mbaya, KG Motlomelo, C Anderson, A Pascal, S Brown, J Germanis, MR Mashego, J A du Plessis and G A Ekama

With complete urine separation, the need for nitrification and denitrification falls away at activated sludge plants, which would be operated at short sludge ages (5 days) with anaerobic phosphate release and aerobic phosphate uptake. Treatment of undiluted source separated urine in a sequencing batch reactor could be described in terms of the normal activated sludge model stoichiometry.

TT 586/13 ISBN: 9781431205042 Overseas Price: $35.00

Introducing the wastewater biorefinery concept

B Verster, Z Madonsela, S Minnaar, B Cohen and STL Harrisson

In this project, the wastewater biorefinery approach is explored in which we aim to use the nutrient component of partially treated domestic waste water for the production of poly (γ-glutamic acid) (γ-PGA) by enriching the microbial ecology for appropriate Bacillus species. The project considers both the specific case of PGA production as well as the broader system needs to achieve a successful biorefinery.

TT 587/13 ISBN: 9781431205035 Overseas Price: $35.00

Water Sensitive Urban Design (WSUD) for South Africa: Framework and guidelines

N Armitage, L Fisher-Jeffes, K Carden, K Winter, V Naidoo, A Spiegel, B Mauck &D Coulson

South Africa (RSA) is a water scarce country challenged with transforming its unsustainably resource-intensive economy whilst also addressing the legacy of Apartheid . The adequate provision of water to RSA's citizens is one of the most significant challenges facing the country. This is particularly relevant in the rapidly-urbanising areas owing to the fact that they are hubs of economic growth, and could without proper management become major drivers for increased water demand. It is evident that alternative, systems-based approaches to conventional water management of water supply and modes of ensuring water quality are required.

TT 588/14 ISBN: 9781431205301 Overseas Price: $45.00

Manual for fish kill investigations in South Africa

B Grant , B Hohls & D Huchzermeyer

Fish kills have become common phenomena that occur worldwide and may be the result of significant environmental changes, disease incidents or pollution events. Mass fish kill events evoke an emotional response in many communities. Such events are often interpreted as a measure of the health of the aquatic resource within which such a kill is observed, and may be interpreted as a potential early warning of an impending environmental problem.

TT 589/14 ISBN: 9781431205318 Overseas Price: $40.00

Guidelines on Best management practices for Rainwater Harvesting and Conservation

C Jarmain, A Singels, E Bastidas-Obando, A Paraskevopoulos, F Olivier, M van der Laan, D Taverna-Turisan, M Dlamini, Z Munch, W Bastiaanssen, J Annandale, C Everson, M Savage and S Walk

The accuracy of the Surface Energy Balance Algorithm for Land (SEBAL) data products, ET, biomass production and biomass water use efficiency (WUE), was tested extensively (for two important agricultural crops: sugarcane and maize, representing a range of climatic, soils and agronomic conditions, over a period of 26 months, and against field observation and accepted South African crop growth and water balance models) and found to be acceptable. The SEBAL data products were further developed for sugarcane yield estimation and yield forecasting. It can be concluded that these yield estimates and the forecasted cane yield is an improvement on the current method used. It is also important to note that the yield estimates and forecasting can

be further improved with frequent and consistent updates with the SEBAL data. The SEBAL yield estimates can be improved for maize with the identification of the exact point of flowering. Also, the integration of SEBAL data sets into a crop forecasting system for maize can prove to be very beneficial.

TT 590/14 ISBN: 9781431205608 Overseas Price: $25.00

Wetlands and Wellbeing: A Decision Support System

Donovan Kotze

This decision support system is a product of a research project entitled Wetlands in South Africa: Their Contribution to Wellbeing (Report 1986.1/1/14), commissioned by the Water Research Commission and led by Duncan Hay and Associates.

The work was conducted in association with colleagues at AWARD, the Inina Craft Agency, University of KwaZulu-Natal and WWF Mondi Wetlands Programme. The focus here is on freshwater inland wetlands but the lessons are derived from and could equally be applied to other aquatic systems, particularly rivers, dams, lakes, estuaries and our coastline.

TT 591/14 ISBN: 9781431205356 Overseas Price: $25.00

Towards the effective use of sanitation subsidies: A guide

Melanie Wilkinson and Louiza Duncker

The South African Government has committed itself to universal access to sanitation by 2014. As part of this commitment, the government provides various sanitation subsidies to assist the poor (household expenditure <R1100 per month) to gain access to a basic level of sanitation service; i.e. in the case of basic sanitation, at least a Ventilated Improve Pit toilet. These sanitation subsidies are provided by various funding mechanisms across a number of governmental departments. However, the key funding mechanisms are those which subsidise sanitation facility provision directly to households and those which provide sanitation facilities as part of a subsidised housing service.

TT 592/14 ISBN: 9781431205462 Overseas Price: $30.00

Tools to Determine Enforcement Driven Rehabilitation Objectives on Urban River Reaches

Braid Samantha

It is widely acknowledged that hygienic sanitation is necessary to sustain human life and to ensure good health and human dignity. As a result, the South African Government has committed itself to universal access to sanitation. As part of this commitment, poor households1 are provided various sanitation subsidies to gain access to a basic level of sanitation service. A sanitation subsidy can be defined as any financial support offered to a household to meet national sanitation policy objectives.

TT 593/14 ISBN: 9781431205479 Overseas Price: $30.00

Tools to Determine Enforcement Driven Rehabilitation Objectives on Urban River Reaches. Guideline Document

Braid, Sam

The process of developing the guidelines was an interactive and evolutionary one. Workshops with the target audiences were held during the development stages, in order to ensure the guidelines were tailored to the officials' requirements. This was done to ensure buy-in and support for the utilization of the guidelines beyond research period

TT 594/14 ISBN: 9781431205486 Overseas Price: $35.00

Guidelines for reducing water losses in South African Municipalities

Braid, Sam

There is no single WDM intervention that will always provide the best savings at the least cost. Every water supply system is unique in some way and will have its own specific problems that set it apart from other systems. In reality, reducing water losses from municipal water distribution systems it is not complicated but does require a dedicated and methodical approach if real and sustainable savings are to be achieved.

TT 595/14 ISBN: 9781431205653 Overseas Price: $40.00

Conduit Hydropower pilot plants

SJ van Vuuren, M van Dyk, I Loots

An initial scoping investigation (van Vuuren, 2010) highlighted the potential hydropower generation at the inlets to storage reservoirs. In South Africa there are 284 municipalities and several water supply utilities, mines, all owning and operating gravity water

supply distribution systems which could be considered for small, mini, micro and pico scale hydropower installations. Most of these water supply/distribution systems could be equipped with turbines or pumps as turbines, supplementing and reducing the requirements for pressure control valves.

TT 596/14 ISBN: 9781431205493 Overseas Price: $45.00

Conduit Hydropower development guide

SJ van Vuuren, M van Dijk,I Loots, B Barta & BG Scharfetter

An initial WRC scoping study highlighted the potential hydropower generation at the inlets to storage reservoirs. In South Africa there are 284 municipalities and several water supply utilities, mines, all owning and operating gravity water supply distribution systems which could be considered for small, mini, micro and pico scale hydropower installations.

TT 597/14 ISBN: 9781431205509 Overseas Price: $50.00

A Manual for Cost Benefit Analysis in South Africa

David Mullins, Johan Petrus Botha, David Daniël Mosaka, Franciscus Xavierius Jurgens & Tefelo Julia Majoro

In 1989, the then Central Economic Advisory Services produced the original Manual for Cost-Benefit Analysis in South Africa. This updated Manual builds on a project which was commissioned by the Water Research Commission (WRC) in 2001 entitled: A Manual for Cost-Benefit Analysis with Special Reference to Water Resource Development (WRC Report No TT177/92) which was revised and updated in 2007, and published as WRC Report No TT 305/07. This current report presents an update of the October 2007 manual to reflect 2012 prices. Updates are essential in order to provide users of this Cost-Benefit Analysis (CBA) manual with a set of standardised, uniform parameters that will enable decision makers to arrive at sound conclusions and decisions.

TT 598/14 ISBN: 9781431205523 Overseas Price: $30.00

Introduction to Operation and Maintenance of Water Distribution Systems

A reliable supply of clean and safe water is the first and most critical municipal service that people require. Developing countries like South Africa have made great strides in addressing the inequalities of the past in the provision of water, but unfortunately the focus on expanding service provision has often been at the expense of adequate operation and maintenance of existing infrastructure

TT 600/14 ISBN: 9781431205493 Overseas Price: $35.00

Environmentally Sustainable Beneficiation of Brewery Effluent

Clifford Louis Wilshire Jones, Peter J Britz, Rory Scheepers, Sean Power, Anneke Cilliers and Richard Laubscher

The HRAP/wetland system is an environmentally sustainable method of treatingbrewery effluent that allows for the recovery of water and nutrients from the wastewater. It is a low-energy, low maintenance system (both biologically and physically), driven mainly by gravity and the sun's energy. The only external energy-inputs for HRAP system were two small (0.45 kW) motors that drove the paddlewheels. As such, the cost to build and operate the system could be recovered quickly and the potential exists to recover these costs even faster if the water and nutrients that are recovered are reused or sold.

TT 601/14 ISBN: 9781431205578 Overseas Price: $30.00

Water Use Efficiency of Selected Irrigated Crops Determined with Satellite Imagery

Jarmain C, Singels A, Bastidas-Obando E, Paraskevopoulos A, Olivier F, van der Laan M, Taverna-Turisan, Dlamini M, Munch Z, Bastiaanssen, Annandale J, Everson C, Savage M, Walker S

The need for increased food and timber production due to population increases and economic development has led to substantial increases in land under irrigated agriculture and forestry in South Africa (SA) over the past 50 years. Under current development trajectories, SA is expected to experience particularly severe water shortages in the future. Consequently, the competition for water between different users has increased.

TT 602/14 ISBN: 9781431205738 Overseas Price: $45.00

Quality of harvested rainwater and application of point of use treatment systems

Dobrowsky PH, van Deventer A, Lombard M, de Kwaadsteniet M, Khan W and Cloete TE

The main aim of this project was to determine the microbiological and chemical quality of harvested rainwater and people's perceptions on the use of rainwater. In addition this study was aimed at evaluating options for treatment of the collected rainwater. First the microbiological and chemical quality of rainwater collected in existing DRWH tanks was determined. Rainwater samples were collected from domestic rainwater harvesting tanks (DRWH) in a sustainable housing development in Kleinmond, South Africa. Water samples were collected on eight occasions from 29 tanks during the period of March to August 2012.

TT 603/14 ISBN: 9781431205639 Overseas Price: $35.00

Domestic rainwater harvesting: survey of perceptions of users in Kleinmond

Mannel D, Prozesky H, Cloete TE

The main aim of this project was to determine the microbiological and chemical quality of harvested rainwater and people's perceptions on the use of rainwater. In addition this study was aimed at evaluating options for treatment of the collected rainwater. First the microbiological and chemical quality of rainwater collected in existing DRWH tanks was determined. Rainwater samples were collected from domestic rainwater harvesting tanks (DRWH) in a sustainable housing development in Kleinmond, South Africa.

TT 604/14 ISBN: 9781431205622 Overseas Price: $25.00

Wetlands and Wellbeing: Getting more out of South Africa's wetlands

Duncan Hay, Donovan Kotze, Charles Breen ,Nokothula Dubazane, Derick du Toit, Thandazile Magubane, Fundisewe Biyela and Sholiphi Mhlongo

This handbook is a product of a research project entitled Wetlands in South Africa: Their Contribution to Wellbeing commissioned by the Water Research Commission and led by Duncan Hay and Associates. (Report 1986.1/1/14). The work was conducted in association with colleagues at AWARD, the Inina Craft Agency, University of KwaZulu-Natal and WWF Mondi Wetlands Programme.

The focus is on freshwater inland wetlands but the lessons are derived from and could equally be applied to other aquatic systems, particularly rivers, dams, lakes, estuaries and our coastline.

TT 605/14 ISBN: 9781431205721 Overseas Price: $25.00

AguaSmart Hotels

Melissa Wade, Claudia Bernadette McKenzie, Kirthi Peramaul & Martin Ferreira

The AquaSmart Hotels tool was developed to create awareness regarding water conservation within the hospitality industry by assisting members and owners of hotels, lodges, B&Bs etc., to determine where and how water is being used within their establishment and providing alternative options which could reduce their water consumption.

TT 606/14 ISBN: 9781431205783 Overseas Price: $30.00

Volume 2: Guidance on water conservation in food value chains: Part 1: Guidebook for Emerging Farmers in the Maruleng Municipal Area

Karen Nortje, Nikki Funke and Willem de Lange

The overall objective of the project was to support efficient and sustainable conservation of water as a production input in food value chains following equitable allocation of water resources in irrigated agriculture.

The research findings highlight that much still has to be done to align land reform and water allocation reform. This has also been clear from the project's case study area, where water allocation reform has not been nearly as prominent or influential as the land reform process. In fact, water allocation reform has for the most part been non-existent, with the majority of beneficiaries not having any knowledge of water allocation reform processes in their area.

TT 607/1/14 ISBN: 9781431205806 Overseas Price: $20.00

Volume 2: Guidance on water conservation in food value chains: Part 2: Guidebook for Extension Officers in the Maruleng Municipal Area

Karen Nortje, Nikki Funke and Willem de Lange

The overall objective of the project was to support efficient and sustainable conservation of water as a production input in food value chains following equitable allocation of water resources in irrigated agriculture.

The research findings highlight that much still has to be done to align land reform and water allocation reform. This has also been clear from the project's case study area, where water allocation reform has not been nearly as prominent or influential as the land reform process. In fact, water allocation reform has for the most part been non-existent, with the majority of beneficiaries not having any knowledge of water allocation reform processes in their area.

TT 607/2/14 ISBN: 9781431205813 Overseas Price: $20.00

Volume 2: Guidance on water conservation in food value chains: Part 3: Guidebook on different types of emerging farmers and the everyday challenges they face: insights for policy advisors
Karen Nortje, Nikke Funke and Willem de Lange

The potential of rainwater harvesting has not been fully explored and implemented in South Africa. Rain Water Harvesting has a potential to contribute to the equitable, efficient and sustainable use of water resources with little input costs and effort. Communities that are currently outside the areas with water services stand to benefit from wide application of well-designed rainwater harvesting schemes.

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Review of available methods for the assessment of the ecological condition of wetlands in South Africa
DJ Ollis and HL Malan

Directorates within the Department of Water Affairs (DWA) and other regulatory authorities (such as provincial environmental and conservation departments) require methods for the assessment of wetlands Present Ecological State (PES) and a Decision Support System (DSS) or Decision Support Tree (DST), in order to allow more effective and consistent decision-making with regard to the protection of wetlands.

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Development of Decision-Support Tools for Assessment of Wetland Present Ecological Status (PES) Volume 2
DJ Ollis, JA Day, HL Malan, JL Ewart-Smith and NM Job

There are currently two main assessment methods to determine the present ecological state (PES) of wetlands. These are used interchangeably by wetland assessment practitioners. Where gaps in these methods,existed, additional assessment tools were developed. Now there are significant problems regarding consistent standards of data collection and reporting, as well as confidence in the assessments.

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Preliminary guideline for the determination of buffer zones for rivers, wetlands and estuaries
DM Macfarlane, IP Bredin, JB Adams, MM Zungu, GC Bate and CWS Dickens

South Africa's water ecosystems are under increasing pressure, with impacts such as regulation of flow by impoundments, pollution, over-extraction of water, and the breakdown of natural bio-geographical barriers. All affect the ecological condition of these resources. Wetlands have been subject to widespread degradation with an estimated 50% of South Africa's wetlands having been destroyed or converted (Department of Environmental Affairs and Tourism, 2005). While Reserve determination, resource classification and resource quality objectives are legislative tools developed to reverse or prevent these impacts, the implementation of these tools is still in the early stages, with costly implications for reversing existing impacts or rehabilitation. The need for preventative measures to prevent further degradation of these resources has therefore been highlighted.

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Wastewater reclamation for potable reuse volume 2: Integration of MBR technology with advanced treatment processes
Graham Metcalf, Lingam Pillay, Cyprian Murutu, Sandile Chiburi, Nhlanhla Gumede and Paul Gaydon

There are a range of technologies and combinations of treatment technologies that can be used to reclaim water from domestic wastewater effluent. The choice of treatment train that will meet quality, cost and operational requirements is thus a difficult one. The intention of this research project is to test a range of treatment

technologies in different combinations and to establish a preferred reclamation treatment process train for water reclamation.

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Manual to monitor fish behaviour and water variables remotely in real time in South African inland aquatic ecosystems

GC O'Brien, FJ Jacobs, IF Botha, M O'Brien

There are many ecosystem monitoring techniques in South Africa. Fortunately most of these tools are informative, easy to use and follow best practice scientific techniques. The demand for real time monitoring data has increased as the complexity of land use and impacts of pollution and demands for conservation have escalated.

TT 613/14 ISBN: 9781431205974 Overseas Price: $25.00

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