WATER RESEARCH COMMISSION

KNOWLEDGE REVIEW 2013/14


WATER
RESEARCH
COMMISSION

CONTENTS

INTRODUCTION

INVESTING IN THE CREATION AND SHARING OF WATER-CENTRED KNOWLEDGE

During 2013/14, 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 2013/14 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

Water Resource Management	Water resource institutional arrangements Water resource assessment and planning Water quality management Water resource protection Water resources and climate
Water-Linked Ecosystems	Ecosystem processes Ecosystem management and utilisation Ecosystem rehabilitation, remediation and restoration Sustainable ecosytem utilisation and development Ecosystems and global change
Water Use and Waste Management	Water services – institutional and management issues Water supply and treatment technology Sustainable municipal wastewater and sanitation Sustainable and integrated industrial water management Mine water treatment and management Watersmart fund
Water Utilisation in Agriculture	Water utilisation for food and fibre production Water utilisation for fuel-wood and timber production Water utilisation for poverty reduction and wealth creation in agriculture Water resource protection and reclamation in agriculture
Business Development, Marketing and Communications	Research – water-centred knowledge Technology transfer and IP management Strategic positioning and partnerships Public relations and communications Business systems management Production and knowledge packaging

Legislative and other mandates

The WRC's annual operational work plan is guided by numerous legislative and other mandates, several of which are in a state of review and revision. The WRC is governed by the Water Research Act, which outlines the purpose and mandated objectives of the organisation. The mandated objectives of the WRC are also in accordance with the requirements of the policies of the Department of Water Affairs (DWA), most notably, the National Water Act (Act No. 36 of 1998) and the Water Services Act (Act No. 108 of 1997).

Water Research Act (Act No. 34 of 1971 as amended)

The principal aim of the WRA is to provide for the promotion of water and related research. The Act requires the establishment of the WRC and the Water Research Fund, and sets the framework within which the WRC operates. The WRC's mandate as set out in this Act highlights the following functions to be carried out by the organisation:

- Promote co-ordination, co-operation and communication in the area of water research and development
- Establish water research needs and priorities
- Stimulate and fund water research according to priority
- Promote the effective transfer of information and technology
- Enhance knowledge and capacity building within the water sector

National Water Act (Act No. 36 of 1998)

The objective of the National Water Act (NWA) is to ensure that South Africa's water resources are protected, used, developed, conserved, managed, and controlled in a sustainable and equitable manner, for the benefit of all persons. The NWA also provides for the pricing strategy for water use charges, the primary mechanism for the calculation of a charge, payable by some or all raw water users, that is also set for research purposes by the WRC. The role of the WRC is to align its funding priorities with those key national water challenges articulated in the NWA, and to help solve water-related problems which are critical to South Africa's sustainable development and economic growth.

Water Services Act (Act No. 108 of 1997)

The objective of the Water Services Act (WSA) is to provide for the right of access to basic water supply and basic sanitation by setting national standards and norms. Section 156, read in conjunction with Part B of Schedule 4 of the Constitution of the Republic of South Africa (Act No. 108 of 1996), vests in the Executive Authority the responsibility to support and strengthen the capacity of municipalities to manage their own affairs, to exercise their powers and to perform their functions. Again, the applicability of the WSA to the WRC rests in the WRC's duty to respond to water supply and sanitation needs with research and development that helps to address those needs.

Contributing towards achieving Government Outcomes

As a national public agency, the WRC actively strives to support the Government of South Africa in achieving its strategic outcomes, with particular reference to the Corporate Plan (Annual Performance Plan) of the Department of Water Affairs (DWA) and the performance agreement of the Minister of Water and Environmental Affairs. Of particular relevance to the work of the Commission is Government Outcome 10, as well as Outcomes 6, 7, and 9:

- Outcome 6 – the WRC actively strives to align its projects and activities with achieving an efficient, competitive and responsive economic infrastructure network
- Outcome 7 – the WRC actively strives to align its projects and activities with achieving vibrant, equitable and sustainable rural communities and food security for all
- Outcome 9 – the WRC actively strives to align its projects and activities with achieving a responsive, accountable, effective and efficient local government system
- Outcome 10 – the WRC actively strives to align its projects and activities with achieving protection and enhancement of the country's environmental assets and natural resources

ACHIEVING THE GOALS OF THE 'WRC KNOWLEDGE TREE'

A fundamental guiding framework and strategic planning tool for the WRC's operations at the beginning of its fifth decade is the construct of the WRC Knowledge Tree. The tree metaphor reflects strength in foundation (i.e., 'roots' firmly embedded in sound knowledge) and strong growth (i.e., 'branches and leaves' growing vigorously from this knowledge). It also acts as a yardstick with which to measure the WRC's impact in key domains.

Each of the Knowledge Tree strategic outcome-oriented goals provides a specific priority categorisation for the WRC's projects and activities. Each has its own kind of contribution to the Government Outcomes, either directly or indirectly. The goals are not mutually exclusive. For example, a 'new product' may be a 'sustainable development solution' that 'empowers communities' and 'informs policy and decision making'.

The guiding principle is that every WRC project will strive to achieve as many of the WRC Knowledge Tree outcomes as reasonably possible. This applies within the project, to post-project actions, and to follow-on projects.


~The WRC Knowledge Tree~
Transformation & Redress
Empowerment of Communities
HCD in Water & Science Sectors
Inform Policy & Decision Making
New Products & Services for Economic Development
Sustainable Development Solutions
Knowledge Generated ~by the WRC~
Research

Strategic outcome-oriented goals

The WRC's strategic outcome-orientated goals comprise of five impact areas based on the operationalisation of the WRC Knowledge Tree:

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 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.

The WRC Lighthouses

The construct of the WRC Lighthouse is another strategic developmental tool initiated in the 2013/14 financial year and which will be further developed and implemented to direct research in key areas identified by the WRC. These Lighthouses are flagship programmes, and are trans-disciplinary, multi-KSA and inter-institutional mega-projects that will examine priority water issues across the innovation value chain. Five Lighthouse programmes have been initiated: the green village; water governance, water-sensitive urban design, the water–energy–food nexus and climate change interventions.

SUPPORTING RESEARCH PROJECTS

In 2013/14, the WRC initiated 87 new projects and also completed 87 projects. This represents a cumulative increase in the amount of new research and finalised research funded over the past 5 years. Over the past 5 years the WRC has finalised 401 research projects (Figure 1), indicating a significant contribution to knowledge in the water sector. An average number of 80 projects were finalised per year, for the past 5 years. Over the same 5-year period 381 new projects were initiated (Figure 2), ensuring the continuous contribution of new knowledge to the sector. An average number of 76 new projects were started per year, over the past 5 years. Of the 484 students supported in 2013/14 financial year, 402 were from designated groups.

Figure 1: Annual and cumulative number of projects finalised over the past five years

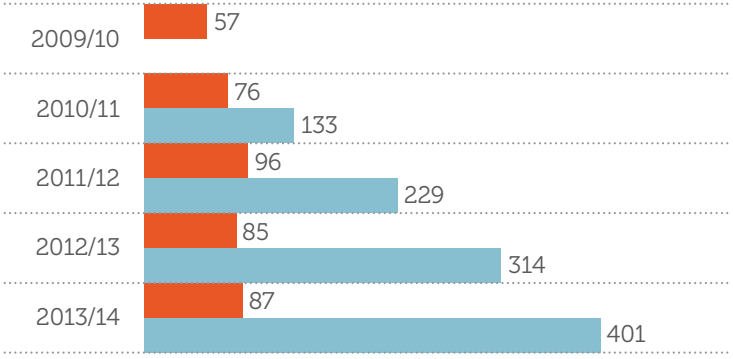
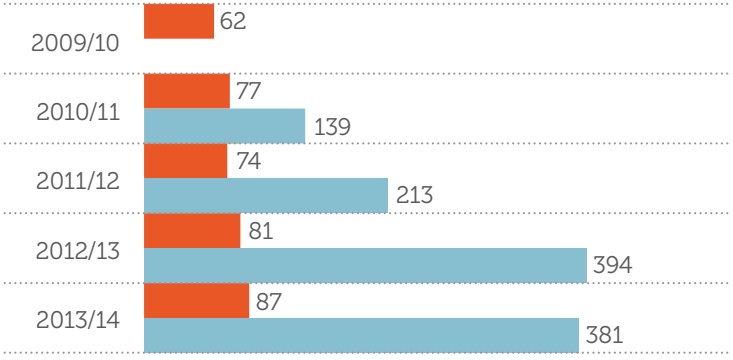


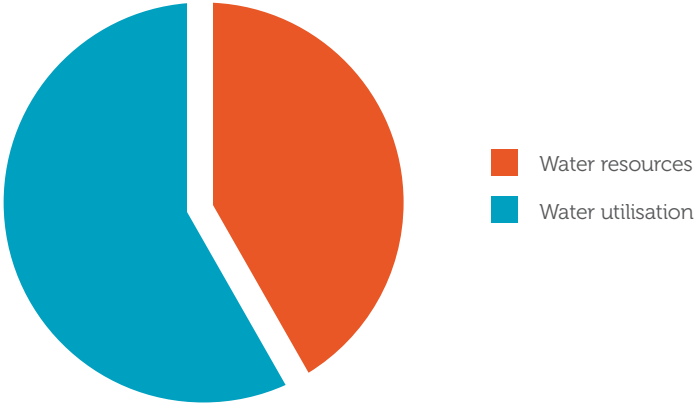
Figure 2: Annual and cumulative number of projects initiated over the past five years



The percentage utilisation of research project funds by the KSAs during 2013/14 (Figure 3) indicates that approximately 44% (compared with 48% for 2012/13) was invested in projects that focused on water resources (including water-linked ecosystems) and approximately 56% (compared with 52% for 2012/13) in projects that focused on water utilisation (including effluent treatment and management, as well as agriculture). This is based on the actual amount paid out as well as accrued for research projects during the financial year under review. The allocation of about 50%

of the fund to issues related to resource management and 50% to issues related to water utilisation was a strategic allocation based on the medium- to long-term needs for research.

Figure 3: Percentage utilisation of research funds in 2013/14



The overall investment in research projects (knowledge creation) amounted to R118.5 m. This was marginally more than what was reported in the previous year, with an increase of 1% (R116.7 m. for 2012/13). Total investment in the support of knowledge creation, sharing and dissemination amounted to R150.0 m. This represents an increase of 3.7% from the previous year (R144.7 m. total investment was reported in 2012/13).

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

During the year under review the WRC continued to leverage levy income by striving to obtain funds from other sources to support water research. During 2013/14 this drive was fairly successful, but substantial amounts were rolled over into 2014/15, e.g., the upfront funding received from the Bill and Melinda Gates Foundation for sanitation research in sub-Saharan Africa, the Blue/Green Drop project, the Gates Sanitation Demonstration project and the DST Innovation for Rural Development Partnership programme. The WRC income originating from sources other than the levy for 2013/14 amounted to R19.2 million. Leveraged income included funds allocated to a number of KSAs for direct support of research projects and funds provided for capacity building, knowledge sharing and dissemination. Leveraged income was obtained from both local and international sources, where the main source of income was due to support by various Government departments for specific research and for other knowledge-sharing projects. Sources of income other than the levy for 2013/14 amounted to about 10% of the total income.

WRC RESEARCH PORTFOLIO 2013/14

What follows is a summary of the WRC's investment in the creation and sharing of water-centred knowledge, over the 2013/14 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.

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

Eiman Karar: Executive Manager

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. The bulk of the research in this KSA is in support of Government Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 1, 2, 3 and 4. Thrust 5 supports Output 2: 'Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality'. Thrust 3 also addresses aspects of Output 3: 'Protected biodiversity'.

Integration, transdisciplinarity, synthesis, adaptive management, absorptive capacity and requisite level of simplicity are the principles guiding the future research approach. Emerging research areas are around water security and trade-offs between water, food, energy and the environment; the need for an equity framework and revised tenure systems for water; complete value chain assessments from water resources to raw water supply, tap water supply, wastewater treatment and finally back to freshwater systems or the coast.

OBJECTIVES

The ultimate objectives of the research in this KSA are to grow and maintain appropriate scientific capacity (i.e. the people-based knowledge pool), and to develop efficient and effective knowledge tools that meet the changing needs of water resource management in South Africa in which the human dimension is very central. This necessitates proactive, innovative, scientific, technological and institutional experientially-based solutions. A better understanding of water resources and their management requires a more holistic conceptual framework encompassing regional-scale hydrologic systems, land-atmosphere interactions and the biogeochemical cycles that control contaminant transport. Holistic approaches to water resource management are particularly pertinent in this area of research and must take account of all sources of water from quality, quantity and accessibility perspectives.

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

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 sub-sequent 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 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:** SClimate 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.

STRATEGIC CONTEXT

In December 2010, the United Nations General Assembly declared 2013 as the United Nations International Year of Water Cooperation. There was thus a focus in 2013/14 on raising awareness, both on the potential for increased cooperation, and on the challenges facing water management in light of the increase in demand for water access, allocation and services. Successful water cooperation initiatives were highlighted, as well as ongoing challenges such as capacity building, water governance, transboundary water management, national and international legal frameworks, and infrastructure development. Particular challenges faced in South Africa include: institutional fragmentation, mainly poorly coordinated multi-level governance vertically and horizontally; limited capacity at the local level to participate in water-related decision making; and a struggling allocation reform process. Inadequate means for measuring performance have also contributed to weak transformation and reforms. These obstacles seem to be rooted in the insufficient definition of policies and regulations related to the National Water Act and the overall lack of common vision regarding water in the tri-central focus of economy, society and the environment.

It is well known that there is no one-size-fits-all answer or magic blueprint to respond to governance challenges in the water sector. Local and spatially-defined policies integrating boundary specificities and local concerns, water management institutions, catchment management agencies, water user associations, transboundary commissions, etc., are at different developmental stages but tend to face common challenges, which will need to be examined, with the benefit of hindsight, to provide adequate policy responses. In order to do so, there is a pressing need to take stock of recent experiences, identify and document good practices and develop pragmatic tools across different levels of government and other stakeholders for engaging shared, effective, and implementable water policies.

A main effort in this KSA is to continue understanding the water cycle and how it operates, how it affects land-use practices and is affected by them and other atmospheric and anthropogenic processes. Climate change and the focus on allocating scarce water resources will require strategies for managing demand, increasing efficiency, and creating new sources of water from desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., which can be viewed as part of Outcome 6: 'An efficient, competitive and responsive economic infrastructure network' which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', relates to these pertinent aspects.

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological measurements and how these are interpreted in water resource simulations and other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes can only suffice if real, reliable data are available at reasonable spatial and temporal resolutions for verification.
The KSA has invested heavily in enhancing the estimates for quantifying water use and water availability. Furthermore, the need for integrating surface water and ground¬water models has been highlighted. Concerted effort is being made to bridge this gap and to create a continuum, starting with improving evapotranspiration estimates, which take into account the unsaturated zone, informed by groundwater dynamics.

The marked inequities in the physical, social, as well as institutional, access to this important resource remain a challenge. At its heart, sustainable development is about giving people the opportunity to build resilience by providing them with more options in their lives and livelihoods. The focus is on the poor and the disempowered majority whose ability to pay for water is limited. Delivering water services to this majority and ensuring that there are adequate water resources for new productive users, such as emerging farmers in rural areas, is a main target of Outcome 7: 'Vibrant and sustainable rural communities and food security for all'. Output 1: 'Sustainable agrarian reform' is a major focus for the KSA dealing with Water and Agriculture, but in this KSA the main focus is from the perspectives of climate change and adaptation, resource assessment and the institutional arrangements pertaining to addressing equity aspects as well as water licensing and allocation reform.

The KSA's contribution to the national service-delivery-based outcomes is hence through conducting research that can yield impacts on sustainable development's triple bottom line, through improved water allocation and optimisation of water use between social development, economic growth and environmental sustainability.

Water and society

The National Water Act (NWA) places emphasis on stakeholder participation in water resource manage-ment, which forms a blend between decentralisation and democratisation for decision making. Vast resources have been used in ensuring that adequate consultation takes place, without necessarily reflecting much value from those investments. International literature confirms that empowerment is a long path which is progressive in nature and highly non-linear. Since the primary focus is to make an impact on the lives of people, the KSA has commissioned studies to establish the lowest appropriate level for decision making in water management in South Africa, the benefits from such engagements and their impact on the lives of women and the poor. The role of local government as the democratic representative in water-related decision making in South Africa is an area that needs further investigation.

Water and the economy

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

The KSA has initiated a comprehensive research programme on climate-change impacts on water resources, with a view to gaining insight into the magnitude of the impacts and subsequently the consequential adaptation needs for the economy; the first steps to incorporate research on vulnerability, mitigation and adaptation have already been taken. The success of this research relies on the outcomes of considerable prior investment by the WRC in water-related climate, atmosphere and ocean-atmosphere research, as well as hydrological modelling research, done over a period of more than 15 years.

Water and the environment

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

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed and approved funding budget, inclusive of roll-over, of R33 850 278.

Research portfolio	Approved 2013/14 (R)
Current projects	24 081 184
New projects	9 769 094
Total	**33 850 278**

RESEARCH PORTFOLIO FOR 2013/14

The primary objective of the research in this KSA continues to be to ensure that water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The research portfolio for 2013/14 addressed this primary objective through Government delivery Outcomes 6, 7, 9 and 10, and as reflected by the following secondary aims:

- Broaden the scope for policy and institutional studies to deal holistically with political, legal, economic, compliance and implementation aspects
- Improve water resource information systems and access to data
- Protection of water sources in a comprehensive and integrated manner by focusing on supporting implementers
- Mainstreaming climate change discourse to pay closer attention to water

COMPLETED PROJECTS

THRUST 3: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

The development of an institutional adequacy index using the multi-dimensional poverty approach
Brooks World Poverty Institute; University of the Western Cape; University of Oxford
No. 1971

There are obvious links between water and poverty, links that are implicit in the water policy legislation (National Water Act, 1998) and guiding frameworks such as the framework Water for Growth and Development, Catchment Management Strategies and Water Services Development Plans. The Act prescribes that suitable water management institutions must promote social and economic development through the use of water. The water sector operates in an epistemological framework that is predominantly positivist. The poverty frameworks and notions of human development that cannot be captured from within that frame remain underdeveloped. One of the core principles of integrated water resource management (IWRM) is that resources should be managed by users who are closest to the resource and that there should be suitable institutions put in place with multi-stakeholder representation at the lowest possible levels. The reason for multi-stakeholder representation is that the stakeholders themselves should have the opportunity to make decisions in line with ideals of social equity, financial feasibility and environmental sustainability. However, our eagerness to implement policy in the sector all too often results in what Crocker (2011) calls 'palliative remedies', where the intended good of representation and inclusivity is all too often lost, with not enough attention given to the conditions that are necessary for these institutions to be 'suitable.'

Cost: R1 590 000
Term: 2010 - 2013

Change-oriented learning and water management practices: knowledge flows and mediation tools
Rhodes University; Masithethe; Mvula Trust; AWARD
No. 2074

This project has drawn on 15-20 years of research into participatory integrated water resource management and environmental learning, in an endeavour to understand the role of learning in the democratic management of natural resources, in this case water. Research into integrated water resource management in South Africa first focused on trying to understand how to implement the principles of the then new National Water Act. This included establishing decentralised institutions of water management. The assumption was that residents of catchments would be more equipped and should have the right to make important decisions about the management of their natural resources.

The emphasis was on participation, representivity and inclusion. Right from the start it became apparent that part of the process of decentralisation of power and decision making was a need to capacitate. Learning how to manage a catchment, how to work together and how to develop appropriate practices and responses did not happen automatically but needed to be mediated.

Cost: R900 000
Term: 2011 - 2014

Investigating stakeholder engagement cycles and identities within water resource management, using narrative techniques
The Narrative Lab; Nelson Mandela Metropolitan University; SANParks
No. 2076

This project investigated the social dynamics of stakeholder engagement and volunteerism, using narrative techniques at two study sites in the Western Cape, namely, the Wilderness and Swartvlei estuaries, situated on the Garden Route, close to the towns of Wilderness and Sedgefield. In particular, the study aimed to understand why citizens choose to engage with water resource challenges, how they translate that engagement into action and participation and how such engagement may be cyclical in nature. The study investigates how citizens become and remain engaged in decision making regarding the management of the natural resource, to determine: (i) if they feel they are empowered, and (ii) if they have sufficient knowledge, as well as (iii) guiding principles on how to act or start an active engagement process.

Cost: R746 108
Term: 2011 - 2013

Programme 3: Pricing and financing WRM

Approaches to engaging basin risk and the political economy of water in the Western Cape system
Pegasys International
No. 2075

Historically, water planning has focused on water resources infrastructure development and operation, supported by demand management initiatives to reconcile water requirements and availability. However, as water resources are increasingly developed and utilised, catchment quantity and quality stress tend to increase. The resulting complexity in management and use requires a shift towards improved governance and balancing of competing economic, social and ecological interests. This project investigated possible ways of assessing regional water resources in the Western Cape system (Berg and Breede-Overberg WMAs) from a political-economic and developmental perspective.
This can be used to inform water management strategy processes (both the National Water Resources Strategy and

Catchment Management Strategies) as well as provide the types of information that allow effective engagement with provincial and local government planning processes.

Cost: R700 000
Term: 2011 - 2014

An analysis of water pricing instruments governed by the DWA water pricing strategy, and its potential for generating revenue for CMAs
Prime Africa Consultants (previously CIC International); Inkomati Catchment Management Agency
No. 2078

CMAs are statutory bodies with jurisdiction in defined water management areas. The mandate of the CMA has been clearly defined. The various functions required of the CMA have been spelled out in the National Water Act and various publications of the Department of Water Affairs. The foundational strategies, as defined in this report, address the core business of managing water resources and of complying with the business requirements, and with the other functions vested in the Minister. As the CMA becomes established, the Minister will progressively delegate further powers to the CMA to broaden its functioning. In the initial phase the CMA is required to develop policy and strategy and organisational and administrative support. Following this the Minister may delegate certain financial functions such as the registration of water users and the setting of water use charges. The physical implementation and information management of the WMA are then to be delegated before the CMA will become the responsible authority in the WMA. Recognising that some of the CMAs will serve areas with a relatively small water use management component, while others will serve WMAs with a large and diverse economy, the size and powers of the CMA would differ accordingly. The current raw water charge structure does not reflect the full cost of water resource management and is therefore subsidised by a substantial amount from the national fiscus. The current water use charge levels will yield a total revenue of between R223 million and R273 million by the year 2025. An increase of about 270% would be required to raise CMA revenue to the level where the cost of the CMAs could be 100% accounted for. At this tariff level, the average charge per cubic metre would be 5.86 cents and would generate revenue of approximately R828 million, which will fully cover the estimated cost of running 9 fully functional CMAs.

Cost: R610 000
Term: 2011 - 2014

Programme 5: Future scenarios

An analysis of paradigms shaping water research in South Africa: questions for future research
University of Cape Town
No. 2170

Limited historical data are available to describe water research in South Africa over the first half of the 20th century. Many authors recognise that this period was dominated by technological developments, breakthrough research and projects in water storage and transfer, and frequently characterised by a positivist approach to nature and development. A new era in water research in South Africa began with the promulgation of the Water Research Act No. 34 of 1971. The Act led to the formation of the Water Research Commission (WRC) and the Water Research Fund with the purpose of initiating, managing and financing water research. The objectives of the WRC, as stated in the Act, were to co-ordinate, promote, and encourage research in respect of a wide range of purposes and activities (Republic of South Africa, 1971). A shift in the political landscape, marked by the first democratic elections in South Africa in 1994, contributed to a major shift in the existing water resource management paradigm. Legislative reform coincided with growing concerns about the state of the country's waterways and the rising capital expenses in supply schemes, coupled with the growing environmental concerns globally. South Africa is lauded as being the first country in the world to have promulgated national water legislation which uses water to achieve societal transformation and which focuses attention on environmental and social justice. This study commenced with the identification of the prevailing paradigms that have influenced the history of water research in South Africa, by analysing the publication output over the last four decades, and identifies research questions proposed by a range of researchers active in the water sector in South Africa.

Cost:	R300 000
Term:	2012 - 2013

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 2: Surface water / groundwater hydrology

The use of isotope hydrology to characterise and assess water resources in South(ern) Africa
University of the Western Cape; iThemba Laboratory for Accelerator-Based Sciences; Department of Water Affairs; University of Cape Town; University of KwaZulu-Natal (Pietermaritzburg); Mannie Levin; AS Talma; University of the Witwatersrand
No.1907

Environmental isotopes are routinely employed world-wide in the study of groundwater and surface water, as they provide unique information on transport and interconnectivity of water resources and reservoirs. The term environmental isotope embraces the measurement of isotope ratios of the elements making up the water molecule and of substances dissolved in water. These are subject to environmental processes and undergo changes, for example during evaporation. Water in specific environments thus obtains isotopic labels that are transported and

can be traced along the flow pathway. The sustainable development and management of groundwater resources requires an accurate assessment of their occurrence, availability, sustainability and vulnerability to deterioration. Environmental isotope studies have been shown to provide important information useful in the effective management of both groundwater resources and surface water systems.

Cost: R2 000 000
Term: 2009 - 2013

The long-term impact of *Acacia mearnsii* trees on evaporation, streamflow, low flows and groundwater resources. Phase II: Understanding the controlling environmental variables and soil water processes over a full crop rotation
Department of Water Affairs; Mondi; CSIR; University of KwaZulu-Natal (Pietermaritzburg)
No. 2022

Internationally, long-term catchment studies such as those conducted at the Two Streams research site which include actual measurements of all of the water balance components (some since 1999, and to 2013) are scarce, while locally this represents a unique study on the impact of an exotic tree plantation on catchment hydrological processes. Detailed measurements of total evaporation, streamflow, rainfall and groundwater were compiled to show a deficit in the water balance over the past seven years. Additional research was conducted on canopy and litter interception and stemflow contributions. During the most recent phase of work, isotope samples were collected using conventional automatic samples from the stream as well as newly developed rainfall samplers. In addition, techniques to extract isotope samples from the soil profile were improved, providing information on the water pathways through the catchment. Tree water-use measurements on different slope positions showed significant differences depending on distance from the river and aspect. These detailed process studies continue to enhance our understanding of the impacts of commercial forestry on the hydrological cycle, providing invaluable information to support hydrological models and policy development within the water sector.

Cost: R2 295 872
Term: 2011 - 2015

Groundwater–surface water interaction: From theory to practice
University of the Free State; Rhodes University; University of KwaZulu-Natal (Pietermaritzburg)
No. 2054

Surface water and groundwater resources as well as atmospheric processes are all components of the larger, interconnected hydrological system and the development of either resource will affect both the quantity and quality of the other. In the past, surface water and groundwater were seen as separate water resources and dealt with individually. However, in more recent times the inter-connectedness of these two resources has become evident.

It stands to reason that understanding and quantifying the amount of groundwater feeding the surface water system at the river–aquifer interface is an essential component of understanding the whole hydrological system to ensure the responsible use of both water resources. Furthermore, in South Africa, data is segmented into purely atmospheric, surface hydrology or geohydrological data for specific areas. Commonly, no significant overlap exists between the surface and sub-surface hydrological data that could enable the establishment of a relationship between these two components of the hydrological cycle. In light of this, the current project is aimed at investigating surface water–groundwater interaction at specific test sites, where this interaction can be studied using a multi-disciplinary approach. The multi-disciplinary approach aims to include surface hydrology, evapotranspiration, vadose zone hydrology and geohydrology. The data gathered at the specific test sites will be used to identify important processes taking place, define the contributing sources to the river and the quantification of these source volumes.

Cost: R3 000 000
Term: 2011 - 2013

Investigation of groundwater potential in fractured crystalline rocks of the North West Province, South Africa
University of Venda; Council for Geoscience
No. 2055

In this study, investigation of groundwater potential in crystalline basement rocks of the North West Province was carried out. The area of study is located in the Naledi Local Municipality situated in the central part of the North West Province. It covers an area of ~7 260 km^2 and consists of 8 quaternary catchments. Hydrogeologically, a large part of the area falls within the Lower Vaal catchment. The average annual precipitation in the area is ~350 mm and temperature varies from very cold (below freezing point) to 35°C during the warm season. Groundwater recharge in the area is low (<10 mm) and largely depends on temperature and the seasonality and intensity of rainfall. Potential evaporation rate ranges from 1 960 mm to 2 100 mm per annum, exceeding annual rainfall. It is typically a semi-arid to arid region, and groundwater is the main source of water supply for domestic and agricultural use. The resulting map shows a number of groundwater potential zones varying from 'very good' to 'very poor'. The zone shown as 'very good' and 'good' groundwater potential covers ~17% and ~22% of the study area, respectively. The superimposed borehole yield also confirms the results derived from multivariate statistical modelling approaches, whereby high borehole yields (> 15 L/s) occur within carbonate rocks consisting of dolomite and limestone and located in the southern part of the area. In addition, follow-up geophysical surveys carried out at selected sites confirmed the presence of conductive layers varying in depth from 20 m to 35 m. The high conductivity possibly indicates the presence of water-bearing formations, in particular dolomite, located around Vryburg, and highly-fractured granite just south of Stella. The high-yielding wellfields can be attributed to dissolution of carbonate rocks by water that percolates through pre-existing fractures leading to enlarged fracture apertures, and consequently resulting in the development of large cavities that can store and supply significant amounts of water.

Cost: R1 000 000
Term: 2011 - 2013

Development of the pressure release flowing test method for artesian flow aquifers with case study in TMG
University of the Western Cape; Council for Geoscience
No. 2058

The Table Mountain Group (TMG) is a strategic aquifer system in South Africa. The sustainable utilization of groundwater resources in TMG still presents challenges, as many flowing artesian boreholes cannot be properly tested using conventional pumping test approaches. Due to the unique characteristic of flowing artesian boreholes, a free-flowing test is preferential to the conventional constant-rate pumping test approach. Discharge rate and pressure head at pumping and/or observation boreholes are required to be measured simultaneously during the test. Therefore, a test unit for capturing the data accurately is deemed to be critical for data interpretation afterwards. Two case studies in TMG are presented in this report. For the artesian borehole in Rawsonville, the test unit was installed and utilized to capture the data during the free-flowing test, which are interpreted by the program afterwards. The resultant parameters were verified by the single-packer tests conducted in 2006. For the case study in the Oudtshoorn artesian basin, data from a two-month free-flowing test in a flowing artesian borehole were manually captured from both the test borehole and observation borehole. The results from both cases indicate that the aquifers are somehow bounded by no-flow conditions, especially in the case of Rawsonville where the recorded data supported this hypothesis. Furthermore, there is a negative skin zone surrounding the test boreholes. Skin factor ranges between –3 and –2 with effective radius ranging from 0.5 to 1.58 m for the artesian borehole in Rawsonville; while the skin factor and effective radius of the artesian borehole in Oudtshoorn are approximately –2.2 and 0.92 m, respectively, as derived with the data from the observation hole. The transmissivity of the artesian aquifer in TMG ranges from 4 to 24.4 m^2/d, calculated with recovery test data, while, based on the values for effective radius, it varies from 13.7 to 78.3 m^2/d, derived with free-flowing test data. The storativity of the artesian aquifer in Rawsonville is about 2.0×10^{-4} to 5.5×10^{-4}, and in Oudtshoorn is approx.1.16×10^{-3}. The transmissivity of the aquifer derived by the recovery test method is lower but more reliable than that derived by the conventional pumping test method.

Cost: R400 000
Term: 2011 - 2014

Validation of the forcing variables (evaporation and soil moisture) in hydrometeorogical models
University of KwaZulu-Natal (Pietermaritzburg); WaterWatch; Pegram and Associates (Pty) Ltd
No. 2066

Evapotranspiration (ET) and soil moisture (SM) have only been available at isolated sites until recently, when the work carried out during two WRC research projects (Pegram et al., 2010; Sinclair and Pegram, 2013) developed a detailed spatial product of real-time estimates of SM and ET. The model has shown great promise, but still required

further development as errors in the input data streams are hampering the quality of the product. This project was commissioned to provide a spatially explicit validation procedure for the 1-km grid of ET and SM which are produced through the HYLARSMET and PyTOPKAPI models, as well as other hydrological models. The specific objectives of the project included (i) disseminating knowledge on the process of soil modelling using the distributed PyTOPKAPI model; (ii) establishing the best method for verification of modelled results (iii) identifying suitable scales and replication of field measurements required, and (iv) selecting the most suitable catchment where data networks and suitable land uses are in place. The project provided field measured ET and SM data during the two validation experiments, using the eddy covariance method and profile soil water content measurements. The SEBS model was used for ET and SM estimates for inter-comparison with the HYLARSMET model. In addition to spatial estimates of ET, the project aimed to use spatially-distributed field-based measurements of SM to verify SM sensors which were planned to be rolled out at SAWS weather stations. The spatial knowledge of land surface ET and SM is crucial for water resources management, crop modelling, optimizing irrigation water use, and flood forecasting.

Cost:	R700 000
Term:	2011 - 2014

Programme 3: Water resource planning

An Investigation into the effects of atmospheric pollutants on surface water quality in the eastern regions of South Africa
Univ. of KwaZulu-Natal (Pietermaritzburg); Golder & Associates; Univ. of Stellenbosch; Umfula Wempilo Consulting
No. 1697

The aim of the project was to determine if emissions from fossil fuel burning on the Mpumalanga Highveld are likely to increase salinization of surface water and degrade soil resources. The approach was to first identify and select three catchments which fall within the area of heavy deposition of acids of atmospheric origin, then estimate deposition of acidic substances originating from gaseous emissions from fossil fuel burning, analyse streamflow, and undertake soil chemistry tests. The findings were that both acid emissions and acid deposition have been increasing expon-entially, as well as loads of sulphate and base cations exported from each catchment.
Soils, on the other hand, were found to have a high buffering capacity due to high organic content.

Cost:	R1 435 300
Term:	2006 - 2013

Optimal utilisation of geothermal water resources
University of South Africa; Council for Geoscience; University of Pretoria
No. 1959

The aim of the project was to identify the optimal uses of thermal springs in South Africa. The objectives were three-fold, including the determination of the geological, biological, physical and chemical characteristics of the thermal springs in South Africa; their fitness for current use; and their suitability for alternative uses. Various countries around the world have recognised alternative uses for waters and heat generated from thermal springs. Currently, the South African thermal springs are underutilized. This project has explored the suitability of South African thermal springs for a variety of alternative uses as applied elsewhere in the world. Alternative uses included geothermal power generation, the bottling of thermal waters, use for agriculture, such as greenhouse heating, the production of fish and Spirulina and the extraction of minerals. It has also sought to assess the suitability of thermal springs for more unusual uses such as for cosmetic purposes and to identify springs that could possibly associated with Kieselguhr deposits.

Cost: R 2 380 655
Term: 2010 - 2013

Development of a groundwater resource assessment methodology for South Africa: towards a holistic approach
University of the Free State; GEOSS - Geohydrological and Spatial Solutions International (Pty) Ltd; Water Geosciences Consulting; IWR Water Resources
No. 2048

With growing water demand in South Africa, the limit of what surface water can supply has nearly been reached, and many experts are calling for more groundwater use and better groundwater management. However, estimating the groundwater that can be safely abstracted from an area or catchment without harming the environment and other water users is difficult. Over the years, scientists have developed various models to quantify the groundwater resources and these have been standardised in a number of countries. In South Africa there is no standardised approach with which to assess groundwater resources. The purpose of this study is to develop and test (to a limited extent) a more consistent approach to quantify groundwater resources for South African conditions. The proposed mixing cell model (MCM) takes into account both the physical flow of water in a river and the changes in natural river water chemistry that can signify groundwater baseflow. The method will be considered for incorporation into the existing methods for assessing South Africa's total water resources.

Cost: R980 000
Term: 2011 - 2013

Non-parametric multi-site stochastic rainfall generation including climate change–related non-stationarity
University of the Witwatersrand
No. 2148

The planning and operation of most of the large water resource systems in South Africa has been applying a multi-site monthly streamflow generator since the 1990s, but it has recently been recognized that the use of stochastic rainfall

generation may hold several advantages over stochastic streamflow generation. Since rainfall is the main input to the hydrological cycle, applying stochastics on rainfall rather than streamflow is naturally more inclusive. With stochastic rainfall, probabilistic analysis can be included more realistically and easily in the analysis of catchment hydrological processes and rainfall-dependent activities such as irrigation. The impacts of climate change and increasing variability on basin hydrology and water resources can also be studied with more ease with a rainfall rather than streamflow stochastic generator. Consequently, this project was proposed to develop and test a monthly non-parametric stochastic rainfall generator that would comprehensively incorporate climate change and changing variability, including information from global climate model (GCM) projections.

Cost: R417 600
Term: 2012 - 2014

Evaluation of the monthly stochastic rainfall generator in existing Department of Water Affairs risk-based water resources yield assessment processes
Hydrosol; University of Stellenbosch; University of KwaZulu-Natal (Pietermaritzburg)
No. 2155

The application of spatially-correlated time-series of monthly stochastic streamflow in South African water resources planning processes is widely considered to be world-leading technology. With the recent development of a monthly spatially-correlated stochastic rainfall generator (PEGRAIM-W), the aim of this project was to assess the impact of applying stochastic rainfall from PEGRAIM-W in yield assessments for four climatically diverse water resource systems. The use of stochastic rainfall presents significant potential advantages, including the explicit stochastic modelling of hydrological processes such as surface–groundwater interaction, irrigation requirements, the impacts of streamflow reduction activities and water quality in yield and planning scenario analyses. Other advantages are the potential for modelling climate change impacts on rainfall stochastically and contributing towards current initiatives to quantify uncertainty in hydrological and yield assessments. Based on the results of the research project it was concluded that the yield and assurance of supply characteristics resulting from analyses undertaken based on stochastic rainfall and stochastic streamflows compare remarkably well. In view of this finding, as well as the associated advantages mentioned earlier, it is strongly recommended that the stochastic-rainfall approach is implemented as an alternative option for undertaking risk-based water resource yield assessments in South Africa.

Cost: R700 000
Term: 2012 - 2014

Programme 4: Water resource infrastructure

Structural health monitoring of arch dams using dynamic and static measurements
Department of Water Affairs; University of Cape Town
No. 2025

The key objective of this project was to develop a holistic approach to structural safety assessment of concrete arch dams, while developing high level manpower in the field of dam safety. Two methodologies, the ambient vibration method (AVM) and the Westergaard method, which is the most commonly adopted approach for dynamic analysis of dams, were tested to establish their applicability in finite element model updating of arch dams based on ambient vibration testing. The project demonstrated that ambient vibration testing (AVM) is a viable methodology for surveillance and monitoring of arch dams, while the Westergaard method tends to overestimate the added mass of water for divergent and/or skewed reservoirs. A significant finding is that the Westergaard method cannot be directly applied to dams with divergent and/or skewed reservoirs. Additionally, the effect of seasonal temperature variations on arch dams was modelled and the results show that it is critical to include temperature effects for dynamic analysis of arch dams. However once the initial thermal stresses have been introduced, the influence of seasonal temperature variations on dynamic characteristics is negligible.

Cost:	R1 500 000
Term:	2010 - 2013

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

Implementation of the rule-based agent for *Microcystis* in Rietvlei Dam
Cripsis Environment; City of Tshwane; North-West University (Potchefstroom)
No. 1962

In a study done by Van Ginkel (2008), an early warning/prediction tool (a real-time rule-based agent) for *Microcystis aeruginosa* blooms was developed and validated by means of a merged limnological time-series dataset of hypertrophic reservoirs, Hartbeespoort, Rietvlei and Roodeplaat Dams, using hybrid evolutionary algorithms (HEA). This rule set was then tested on data from two other hypertrophic dams, Bon Accord and Klipvoor Dams, which had not been used in the training data set. The agent proved to be generic for the five warm, temperate and hypertrophic reservoirs, four of which were monomictic and one dimictic. Although this model has already been validated

conceptually, there is a need for the model to be validated operationally, and the data to be used should be statistically validated for it to be acceptable as a prediction tool. In this study the prediction tool (CEGAP), for *Microcystis aeruginosa*, was validated operationally using data obtained from the Rietvlei Dam WTW. However, due to the recent deployment of the SolarBees, data from Bronkhorstspruit Dam was also used for further validation. The prediction tool (CEGAP) has been prepared in a ready-to-use Excel (2007) format and can be used by local water resource managers to predict blooms up to 28 days in advance. With the aid of this predictive tool the proper drinking water treatment procedures can be incorporated in advance, in order to ensure the production of safe drinking water, thereby managing the risk imposed by the cyanobacterial blooms in the water resource on drinking water facilities and the health of recreational users. The following were the aims of the project:

- To compile a recent ecological overview of the water quality of the Rietvlei Dam and to describe the process configuration and advanced treatment options already employed to produce potable water
- To investigate the effect of habitat disturbance created by long-distance circulation of the SolarBees on the development of cyanobacterial blooms and water quality
- To implement the prediction tool CEGAP and evaluate its performance as an early warning/prediction tool for water treatment works' managers

Cost:	R175 000
Term:	2010 - 2015

Programme 3: Impacts on and of water quality

Guideline for EDC management in water resources: Volume 1: Monitoring and Assessment
University of Pretoria; CSIR; Department of Water Affairs; Rhodes University; independent consultants
No.1915

A significant aspect of the project that was investigated related to the current data sources and data quality for EDC detection and monitoring in South Africa. This allowed for needs, capacities and capabilities to be determined for the monitoring and assessment of EDCs. These outcomes were then tested in practical site-specific case studies in which monitoring and assessment of EDCs was conducted. The objective was to not only provide an example of how to proceed with the monitoring and assessment of EDCs but to also evaluate the methods presented in the various Volumes of the Manual. The case studies also included, for the first time in the WRC EDC programme, the investigation and presentation of thyroid dysfunction due to potential EDC exposure via drinking-water in a sentinel livestock species. A robust, cost-effective method for investigating several EDC endpoints in a sentinel livestock species was tested and, based on the results, proposed as a viable addition to EDC monitoring and assessment. Analytical procedures required to routinely assess inorganic EDCs were also developed and tested for the case studies. Whilst conducting the case studies the project engaged with several Government departments, notably the Department

of Mineral Resources, the Department of Environmental Affairs, the Department of Agriculture, and the Department of Water Affairs. It was established that in order for the monitoring and assessment of EDCs to have any significant impact legal compliance with the relevant sections of several Acts and Government Notices was essential. Although this related primarily to the manner in which current monitoring requirements were being formulated within the directions and intentions of existing legislation, stakeholder consultation and comments submitted for various reviews and Government Notices, resulted in an invitation to submit proposals for best-practice guidelines. Since this was not accommodated in the scope of this Volume, nor the Manual, it remains a recommendation to develop a single guideline document for the Directorate of Water Resource Protection and Waste at the Department of Water Affairs. The fundamental objective of the project was thus to highlight the approach required for the regulator/health authorities to make informed decisions based on acceptable scientific data within the context of the challenges posed by the monitoring and assessment of EDCs. As with other the Volumes the approach adopted remains based on the precautionary principle, as many of the EDC potential hazards posed are new and not yet fully described.

Cost: R1 500 000
Term: 2009 - 2013

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Vadose zone hydrology: Spatial and temporal influences, assessment techniques and aquifer susceptibility
WSM Leshika Consulting (Pty) Ltd; University of Pretoria; independent consultant
No. 2052

The vadose zone can also be considered as 'the zone between the land surface and the water table', which includes the plant root and intermediate zones and the capillary fringe, representing that portion of the crust where the pore spaces contain water at pressures below atmospheric, air and other gases. The vadose zone falls within a framework overlapping between and combining the specialisation of many different disciplines. Vadose zone hydrology includes the specialist input of, notably, soil scientists, surface water hydrologists, hydrogeologists and engineering geologists, but such collaborative efforts are still mostly limited to the implications of soil water on biodiversity or the protection offered to the aquifer by the overlying unsaturated media, and hence closely linked with studies in geotechnical engineering and ecology. The safe locating of such potential sources of contamination and the mitigation and rehabilitation of contamination can be better assessed based on an improved understanding of the spatial (or lateral), vertical (or horizon-based) and temporal (or time-dependent) influences on vadose zone seepage. The project had the following aims:

- Evaluate by means of a thorough literature survey and intensive, long-term testing, the most common methods applied to assess unsaturated flow in the field, laboratory, or based on empirical approaches
- Evaluate some new parameters and refine the determination of porosity, effective grain size and hydraulic conductivity or permeability
- Assess the movement of ions and fine material through leaching processes which may, over fairly short periods, alter the subsurface hydraulic properties permanently, as well as the leaching processes changing the subsurface hydrology and the influences on these processes
- Evaluate the spatial and temporal influences on unsaturated flow and apply the results to conceptual issues such as sanitation systems, cemeteries, underground storage tanks, waste disposal sites, sludge dams, tailings, etc.
- Clarify the concepts and approaches applying to unsaturated flow in a multi-disciplinary approach (including hydrogeology, geotechnical engineering and soil science) in a vadose zone handbook and glossary
- Apply and evaluate the preliminary vadose zone classification methodology, followed by refining of the method and finalising the methodology
- Create awareness regarding the unsaturated zone by means of workshops, thus accentuating the importance of the vadose zone in terms of contamination, recharge and sustainable development

Cost: R1 000 000
Term: 2011 - 2014

Towards an integrated framework for the assessment and management of sediment-related impacts on water resources in South Africa: A dam performance case
Muondli Consulting and Projects; University of South Africa; University of Venda
No. 2064

South Africa does not have a sediment management framework in place; nevertheless, a number of studies have been and or are being undertaken around sedimentation. These studies have dealt with site(problem)-specific cases regarding sedimentation; however, with the movement towards integrated management of water resources, it is necessary to collate the results of these studies to come up with a holistic understanding of the impacts. This requires an integrated framework which will ensure that the assessment and management methodologies for each site-specific case are consistent with each other, and can therefore be easily integrated. Hence, the purpose of this project was to develop an integrated framework for the assessment and management of sediment-related impacts on water resources in South Africa. The framework incorporates source-specific interventions, particularly aimed at regulating the activities responsible for sediment production, coupled with strict monitoring.

Cost: R1 000 000
Term: 2011 - 2013

Guidelines for the delineation of protection zones in a complex aquifer setting
Groundwater Consulting Services; University of the Western Cape
No. 2288

Choosing the appropriate protection zoning method requires specific procedures that consider the amount of hydrogeological data that is necessary, the hydrogeological complexity, the required accuracy of the results, time, human resources, the capabilities of the groundwater management agency, and available funding. In the South African context it should be recognised that the data and resources to protect the critical water resources will probably not be available and that a phased protection approach needs to be adopted. The phased protection approach has been adopted in developing countries like Argentina, where a basic protection zoning scheme is implemented and improved over time as more data becomes available. Monitoring and periodic revision of the protection zones is therefore an important component in the iterative process to ensure the protection of drinking water quality. High borehole yields in hard rock aquifers – typical South African aquifers – are associated with fractures, faults and bedding planes, complicating the flow of water and contaminants to the boreholes. Protection zones will have to be determined for these types of complex aquifer settings, especially in aquifers like the Table Mountain Group (TMG) and Karoo, where faults and dykes are targeted for water supply. The establishment of protection zones will generally be a compromise between what is desirable and what is feasible. Zoning regulations could have adverse economic effects on a community if an inappropriate amount of land were to be placed in an area zoned for stringent protection. When considering public health, however, the delineated area should not result in under-protection. The implementation of resource protection strategies like protection zoning is not visible and benefits are difficult to measure, but provide benefits to communities, water supply companies, ecosystems and policy makers. These benefits must be communicated to the stakeholders to initiate implementation at all management levels.

Cost: R510 000
Term: 2013 - 2014

Hydrogeological heritage overview: Upper and Lower Fountains, Pretoria, City of Tshwane
University of Pretoria; independent consultant
No. 2150

Despite the majority of the terrestrial freshwater resources being groundwater, there still exists a public perception that the only source of potable water is from surface water bodies. Due to this misperception, the general public often forgets the importance of groundwater as a resource. This is evident in the lack of knowledge regarding the Upper and Lower Fountains in Pretoria, as the main reason for various historical events in and around the city, leading to it eventually becoming the capital of South Africa. This project, which introduces a broader Hydrological Heritage Overview programme, is intended to create awareness regarding the history and importance of water in the development of South Africa, and to improve public understanding of the important role that hydrology and hydrogeology is playing in our day-to-day lives. Such an awareness programme will be beneficial in terms

of community engagement and education in the long run, creating an opportunity for educators and the general public to appreciate the importance of hydrogeology in South Africa. Public awareness is also essential in the long-term conservation of water resources. For this reason, the focus is more on the awareness of hydrogeology and, to a lesser extent, surface hydrology, than the detailed history behind the founding of Pretoria, and additionally on making the available data (trends and quality) available to the scientific community where possible.

Cost:	R100 000
Term:	2012 - 2013

The economics of sustainable aquifer ecosystem services: a guideline for the comprehensive valuation of aquifers and groundwater
Prime Africa Consultants (previously CIC International); Umvoto Africa
No. 2165

As groundwater gains increasing recognition in South Africa, so efforts have been bolstered to detail the extent to which the unseen resource is utilized and consumed. As the emphasis for water resource development shifts away from surface water resources towards alternative supplies, there is an increasing need to understand the economic incentives/arguments for groundwater use. In order to understand these incentives/arguments, it is necessary to consider groundwater resources and aquifer systems holistically, looking at their role in the freshwater supply value chain, and within the larger economic framework. Herein lays the challenge, and the objective of this study, which is to begin to construct a comprehensive and integrated framework for the economic assessment of groundwater resources and aquifer systems. However, in order to understand the economic contribution of a given groundwater resource to the water supply system, and to the economy as a whole, it is first necessary to identify and isolate the particular sources of value attributable to groundwater resources, after which consideration needs to be given to their quantification. Using this framework, in combination with a workshopping method known as a Comparative Risk Assessment (CRA), this study investigated the ecosystem services of groundwater resources through the expert analysis of three case studies, specifically, the fractured rock aquifer systems being utilized in the Hermanus area, the dolomitic aquifer systems in the Krugersdorp area, and the primary aquifer in the Sandveld region. The exercise identified the following priority ecosystem services, including: (i) provisioning services: provisioning of fresh water, provisioning of biodiversity and genetic resources; (ii) regulating services: water regulation, storage and retention, water purification and waste treatment; (iii) cultural services: recreation and tourism. Key findings of the study are as follows: firstly, the findings support the notion that the regulation, storage and retention ecosystem services provided by groundwater resources improve the efficiency profile of a water supply system. Secondly, water allocation and restriction controls that are compiled in relation to the status of both groundwater and surface water resources, as opposed to just surface water resource, are a more efficient means of systems control, benefiting from consideration of a wider pool of information. The controls that guide/manage the allocation of water resources within a given entity (i.e. community, municipality, etc.) are designed based on the constraints of surface water resources, and do not, as yet, factor in the constraints associated with groundwater resources and aquifer assets. Allocation/restriction control

within a conjunctive use water supply system should be designed around the availability of both surface water and groundwater resources.

Cost:	R827 350
Term:	2012 - 2014

Programme 2: Land-water linkages

Water Sensitive Urban Design (WSUD) or Low Impact Design (LID) for improving water resource protection/ conservation and reuse in urban landscapes
University of Cape Town; University of the Witwatersrand; University of Stellenbosch; City of Cape Town; eThekwini Municipality; Johannesburg Municipality; City of Tshwane; University of the Western Cape
No. 2071

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. A systems approach with multiple objectives is called for; one that takes into account community values and aspirations when dealing with water supply, wet and dry sanitation, biological and chemical treatment of associated contaminants, drainage and the management of industrial effluents, whilst also acknowledging the range of users, including residential, institutional, commercial and industrial. An integrated systems-based approach such as this has the potential to facilitate a change in urban areas, from 'water-wasteful' to 'water-sensitive' settlements, where a 'settlement' is to be broadly understood as comprising a concentration of people within a specific area and serviced by some public infrastructure and services. This study was thus aimed at providing strategic guidance to urban water management decision-makers (primarily city managers and other local authority officials) on the use of WSUD in a South African context. It introduces the philosophy of WSUD – a new paradigm in urban water management – and starts to build the case for its adoption in a water-scarce country such as RSA, as well as providing a base for future studies. It is aimed at defining what 'water sensitivity' might mean within the RSA context – including expanding the definition of 'city' in WSC to include a broader range of settlement types – so as to motivate for adopting a context-specific vision for water sensitivity. In this regard it suggests a strategic framework with four different components to enable the transformation to Water Sensitive Settlements (WSS) in RSA, and provides guidance on the various WSUD strategies that could be adopted to achieve this, as well as giving an indication of appropriate modelling tools. A policy review (including institutional and legal issues) was also carried out in order to identify obstacles to WSUD and to provide recommendations on how they may be overcome.

Cost: R2 000 000
Term: 2011 - 2014

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

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

The project aimed to identify potential impacts and threats of climate change to sustainable water services delivery, as well as the uncertainties associated with these, with regards to changes in water quantity, water quality and socio-economic developments. The methodology was developed for assessing risks and vulnerabilities (including uncertainties in predictions) to climate change. A strategy and monitoring network for water audits in order to monitor indicators of change were also developed; and the Thresholds of Potential Concern (TPCs) for water quality and quantity issues derived for Water Boards related to raw and potable water, discharges, pricing effects, etc., based on the outputs of the climate models. Lastly, a decision-support framework for an adaptive management strategy was developed to assess and modify water services delivery and development plans of the Water Boards in terms of infrastructure repair and developments, water conservation and demand management, water pricing changes and other associated issues. The results show that the minimum monthly storage expected under the near-future climate scenarios for reservoirs is higher than with that simulated for the current-day climate situations, probably due to an increase in expected rainfall under the near-future climate scenarios for the Amathole area. The report's results are also relevant to water services delivery and water resources management.

Cost: R1 000 000
Term: 2010 - 2013

Projected impacts of climate change on water quantity and quality in the uMngeni Catchment
University of KwaZulu-Natal (Pietermaritzburg); Umgeni Water; University of Cape Town; Swedish Meteorological and Hydrological Institute (SMHI)
No. 1961

The ability of the ACRU agro-hydrological model to assess the interactions between land-use change, climate change and hydrological responses was confirmed by comparing its output with observed streamflow data sets from the uMngeni catchment. Then the Water Management Units of the uMngeni were delineated into 145 relatively homogeneous WMUs. Each subcatchment was further divided into major land-use units for modelling purposes. Daily rainfall and evaporation as input to the model streamflow of the catchment was simulated to assess hydrological responses, climate change and land-use impacts. Then the potential impact of climate change on the yield of dams was determined based on various scenarios. The results reflected uncertainties in model projections, hence, unpredictable futures, though most scenarios projected increased mean annual precipitation. The results also show that climate-change impacts may either amplify or dampen the impact of land-use change, and the impacts of land-use change will have feedbacks on the climate.

Cost: R 1492000
Term: 2010 - 2013

Modelling daily rain-gauge network measurement responses under changing climate scenarios
Pegram and Associates (Pty) Ltd; University of Kwazulu-Natal (Westville); University of Cape Town; University of Melbourne; University of Stuttgart
No. 1964

This project was aimed at modelling the daily rain-gauge measurement responses under the changing climate. Two periods of recorded daily rainfall which are matched by contemporaneous RCM estimates were used. One period was used to find the statistical and stochastic links between them; while the second period was used for calibration. The other task was to check the downscaled estimates against the observed gauge rainfall during the second period in order to validate them. In addition, the characteristics required of a stochastic multisite rainfall model were determined and the model is currently being used by DWA for its water resource planning.

Cost: R1 000 000
Term: 2010 - 2013

South African climate multidisciplinary analysis
University of Cape Town; South African Weather Service; University of Kwazulu-Natal (Westville); University of Bourgogne; IRD; Joseph Fourier University of Grenoble; IFREMER; Eduardo Mondlane University; CSIR; Africa Centre for Climate and Earth Systems Science
No. 2060

The aim of the project was to create a synergy between various research groups or individuals interested in ocean and atmosphere climate variability and its impact on society and water resources of Southern Africa. It also established the impact of the El Niño Southern Oscillation on the Western Cape winter rainfall. Findings were that ENSO

impacted coastal wind and sea surface temperature in summer. The impact on streamflows and rainfall of the Water Management Areas was estimated using WR2005 data. Reasons for warming of the Agulhas Current system were explained through this project. The origin of Benguela Niño, a local phenomenon that is linked to rainfall variability in South Africa, was also unravelled.

Cost: R1 200 000
Term: 2011 - 2014

Programme 2: Climate change risk, vulnerability and adaptation

Developing water related climate change adaptation options to support implementation of policy and strategies for Water for Growth and Development
University of KwaZulu-Natal (Pietermaritzburg); University of the Witwatersrand; Department of Water Affairs; German Development Institute; Khanya-African Institute for Community-Driven Development
No. 1965

This objective of the project was to develop methodologies that would provide support to the South African water sector in mainstreaming climate-change adaptation measures into water resources management. The main report is a comprehensive reference guide on adaptation in the water sector, while the other two shorter versions are more user-oriented handbooks on adaptation. A core feature of the narrative structure of the reference guides is a focus on 'framing', since framing matters in climate-change adaptation for various reasons.

Cost: R3 000 000
Term: 2010 - 2014

Development of decision-support guidelines for vulnerability assessments and adaptation requirements among rural economies and communities, including gender issues (Phase 1)
North-West University (Potchefstroom); North-West University, Potchefstroom Campus
No. 2282

Access to safe potable water is normally one of the greatest challenges for rural communities. This project was aimed at developing decision-support guidelines for vulnerability assessments and adaptation requirements among rural economies and communities including gender issues. The approach used entailed development of a framework that consists of a series of steps required for identifying and prioritizing key vulnerabilities as well as adaptation requirements for rural communities. A two-tiered approach was followed to evaluate potential impacts of climate change on the rural communities. A decision support tool (an Excel spreadsheet) was developed to determine vulnerability, by accessing data from the groundwater resource assessment database and the WR2005 database and

then using the information to determine sensitivity to projected change in climate as well as adaptation requirements.

Cost: R350 000
Term: 2013 - 2013

The role of local community institutions in the adaptation of rural and urban communities to the impacts of climate change on water access and use
University of South Africa; Department of Water Affairs; HSRC; CSIR (NRE); University of Cape Town; University of Birmingham; Hydrosoft Institute
No. 1963

The purpose of this project was to investigate the capacity and role of community institutions in the adaptation of communities to climate change impacts on water access and use, and accordingly to develop a generic framework for institutional support. However, vulnerabilities of both rural and urban communities to climate change vary widely, while local institutions are often under-capacitated and not adequately equipped to take on the additional burden of providing climate-change adaptation support measures. The methodology entailed a literature study, engaging stakeholders and experts through workshop sessions, community vulnerability assessments and mapping, capturing data and information on water provision, access, and use, evaluating adaptive capacity of local institutions and developing a Climate Change Adaptation Framework (CCAF) for local institutions. Then a pilot study was undertaken in both rural and urban community settings to assess climate-change impacts for the different communities through case studies. The research results and products include comprehensive maps of climate change vulnerability at community level; toolboxes of possible adaptation, proposed policy and legal frameworks for supporting climate change adaptation; and the Climate Change Adaptation Framework.

Cost: R3 000 000
Term: 2010 - 2013

CURRENT PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

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

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

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

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

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

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

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

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
University of Stellenbosch
No. 2077

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

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

Programme 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
No. 2166

- To conduct information sharing sessions and workshops to build capacity as well as create an aligned understanding of the governance framework and its implementation
- To generate an understanding of the challenges and problems that these communities face in terms of using water productively
- To map out the difficulties that Government departments have faced in terms of supporting community upliftment projects linked to water and productive use, as well current plans for future support

- To develop an overarching governance framework and guidelines to assist Government in providing the necessary support to communities

Estimated cost: R580 000
Expected 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
No. 2049

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

Estimated cost: R700 000
Expected term: 2011 - 2013

Developing a citizen-based rainfall monitoring system
Pegasys Strategy and Development (Pty) Ltd
No. 2057

This project aims:

- To synthesise experiences, both locally and internationally, with regards to supplementing rainfall data with differing data sources, particularly citizen-based gauging
- To source and collect citizen-based rainfall data, bearing in mind the need to develop a more systematised manner for submission of this information
- To evaluate citizen-based data against other data sources such SAWS and satellite data as well as broadly assessing the uncertainties related to the various data sources
- To model the impacts of the various rainfall data sources upon the understanding of water resources within the Breede Water Management Area and from this to generate key lessons

- To provide insights into systems issues and requirements together with key role players such as DWA, BOCMA, and SAWS
- To develop some practical steps to improve the rainfall monitoring networks supported by citizen-based networks, bearing in mind the various institutional roles and responsibilities

Estimated cost: R400 000
Expected term: 2011 - 2013

The establishment of rain gauge networks for rainfall estimation calibration of the South African new weather radar network
University of the Witwatersrand
No. 2062

Overall, this project aims:

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

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

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

WRF rainfall parameterisation and verification
EScience Associates (Pty) Ltd
No. 2162

The aims of this project are to:

- Determine the best parameterisation and model set-up for WRF in terms of modelling rainfall
- Install rain gauge network for model verification in case study areas
- Input WRF into a hydrological model and verify against stream discharge measurements

• Forecast rain events based on parameterisation in the first aim

Estimated cost: R748 651
Expected term: 2012 - 2014

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

Programme 2: Surface water / groundwater hydrology

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

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

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

Surface water, groundwater and vadose zone interactions in selected pristine catchments in the Kruger National Park
University of KwaZulu-Natal (Pietermaritzburg)
No. 2051

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

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

Impact of fault structures on the occurrence of groundwater in fractured rock aquifers
Council for Geoscience
No. 2053

Amongst geological features in fractured rocks, faults are one of the most important geological structures that control the occurrence of groundwater in fractured rock aquifers. Fault-controlled aquifers have been one of the most important wellfield development targets for water supply. Problems often arise from the application of current conceptual models on the evaluation of fault-related aquifers. This is mainly due to many unknown parameters of faults that are often required as input to both qualitative and quantitative models. This study aims to (a) develop multiply approaches to the delineation and characterisation of fault-controlled fractured aquifers; (b) develop sound methods for the establishment of conceptual models of fault-controlled aquifer types which will produce both 2-D and 3-D models; and (c) estimate aquifer properties and groundwater flow based on established conceptual models, using well-calibrated numerical models.

Estimated cost: R600 000
Expected term: 2011 - 2014

Favourable zone identification for groundwater development: Options analysis for local municipalities
Metago Water Geosciences (Pty) Ltd
No. 2158

The aims of this project are to:

- Mainly, develop a methodology and atlas of favourable target zones for groundwater development for priority municipal areas
- Prioritise areas based on aquifer characteristics and socio-economic factors
- Develop indicators for groundwater options analysis
- Delineate and map the potential target zones (based on desktop analyses and fieldwork)
- Prioritise the target zones based on aquifer yield, infrastructure costs and treatment costs

- Develop conceptual models for all the selected sites
- Develop protection zone strategies for the selected target zones
- Repackaging of existing management plans for local municipalities
- Identify new or improved research and educational opportunities

Estimated cost: R2 000 000
Expected term: 2012 - 2014

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

Implementing uncertainty analysis in water resource assessment and planning
Rhodes University
No. 2056

Project aims:

- To utilise newly emerging field-based information on the various processes involved in surface-groundwater interactions (recharge, storage, evaporation losses, discharge to rivers, etc.) to test and, where appropriate, improve the algorithms of the Pitman model as well as improving the quantification of the relevant parameters, thereby reducing the overall uncertainty in the use of this part of the model
- To further assess rainfall input uncertainties and the possibilities of reducing the uncertainty through the use of different sources of information
- To ensure that the climate change uncertainty assessments are integrated with other approaches designed to reduce uncertainty
- Facilitation to ensure that water resource engineers understand and appreciate the value of including uncertainty and are comfortable with the use of new modelling approaches that include uncertainty

- To determine suitable uncertainty bounds around the existing regional parameters (part of WR2005) of the Pitman model
- To further develop practical procedures for constraining the uncertain outputs from hydrological models using either regional indices of hydrological behaviour and/or observed streamflow data (that may themselves be uncertain)

Estimated cost: R600 000
Expected term: 2011 - 2014

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
University of Stellenbosch
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

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

Presence, levels, and potential implications of HIV anti-retrovirals in drinking, treated, and natural waters
North-West University
No. 2144

The aims of this project are:

- To conduct a literature survey on HIV-ARV presence in the environment. A first screening shows no reports whatsoever. The literature review will therefore expand to generic pharmaceuticals as well as other ARVs.
- To determine the major HIV-ARV compounds used in SA. This will be done in collaboration with role players such as the pharmaceutical industry and Departments of Health. If there are too many compounds of concern, we will select a cross-section based on modes of action.
- To develop extraction and analytical procedures for selected HIV-ARVs from water and fish. We will use our newly-acquired HPLC-MS for this purpose, as well as extraction equipment used in other WRC projects looking at POPs.
- To collect treated wastewater from four different wastewater treatment works, at least three rivers, and at least three impoundments. The localities will be determined after the literature survey and in consultation with the project reference group.

Estimated cost: R471 000
Expected 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
No. 2145

The aims of this project are:

- To carry out a survey of existing wastewater treatment facilities in the entire Eastern Cape Province, noting their dates of establishment, working capacity and current statuses
- To assess the occurrence and distribution of human viral pathogens and faecal indicator bacteria and their pathogenic strains in the selected wastewater treatment plant effluents
- To assess the occurrence, distribution and antibiogram characteristics of *Vibrio* bacteria pathogens and faecal indicator bacteria including their pathogenic and toxic strains (*E. coli* and *Enterococcus*) in the selected wastewater treatment plant effluents
- To determine the physico-chemical qualities of the selected wastewater treatment plant effluents
- To correlate viral and bacterial pathogen occurrence with seasons and the physicochemical qualities of the selected wastewater treatment plant effluents
- To compare data obtained from typical urban, semi-urban and rural communities of the seven main districts and metro's that make up the province
- To submit a report of these findings to the WRC and Eastern Cape Provincial Government

Estimated cost: R900 000
Expected term: 2012 - 2014

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

Investigating the occurrence and survival of *Vibrio cholerae* in surface water sources in KwaZulu-Natal province of South Africa
University of Johannesburg
No. 2168

The aims of this project are:

- Detection of *V. cholerae* using optimised culture-based real-time PCR method
- Detection of *V. cholerae* using culture-independent real-time PCR method
- Implementation of an internal process control to monitor the performance of *V. cholerae* real-time PCR assays
- Using the newly validated methods, determine the occurrence and distribution of *V. cholerae* from zooplankton, phytoplankton, amoeba, animal stools, sediments and water from rivers in KwaZulu-Natal Province

Estimated cost: R555 000
Expected 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
University of Stellenbosch
No. 2063

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

Estimated cost: R1 000 000
Expected term: 2011 - 2013

Nutritional factors influencing the biosynthesis of the neurotoxin Beta-N-methylamino-L-alanine by cyanobacteria
Nelson Mandela Metropolitan University
No. 2065

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

Estimated cost: R500 000
Expected term: 2011 - 2013

Using an integrated water quality management model to support the implementation of National Water Act water use authorisations.
Golder Associates Africa (Pty) Ltd
No. 2159

The aims of this project are:

- To use the refined model developed and to demonstrate how it can support the implementation of integrated water use licences and other water use authorisations, by setting up management units with the relevant stakeholders such as water use licence holders and catchment stakeholders
- To produce a web-based system that will ultimately link to existing tools such as WMS and eWQMS, the stakeholder database and geographical areas, and be available for use by other water users at various levels
- To present the system at a minimum of two relevant conferences over the proposed two years of the project.

Estimated cost:	R555 000
Expected term:	2012 - 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

Preventing production borehole clogging by in situ iron removal in South African aquifer systems
Council for Geoscience
No. 2070

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

Estimated cost: R600 000
Expected term: 2011 - 2014

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
No. 2149

The aims of this project are to:

- Carry out a background review in order to understand the issues related to hydraulic fracturing and to identify possible risks to the resources (biodiversity and water) of South Africa.
- Produce an interactive map that should mainly assist in aiding decision-makers in determining whether hydraulic fracturing should be allowed in certain sensitive areas of South Africa
- Develop a provisional screening-level monitoring protocol for a typical hydraulic fracturing site (this protocol should

be applied by the regulators to regulate hydraulic fracturing and should monitor, with minimal costs, whether hydraulic fracturing has major potential impacts on any sites where hydraulic fracturing might be allowed and implemented

Estimated cost: R900 000
Expected term: 2012 - 2014

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

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
SANParks
No. 2146

The aims of this project are as follows:
- The key question of this research is to understand the long-term effects of fire frequency, season and intensity on the soil hydraulic properties and the consequent impacts on the soil water balance on two different soil geologies in the Kruger National Park
- To determine the effect of long-term fire and no-fire treatments within basalt and granite geologies on soil hydraulic properties and soil water balance. In order to determine the variation of this effect across these geologies, as a result of a decrease in soil surface crusting and water repellency associated with fire
- To determine the effect of long-term fire regime on the soil hydraulic properties, in order to determine if an increase in fire frequency, season and intensity may alter those soil hydraulic properties associated with infiltration and redistribution across the two geologies

Estimated cost: R320 000
Expected term: 2012 - 2014

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

Unifying weather and climate variability predictions - An operational seamless forecasting system for Southern Africa at time scales from days to seasons
CSIR
No. 2050

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

Estimated cost: R950 000
Expected term: 2011 -2014

Development of defensible regional climate change projections for adaptation and policy
University of Cape Town
No. 2061

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

to natural variability. Methodologies include the following:

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

Estimated cost: R1 317 750
Expected term: 2011 - 2014

The limits of predictability of the South African seasonal climate
University of Cape Town
No. 2067

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

Estimated cost: R1 200 000
Expected term: 2011 - 2014

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

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 stakeholders in dialogue about climate change and water resource adaptation at the local level

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

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

NEW PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Water governance and institutional reforms

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 4: Transboundary water resources

Water's role in driving regional economic integration in Southern Africa
GHT - Southern Africa
No. 2252

The aims of this project are:
- To support more effective and sustainable use of shared water in transboundary river basins and drive regional economic integration in Southern Africa
- To review the current state-of-the-art literature on transboundary water governance and regional economic integration and draw relevant lessons for best-practice
- To analyse the role of different actors, institutions, and processes of regional economic integration and their interface with water with a view to strengthening their capacity
- To assess the challenges and opportunities faced by current regional economic institutional arrangements that support transboundary water governance and regional economic integration in the SADC
- To analyse the emerging economic regionalism in the form of commodity regions and clearly highlight the role of water in this landscape.
- Based on results from the critical assessments, identify the key pillars for sustainable regional cooperation over water leading to better economic integration and recommend appropriate policy options, strategies and institutional steps that may enable African TRBOs and riparian countries to move towards best-practice

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

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

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

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

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
Council for Scientific and Industrial Research
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

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

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

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

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

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KSA 2:
WATER-LINKED ECOSYSTEMS

SCOPE

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

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

In cognisance 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 2013/14 in order to remain relevant and appropriate.

Stanley Liphadzi: Executive Manager

One of the prominent new programmes focuses on coastal zones and the marine environment (coastal and marine ecosystems). The coastline is a unique part of our environment and one that supports many human activities relative to its limited area. The coast also holds great economic value, with coastal goods and services estimated to contribute 35% of South Africa's GDP. In order for coastal economic and social opportunities to be maximised, while conserving coastal resources, development needs to be ecologically, socially and economically sustainable. The coast must be viewed as a system and managed as such. Research on this critical ecosystem has not been conducted in coordination with research on the broader landscape in South

Africa, whereas such a coordinated effort is needed to realise integrated water resource management and attain sustainable development. While many countries have been generating coordinated knowledge about their various ecosystems for years, the WRC and other institutions have, for some time, concentrated on advancing our understanding of the impact of catchment management on the estuarine aquatic environment only. WRC-funded research has enabled the Department of Water Affairs to successfully conduct ecological Reserve determination studies (quality and quantity) for many estuaries in South Africa, and most of the estuaries have been assigned an ecological class, which is required for the evaluation and granting of water use licences. The WRC's new focus on coastal zones and the marine environment will complement efforts by the Department of Environmental Affairs' (DEA) Oceans and Coasts division (formerly Marine and Coastal Management). However, WRC-funded research and development in this field will focus on the aspects of marine and coastal areas that are connected to freshwater and estuarine ecosystems. The R&D for deep oceans and other aspects of the broader marine environment will remain the responsibility of DEA and other agencies, while the WRC will provide necessary support to ensure that there is meaningful collaboration and use of knowledge generated by all research organisations.

The WRC Lighthouses are used by the KSA as a vehicle for knowledge dissemination and transfer, most notably, the Green Village Lighthouse.

OBJECTIVES

The main objective is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water; and to develop an understanding of the ecological processes underlying the delivery of goods and services from water-linked ecosystems in a water-scarce country during a time of demographic and climate change. This will be achieved through the following (secondary) objectives:

- Develop an understanding of the ecological processes underlying the delivery of goods and services
- Develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems
- Transfer the knowledge to appropriate end-users through the development of innovative tools and methods for effective knowledge dissemination
- Promote utilization of research output and innovations in policy making, development and business planning; the knowledge cycle should include or be connected to both generators and users of the knowledge
- Strategically align research with the WRC mandate and Government outcomes and other priorities
- Promote good science and build capacity in both research and management to sustainably manage aquatic ecosystems

THRUSTS AND PROGRAMMES

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, ground-water 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 ground-water 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

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, ground-water, 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.

STRATEGIC CONTEXT

All over the world, there is a growing interest among managers, stakeholders, and government in sustainable innovations and development because of their potential impact on the triple bottom line (social, economic, and environmental performance) of the organization. The research portfolio of this KSA continues to support research studies that advance sustainable use of aquatic ecosystems which enhance sustainable socio-economic development in South Africa and Africa. In 2013, the KSA began implementing new themes and programmes that will facilitate the practical use of science in resolving human challenges.

The core strategy is fundamentally aligned to the WRC's mandate and is evolving to accommodate the ever-changing needs of communities and the country. The research is still focused on the generation of knowledge and development of innovations that will address the needs of society. The newly introduced themes and programmes will strengthen the portfolio because they present platforms for putting knowledge into action. The KSA continues to internalise national initiatives and priorities such as Presidential priorities (Government MTEF), National Planning Commission objectives, and Government outcomes. Research funded from within this KSA will continue to address, within the mission and vision of the WRC, the three legs of sustainability (society, economy, and environment), the needs of the legislation and international conventions (e.g. Convention on Biological Diversity; Ramsar) of South Africa. The development of capacity for both research and implementation will receive special attention. In addition, the KSA's research will provide knowledge needed to address the key issues raised in Core Strategy 5 of the National Water Resource Strategy (2012).

The KSA for Water-Linked Ecosystems may be defined by both the physical boundaries of the area addressed by the KSA, as well as by the strategic role occupied by the WRC in the field, with relevance to organisations active in ecosystem research, utilization and management. Physically, the field includes aquatic and riparian ecosystems as well as those dependent on groundwater. However, knowledge about beneficial or wise use of these resources is paramount in the development of sustainable communities, cities, and economies. Research funded through this KSA not only provides knowledge for the protection of the resource and the biodiversity of aquatic ecosystems, but also supports sustainable utilisation of aquatic resources while ensuring equity between generations.

The KSA subscribes to the notion of promoting ecosystems as natural water infrastructure and shared resources that should be valued by everyone. However, the commercial opportunities endowed by these natural systems have to be explored to address socio-economic challenges in South Africa. Ecosystems provide a variety of services which can be utilized to create wealth and jobs or support livelihoods.

Sustainable development solutions

The majority of the KSA's projects focus on generation of knowledge and innovations that promote sustainable development. Some of the KSA's projects supporting this strategic objective are:

- Hyper-spectral remote sensing of water hyacinth from plant physiology to landscape-level changes. The use of remote sensing in monitoring and controlling water weeds will assist water managers to be proactive in managing water resources.
- Linking land use and water quality for effective water resource and ecosystem management. The project results will contribute knowledge needed for effective integrated environmental water quality in South Africa.
- Potential ecological and human health risk posed by persistent pollutants in aquatic environments in densely industrialised and urbanised environment.

New products and services for economic development

The KSA continues to fund and support projects showing promise to produce new technologies and knowledge required for effective management of water resources and ecosystems. Technology improvement and adaptation will also be supported through this KSA to enable the use of knowledge and tools produced outside the country. Some WRC's research technologies and knowledge anticipated in the next 3 to 5 years are:

- Production of the South African version of telemetry instruments for use in fish and crocodile monitoring
- Decision Support Software (DSS) development for determination and allocation of environmental water (the ecological Reserve)

Human capital development in the water and science sectors and transformation and redress

The KSA will continue to support the WRC's Water KCAP to increase the number of project leaders and postgraduate students from historically disadvantaged groups. Structured well-resourced programmes will be followed to increase human capital development (HCD) to address the declining capacity for research and implementation.

Empowerment of communities

In pursuit of projects supporting the Green Village, the KSA will ensure that community members are actively involved as members of the research/project teams. This objective will be achieved by promoting action research, which accommodates both indigenous knowledge systems (IKS) and contemporary knowledge systems.

Inform policy and decision making

The KSA's projects support and inform policies relating to water, biodiversity, and sustainable development and other strategies such as the National Water Resource Strategy. The KSA continues to fund and manage some projects jointly with DWA to fast-track adoption and implementation of project findings.

Links to Government outcomes

Research on water-linked ecosystems enables good environmental governance and ensures that water is managed in a sustainable manner that protects ecosystems from the adverse impacts of demographic and climate change. The research creates an understanding of the ecological processes underlying the delivery of goods and services, and provides knowledge and expertise to sustainably manage, protect and utilise aquatic ecosystems. Over the medium-term, the WRC will develop the knowledge to sustainably manage, protect and utilise aquatic ecosystems. This research portfolio will contribute in the delivery of Government Outcome 10, 'Environmental assets and natural resources that are well protected and continually enhanced'.

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed funding budget of R16 922 707.

Research portfolio	Approved 2013/14 (R)
Current projects	9 918 705
New projects	7 004 002
Total	16 922 707

RESEARCH PORTFOLIO FOR 2013/14

Healthy people and thriving economies depend on a healthy environment. This is particularly true in the case of the rural and peri-urban poor who rely directly on the environment for their livelihood. This KSA focuses on the protection and sustainable utilisation of the aquatic ecosystems (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. More effort is being placed on addressing land use impacts and terrestrial ecosystem change that impacts on water resources and aquatic ecosystems. Research in this KSA addresses national research needs (long- medium- and short-term) as well as those of international conventions on environmental management. Work done within this KSA continues to contribute in the reviews of the National Water Act (NWA) of 1998, strategies and associated policies, an example being the ecological Reserve. This has meant that work within this field has not only addressed the strategic needs of the country, which have increased in line with the increased global recognition of the importance of the role of sustainable environmental management, but has also addressed some of the immediate research needs related to the NWA and its implementation. Other critical Acts and policies influenced by this KSA include the National Environmental Management: Biodiversity Act (NEMBA: 2004).

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Estuarine, coastal and marine processes

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

Temporarily Open Closed Estuaries generally have low river inflow, a long water residence time due to weak flushing, and prolonged mouth closure, which makes this type of estuary vulnerable to nutrient enrichment and the accumulation of organic matter. In the closed mouth state in the Great Brak, it is unlikely that nutrients in river water passing the head of the estuary at the weir will reach the lower end of the system while the estuary remains closed. It is therefore expected that in the lower reaches the nutrients will be supplied from the benthos, i.e., the system will become benthic driven. After prolonged mouth closure water levels rise and the large salt marshes die back and submerged macrophytes and macroalgae become the dominant plant components within the estuary. As these macrophytes go through their life-cycle, i.e., growth, reproduction and death, they act as sources and sinks for N and P within the estuary, and may be causing an accumulation of organic matter in the benthos. Moreover, the presence of the opportunistic macroalga, *Cladophora glomerata*, which has a much shorter life-cycle than the submerged macrophytes, most likely leads to an even greater accumulation of organic input. The resultant organic load more than likely then fuels subsequent growth, i.e., the remineralised organic matter in the form of DIN and DIP which support the next, or current, cycle of growth for the submerged macrophytes. In this study in the Great Brak, from the time the mouth closes until it reopens, *C. glomerata* stored 9 406 kg TN and 2 176 kg TP. If the mouth of the estuary were to remain closed for a whole year, the estimated storage in the alga could be as high as 17 288 kg TN and 4 675 kg TP. The submerged macrophytes clearly play a significant role in removing and cycling N and P from the water column. Apart from the cycling of nutrients between the submerged macrophytes and macroalgae, the benthos within the estuary acted as a major source of N and P to the water column. Throughout the closed mouth state the benthos contributed about 30% of the TN and 40% of the TP transferred to the water column. Two important findings arose from this work; the benthos of the Great Brak Estuary does have the necessary organic stock to fuel production and the submerged macrophytes make a significant contribution to nutrient cycling. This is the first detailed study that accounts for the nutrient storage in macrophytes by using actual measured data, thereby emphasising just how important the submerged macrophytes and macroalgae are to a nutrient budget of an estuary. It also becomes clear that it is critical to rely on actual measurements of nutrient storage when dealing with nutrient budgets because the contribution of any macrophyte in an estuary or other type of water body is large and cannot simply be ignored. This research has shown that the submerged macrophytes and macroalgae play important roles in storing and subsequently re-cycling nutrients within the Great Brak Estuary. It was also shown that, in the closed mouth state, the benthos becomes the major source of nutrients to the water column and supplies a similar percentage of N and P

to that which gets stored in the submerged macrophytes and macroalgae.

Cost: R955 000
Term: 2010 - 2013

Programme 3: Aquatic, riparian and land connectivity

Linking hydrology and lateral riparian vegetation zones
Southern Waters Ecological Research & Consulting; University of Stellenbosch; CSIRO Land and Water; Water Matters; Aurecon Group; Ezemvelo KZN Wildlife; GroundTruth; Rhodes University; BioRiver Solutions cc
No. 1981

Riparian vegetation communities occur along rivers in lateral zones parallel to the direction of river flow. These zones are sub-sections of a riparian area where groups of plants preferentially grow in association with one another as a result of shared habitat preferences and adaptations to the prevailing hydrogeomorphological conditions. The objective of this project was to quantify the links between components of the flow regime and the occurrence of riparian species in lateral zones alongside rivers. The need to understand and quantity these links rose from the need to predict changes in riparian communities in response to changes in river flow. The central hypotheses under investigation were:

- Vegetation zonation patterns along rivers result from differential species responses to a combination of abiotic factors that vary in space and time
- It is possible to identify one or two key abiotic factors to predict change in the zonation patterns in response to changes in the flow regime of rivers

To develop a framework that explains the existence of different plant communities in different lateral zones, a mechanistic explanation for characteristic differences between the lateral zones must be established. The project aims were:

- To identify the position, number and composition of lateral zones in riparian vegetation communities in a selection of rivers in South Africa
- To suggest standardized names for the identified lateral vegetation zones
- To explore the relationships between these lateral vegetation zones and aspects of the daily flow hydrology and, if possible, link the identified zones to flows of particular return periods
- To seek simple methods for the identification of the lateral vegetation zones
- To produce guidelines on the identification of lateral vegetation zones, and their links to flow, for use in South Africa

Cost: R1 765 310
Term: 2010 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Environmental water requirements for non-perennial systems: Phase III
University of the Free State; Limpopo Province; Rhodes University; University of Cape Town
No. 1798

Research into the development of a non-perennial EWR method started in 2005 using the Seekoei River (a non-perennial southern tributary of the Orange River) as a case study (Seaman et al., 2010). Results from the study showed that the interaction between groundwater and surface water is of critical importance in non-perennial rivers, and probably also in perennial rivers, and that the methods used to determine the EWR should take this into consideration. It was further found that the existing standard hydrological models are inadequate for describing and predicting the hydrology of the full spectrum of non-perennial rivers (episodic to semi-permanent). Licenses for the abstraction or release of water in these rivers would therefore have to be based on a specific understanding of the ecology of non-perennial rivers and a hydrological model that can address surface and groundwater interaction. Due to the shortage of hydrological and ecological data on non-perennial rivers it is difficult to determine the reference/natural ecological conditions in the rivers being studied. It was therefore decided, by the team, that an approach beginning with present day (as most specialists have data for the present) was needed. It was also evident from the study on the Seekoei River that monthly flow data were insufficient to capture the variability of flow in non-perennial rivers and that daily flow data should be used for hydrological modelling. The social and economic aspects of the catchment were also deemed important and needed to be included in the method. Keeping the abovementioned aspects in mind the team involved in the Seekoei River case study examined current EWR methods used in South Africa, namely, Ecoclassification (Kleynhans and Louw, 2007), DRIFT (Downstream Response to Imposed Flow Transformations; Brown et al., 2008 and 2008a) and HFSR (Habitat Flow Stressor Response; O' Keeffe et al., 2002) and found that the DRIFT method included all of the aspects mentioned above and could possibly be used and modified where necessary. A prototype EWR method for non-perennial rivers was then developed using the Seekoei River as case study and for the purpose of this report the prototype method was named Arid-proto.

Cost: R3 000 000
Term: 2009 - 2013

Shared Rivers Initiative: Phase II: Analysis of the ecological Reserve implementation scenarios with the intention to design an effective implementation approach/plan
AWARD; University of Pretoria; Rhodes University; University of the Witwatersrand; SANParks; Water for Africa (Pty) Ltd; Centre for Environmental Rights
No. 1920

The findings of Phase 1 of the Shared Rivers Initiative (SRI) led to this second phase. One component, carried out by AWARD, undertook baseline research specifically so as to identify points of entry aimed at improving the sustainability of the rivers of the Lowveld. More formally, the aim was to provide an assessment of the status of sustainability of the water resources of the six Lowveld river systems, and the factors that constrain or contribute to this, in order to provide a grounding from which the project is able to design and implement real change. Globally the commitment to sustainability is captured in the concept of Environmental Water Requirements (EWRs). In South Africa the 'benchmark' for the statutory commitment to sustainability (or EWRs) is captured in the ecological Reserve which refers to both the quantity and quality of water needed to protect aquatic ecosystems (a river for example) in order to secure ecologically sustainable development and use of the relevant water resource. Phase 1 of SRI revealed great shortcomings related to the role of diverse stakeholders, which are key in the decentralization and democratization of the operation of the National Water Act (NWA). Collective action was researched through three case studies or action research, with guidelines produced on how to engage society in sustainability of water resource management. The other core shortcoming identified in SRI Phase 1 was the lack of understanding and appreciation of the importance of complying, or danger of not complying, with the ecological Reserve in terms of goods and services meant to be secured through the Reserve. What does non-compliance mean to subsistence, commercial, business, mining and other water users? This was researched through another action research approach, firstly by unpacking technical hard-core science to simpler and easy-to-understand concepts for non-scientists who must buy-in for success. A guiding framework was produced on how to simply technical science to public science, emphasising the importance of meeting the Reserve as well as understanding the impacts of one user on downstream users, a shared-resource basic principle. Last, the SRI-1 revealed poor compliance and enforcement of NWA, particularly with regard to the role of the Water Tribunal. This shortfall was unpacked through the examination of court cases, and non-compliance of a Local Municipality to treat wastewater vs. DWA licensing conditions.

Cost: R1 500 000
Term: 2010 - 2013

Programme 3: Land-use and aquatic ecosystem management

Linking land use and water quality for effective water resource and ecosystem management
CSIR; Ground-Truth cc; University of KwaZulu-Natal (Pietermaritzburg); Aquagreen Consulting; Department of Water Affairs; independent consultants
No. 1984

This project was primarily about understanding the influence of land use, in all its forms, on the quality of water in our water resources. This knowledge, if made accessible, has the potential to soundly inform both water quality management and land use management. This will hopefully reverse some of the alarming trends currently apparent in respect of water quality in our rivers, dams and groundwater. The research involved the development of a sound

foundation that will serve to integrate the efforts of scientists within stakeholder sectors. It is envisaged that such socio-technical approaches will greatly assist multi-stakeholder co-development of appropriate options and recommendations in any given land use and water quality impacts context. In order to facilitate detailed input and testing of project concepts and models, two case study catchments were chosen. These were the upper uMngeni River and upper Olifants River catchments. These catchments were used as focus areas for catchment-based stakeholder and institutional engagement as well as testing of the models identified in the study. The investigation confirmed that the use of export coefficients is potentially a useful tool in catchment-level planning for identifying land uses with high pollution potential. The team was successful in implementing a variety of modelling approaches in the case study catchments. All models varied in their application context and had strengths and weaknesses. The assessment of these models provides a guideline on their suitability for making decisions related to water quality impacts on land use. Ultimately, the choice of model is generally dependent on the nature of the problem and the level of detail required to make a decision.

Cost: R1 520 000
Term: 2010 - 2013

Hyperspectral remote sensing of water hyacinth: From plant physiology to landscape-level changes
University of the Witwatersrand; CSIR; Rhodes University
No. 2037

The study investigated the physiological status of water hyacinth grown with eight different heavy metals, in a single metal tub, and with three different simulated acid mine drainage (AMD) treatments in a pool trial, as well as in the Vaal River at the inlets of its tributaries, the Koekmoerspruit and the Schoonspruit, all under the influence of the biocontrol agent, *Neochetina* spp., A hand-held spectrometer, the analytic spectral device (ASD), was used to measure reflectance. The hypothesis that hyperspectral RS can 'see' the response of the plant to both the heavy metals and the biocontrol-induced stresses and their interactions was tested. The effects of the three metals (Cu, Hg and Zn) in the single-metal-tub trial, the medium and high AMD concentration treatments in the simulated AMD pool trial, and the increased pollution level after rain, particularly at the Schoonspruit site, on the weevil's activities and plant growth parameters were consistent with those found using RS data, which confirms the feasibility of using hyperspectral remote sensing (HRS) to identify both metal/AMD and weevil-induced plant stresses and to accurately evaluate water hyacinth. Thus, the results of this study indicate that HRS has potential as a tool to assess the physiological status of water hyacinth from a remote position, and thus to inform management interventions in control of the weed. However, its use at a larger scale requires further study. It was also shown that, although the general activity of the weevils decreased in response to metal pollution and AMD, the weevils nevertheless managed to cause some damage to the plants. However, their use as biocontrol agents will be hindered by pollutants, which suggests that biocontrol should be used synergistically with herbicides.

Cost: R610 561
Term: 2011 - 2013

Programme 4: Integrated environmental and drinking water quality

Critical analysis of water quality in South Africa: historic and current trends
Rhodes University
No. 2184

This research provides a review of changes in water quality management structures, programmes and approaches over the past two decades, and highlights areas where these need updating, completion or revision. As a comparative illustration of changes in water quality with time, changes in 11 water quality parameters in two river systems (the Crocodile River in Mpumalanga, which is moderately impacted, and the Olifants River, in Mpumalanga and Limpopo, which is severely impacted) are presented. This report presents:

- A review and critique of the development of policy, management practice and methodologies associated with environmental water quality
- Recommendations for research that will support implementation of legal, policy and strategy requirements for environmental water quality
- An assessment of the long-term water quality trends in two catchments, selected as examples of systems that are moderately (the Crocodile River, Mpumalanga), and seriously (Olifants River, Mpumalanga/Limpopo) impacted by deteriorating water quality

The results showed that sites that were impacted at the start of the data record generally continue to show that impact over time (though there are some improvements). Changes in water quality are driven by increased orthophosphate levels (though recent records suggest this trend may be changing), increased pH levels, increased salinity, and, for sites in the Olifants River catchment, increased sulphate and calcium levels. Some rivers showed elevated chloride levels consistent with salinization, but this was not widespread. Finally, microbial levels were unacceptably high, though no trends were apparent.

Cost: R300000
Term: 2012 - 2014

Programme 5: Ecosystem risks and disaster management

The effects of sediment as a physical water quality variable on macroinvertebrates as input into sediment water quality guidelines development
Rhodes University; Walter Sisulu University
No. 2040

Though the study was challenged by the ability to maintain consistent concentration of suspended solids in circulation through the artificial streams, the key finding showed that the macroinvertebrates were quite tolerant of suspended solids impact (kaolin was used in the study). Scanning electron microscopy was not useful because gills were broken. Mortality with time impacted on the detailed statistical analysis. It is most likely that the mortality observed as time progressed was due to hunger, not a response to suspended solids, as it occurred in controls as well. The key findings of this study were that the settled sediment causes more damage to gills than suspended solids, which then suggests that the guidelines should pay more attention to settled than suspended solids. The same results were confirmed in the field through correlation of biomonitoring results with invertebrate assemblages/abundances (SASS5), with settled sediment impacting more on invertebrates than suspended solids.

Cost: R1 000 000
Term: 2011 - 2013

Assessment of locally manufactured radio telemetry equipment for manual and remote behavioural monitoring of fish in lentic and lotic freshwater ecosystems in South Africa
Rivers of Life Aquatic Health Services cc; SANParks; De Beers Consolidated Mines; YRless International (Pty) Ltd; University of Johannesburg; North-West University (Potchefstroom)
No. 2111

The functionality of locally designed/adapted biotelemetry systems were compared to available international advanced telemetry systems from USA-EPA. Various specifications and the effectiveness of both systems were technically compared, such as support options, radio telemetry systems (general), receivers and transmitters/ transceivers. The findings indicate that the unique locally-adapted biotelemetry systems out-perform the Advanced Telemetry System approach which has been more widely utilised in inland ecosystems in South Africa to date.

Cost: R841 950
Term: 2011 - 2013

Programme 6: Biodiversity and conservation

Thyroid-disrupting activity in South African waters: Amphibian metamorphosis as biological model to study effects of endocrine contaminants on thyroid function
University of Stellenbosch (Zoology); University of Victoria, British Columbia; University of the Western Cape; Okazaki Institute for Integrative Bioscience; University of Stellenbosch
No. 1680

Amphibian metamorphosis, because of the regulatory role of thyroid hormone (TH) during metamorphosis, has been

recognized as a promising biological model to study potential effects of endocrine disruptors on thyroid function. The overall objective of this study was to review the current knowledge regarding thyroid disruption in the context of endocrine disruption activity in the environment. To achieve this aim, it was necessary to review and validate the protocols for the *Xenopus* Metamorphosis Assay (XEMA) (OECD/USAEPA protocol) for screening and testing waterborne contaminants for thyroid-disrupting activity in South Africa. *Xenopus* tadpoles were bred in the laboratory, with exposure to control chemicals starting at the stage when the forelimbs emerged until 21 days. Results compared well with those obtained in international inter-laboratory studies. Thyroxine (T4) accelerated metamorphosis and propylthiouracil (PTU) inhibited progression of metamorphosis. The study also included sodium perchlorate and bisphenol A as potential toxicants. Tadpoles exposed to perchlorate showed severe arrest of metamorphosis while those exposed to bisphenol A showed moderate inhibition of metamorphosis. More research is needed to design and test the ideal exposure system leading to standard guidelines on the South African adapted protocol.

Cost: R400 000
Term: 2006 - 2013

A study of the interactive effects of pesticide mixtures in water on selected species
University of Stellenbosch; University of the Western Cape; Cape Nature; Florida University; Mpumalanga Tourism & Parks Agency; University of Pretoria; University of Victoria, British Columbia
No. 1932

The present study showed that Roundup, Midstream and Basta formulations are embryo-toxic to *Xenopus laevis*, while Arsenal, Enviro-glyphosate and Kilo Max showed relative low toxicity to the *X. laevis* embryos. Kilo Max, Roundup, Basta, and Arsenal formulations revealed significant growth disruption. In terms of teratogenicity, Midstream showed a strong teratogenic potential, while Enviro-glyphosate showed positive teratogenic potential at relatively high exposure concentrations. In South Africa, the advantages of extensive assessment of a relatively large number of pesticides, including herbicides currently used in intensive agriculture practices, as well as terrestrial and aquatic alien plant control, for example, by the Working for Water and Working for Wetlands programmes, cannot be over-emphasised. Herbicide formulation selection should be done on a scientific basis to ensure limited impacts on wildlife, especially aquatic organisms. Similar toxic effects were revealed in fish. The findings, though difficult to link to specific chemicals rather than a mixture, revealed a more difficult to interpret but obvious impact of herbicides and other biocides.

Cost: R1 400 000
Term: 2009 - 2014

Programme 7: Ecosystem governance, legal framework and ethics

The classification of endorheic wetlands (pans) and the effect of acid mine drainage on the hatching success of the egg banks of selected invertebrate communities within pans
University of Johannesburg; Jeffares & Green (Pty) Ltd
No. 2190

There are many endorheic wetlands (pans) in South Africa occurring in areas where there has been an increase in mining activities. As is the case with most biotic indices and methods used in water resource management, studies on pans are also reliant on the selection of relevant reference conditions. As studies have shown, there is a large variability within the physico-chemical parameters of pans, and the selection of appropriate reference conditions can be complicated. The classification systems suggested by some experts is based mainly on pans in Mpumalanga. Further studies into the different trophic states of pans in various provinces is very important and can contribute to a better understanding of the general ecology of these systems and the potential impacts of anthropogenic activities. Most importantly it can contribute to future selection of appropriate reference conditions, in turn ensuring the effective management and conservation of these ecosystems. As many of these systems are already affected by mining activities, the effect of AMD on the biota is also of particular concern. The effect of AMD on the hatching success of egg banks has not been well studied, especially in South Africa. This study was thus designed to contribute to our knowledge of the effect of water quality changes, in particular, on the branchiopod communities within these systems. This is very important as these branchiopod crustaceans are specifically adapted to these endorheic ecosystems. Many branchiopods (especially *Anostraca*) are also classified as being endangered or threatened according to the IUCN Red List. A dormant egg phase is a dominant feature of most large branchiopod taxa. After production, eggs are deposited on the substrate ultimately forming egg banks. The conditions required to end this dormant stage vary between species and can even vary amongst a population of the same species. Three areas with a high density of pans were selected as study areas – the Lake Chrissie area in Mpumalanga, Wesselsbron in the western Free State and Delareyville in the North West Province. An initial survey was undertaken to select appropriate study sites and to collect sediment for the hatching experiments as well as water samples for physico-chemical analyses. The hatching of branchiopod crustaceans was inhibited by the presence of AMD. An explanation for eggs not hatching in the presence of AMD is that AMD has a high concentration of mineral salts (consisting of toxic metals) and a low pH. Though recovery rates were low following exposure to AMD, the information generated is very important for monitoring and conservation.

Cost:	R684 500
Term:	2012 - 2014

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

Expanding on a National Wetland Vegetation Database for the pur¬pose of conservation planning, monitoring and wetland rehabilitation
University of the Free State (Plant Sciences, QwaQwa); Ekolnfo; Coastec; Sivest Environmental; SANBI (Pretoria); Imperata Consulting; Cape Nature; Rhodes University; Mpumalanga Tourism & Parks Agency; Free State DTEEA; University of Cape Town; Department of Agriculture, Environment and Rural Development; Department of Environmental Affairs; University of KwaZulu-Natal (Pietermaritzburg); ARC; independent consultants
No. 1980

Until recently, wetlands were neglected in terms of conservation and management. Although wetlands are now recognised for their social, economic and ecological functions, many important wetlands have been lost or severely degraded. This is despite the supportive legislation spanning DWA, DEA, DAFF, etc. The situation is improving as these laws slowly get implemented. SA now has 20 Ramsar World Heritage Sites. In recognition of the value of wetlands the Working for Wetlands Programme was launched in 2000 in collaboration with the Mondi Wetlands Project as well as the Department of Water Affairs, and Department of Agriculture, Forestry & Fisheries. Wetland vegetation is an important indicator of wetland quality and integrity, since wetlands are susceptible to terrestrial encroachment and alien invasion. Due to years of neglect, there is a lack of a national wetlands database, with benchmarks against which to base any monitoring of impacts. This study was proposed because the existing data is inadequate to enable a detailed analysis of environmental conditions required by vegetation types (i.e., to determine indicator species for wetland conservation assessment and planning on a national scale). Data were gathered for wetland vegetation across the country, to obtain a baseline description of wetland vegetation for long-term monitoring and conservation. A database was built by first collating vegetation data from existing literature sources, designing a sampling protocol and supplementing this data with field visits. A database made up of 5 583 vegetation plots spread across the entire country is now available, with 244 plant communities recognised and classified. There are highly species-rich wetlands in the country, mostly located in the high mountains, the mistbelt region of KwaZulu-Natal, and the Renosterveld of the Western Cape. The most common wetland plants are mostly grasses, but sedges tend to be dominant in the wettest parts of the wetlands.

Cost: R1 951 000
Term: 2010 - 2014

Wetlands and livelihoods: Restoration of wetland ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods
University of KwaZulu-Natal (CEAD); Charles Breen and Associates; Eco-Futures; Duncan Hay and Associates
No. 1986

Historically, wetlands have played and continue to play a critically important role in the evolution and development of societies. Large sectors of society remain directly and indirectly dependent on the flow of benefits from wetlands. Despite this our recent history is characterised by ongoing destruction on a large scale. Although there is a notable trend towards understanding wetlands as providers of multiple benefits, governance systems that promote wise use of these benefits are still evolving. In South Africa the benefits accruing from wetlands include, amongst others, water, food, spiritual fulfilment, craft material, livestock grazing, etc. The estimated loss of wetland area in SA ranges from 20 to 50%. There is a continuing attrition of traditional rights to wetland resources caused primarily by a lack of appropriate property rights-based governance systems. The overall aim of the study was therefore to rather apply and test the Anderies et al. and other supporting frameworks to better understand how to manage the social-ecological system for resilience. The approach was integrative and participatory, allowing resource users to establish common ground around benefit sharing and trade-offs in a complex system, such as wetlands. Four case studies were earmarked for testing the Anderies framework and adaptive management framework in understanding resilience in socio-ecological management of systems. The testing was done successfully, though mainly at desktop, with practical application in one wetland, involving local wetland beneficiaries at Papenkuils. The interaction improved local resource management, roles and responsibilities. A decision support system was also produced to ease and advise on appropriate decision-making

Cost:	R800 000
Term:	2011 - 2013

Programme 2: Socio-economic dynamics

Setting objectives for urban river rehabilitation
Aurecon Group; Chris Brooker & Associates; University of the West of England; University of the Witwatersrand; Vulamanzi Water Law Advisers; Laughing Waters
No. 2036

Many natural riparian landscapes have become degraded through human activities such as agricultural practices, development, settlement, land use, water abstraction, damming and encroachment on river systems. These activities may be both deliberate or incidental, i.e., degraded due to natural events, and/or exaggerated by human influence. Riparian lands are complex ecosystems which include the land, plants, animals and a network of streams within them. They perform a number of ecological functions such as modulating stream flow, storing water, cycling nutrients, filtering sediments, and providing food sources, habitat and movement pathways for aquatic and terrestrial insects, birds and animals. The biggest challenge is in enforcing the river rehabilitation in the midst of many regulations (NWA, NEMA, CARA, etc.), without guidelines on how to rehabilitate, how to set feasible objectives and how to monitor the impact of rehabilitation. Using a holistic systems approach to river rehabilitation, the project unpacked the legislative framework for each category of rehabilitation project, i.e., landowner initiative, municipal responsibility and enforced

rehabilitation. The project also unpacked a clear set of roles and responsibilities between the different institutions and levels of government for river rehabilitation. The ultimate aim of the project was to develop usable tools for both landowners and officials to assess a property and its rehabilitation requirements, and set clear, feasible and practical objectives for rehabilitation, i.e., in terms of restoration, rehabilitation or remediation, all of which were combined into a user-friendly guideline document for setting urban river rehabilitation objectives. The research drew on international best-practice examples and contextualised these to the South African situation, using existing and current South African case studies. This research focused on rehabilitation of rivers in the South African urban context (which has been seriously overlooked), and, more specifically, enforced rehabilitation, e.g., by directive, compliance notice, or court order. The study produced tested and user-friendly guidelines for urban rivers which if applied will be very useful to municipalities across the country.

Cost: R850 000
Term: 2011 - 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
NWU
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

Trajectories of change of wetlands in the Fynbos Biome: Part A. Habitat transformation, water quality and diatom response
Freshwater Consulting Group
No. 2183

It is commonly reported in the literature that at least 50% of wetlands in South Africa have been lost and many more seriously degraded and yet it is very difficult to establish the veracity of this statement. Certainly, wetlands appear to be increasingly under threat due to the spread of urban infrastructure and expanding agricultural activities. Seventy-five wetlands in the Western Cape were surveyed between 1987 and 1989. As part of that survey, the wetlands were photographed, water chemistry parameters were measured and plant and invertebrate samples taken. However, the project was prematurely terminated and the biological data has never been published. In this project the Western Cape fynbos wetlands will be revisited to collect further data on biota and physico-chemical aspects, and reporting will be updated to encompass the current eco-status approach. The framework developed can be adopted and applied anywhere in the country.

Estimated cost: R1 500 000
Expected 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 NRE (Stellenbosch)
No. 2187

Estuaries form the interface between land and sea and are strongly influenced by runoff, sediments, wind, wave action, air and water temperature and constitute some of the most heavily utilised and productive zones on the planet. A coarse, national-scale preliminary health status assessment of South African estuaries has recently been undertaken as part of the National Biodiversity Assessment (NBA) 2011 of the South African National Biodiversity Institute (SANBI).

However, the NBA status assessment was based on very limited hydrological information (a key determining factor in the health status of many SA estuaries). While the NBA study did provide a 'desired state' for each estuary based on its biodiversity importance, it did not reconcile the health status assessment or present ecological state (PES) with reversibility of pressures (identify Best Obtainable State), national biodiversity plans and targets; or strategic economic development plans in order to propose a provisional ecological classification of estuaries, nor did the NBA 2011 address resilience to future water resource development. This project aims to extend and improve the NBA assessment to contribute to the knowledge pool necessary for the incorporation of estuaries in strategic water resource planning as explained above. The output from this study is intended to inform strategic planning processes and is not aimed at the operational management level, where detailed, site-specific studies (e.g. EWR studies) still remain important.

Estimated cost: R1 400 000
Expected term: 2012 - 2015

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

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

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 (INR)
No. 2200

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

Estimated cost: R600 000
Expected term: 2013 - 2014

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Biological temperature thresholds for the ecological Reserve
Freshwater Consulting Group
No. 2182

The refinement of upper thermal limits and the formulation of biological temperature thresholds for incorporation into the water temperature component of the ecological Reserve is considered critical for the protection of aquatic ecosystems. Existing stress on aquatic resources, including both water quantity and quality, is likely to increase in response to demand for water (Dallas and Rivers-Moore, 2009). There will likely be an increase in impacts on water temperature as a result of climate change, hydrological changes (e.g. water abstraction, low flows, river regulation, dams, interbasin water transfers), changes in rainfall patterns, etc. The links between water temperature and flow and flow and ecosystem response are well known. How much change is acceptable to society? Increased thermal stress is likely to lead to homogenisation of freshwater communities, loss of specialist species, and lowered system resilience. As a signatory to the Convention on Biological Diversity, South Africa has an obligation to meet conservation and biodiversity targets. Thermal stress is also likely to exacerbate water quality issues such as increased outbreaks of algal blooms and spread of disease vectors. Such water quality effects have obvious health and economic impacts for society. Understanding of the biological consequences of thermal stress, and incorporation of this stress in the form of biological temperature thresholds, applied within the context of the ecological Reserve, will provide a valuable tool for managing aquatic resources.

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

Programme 3: Land-use and aquatic ecosystem management

Biodiversity, conservation and management of Nelson Mandela Bay temporary wetlands
Nelson Mandela Metropolitan University
No. 2181

The unpredictable rainfall makes temporary or ephemeral wetlands more cryptic and difficult to delineate. The combination of broad-scale desktop analyses and fine-scale site level field and laboratory data will bring new understanding of the types of wetlands in this region, their vegetation and aquatic invertebrate communities and biodiversity, including interactions between physical structure and chemical processes. Much needed data about

the wetlands of this region will aid in conservation planning, in particular that of the Nelson Mandela Bay (NMB) municipality, which would help protect vulnerable and rare wetland ecosystems and assist in the management of development within in the municipal boundaries. It is, equally, an important test of the new national classification system that will provide feedback into the NWCS and either support the desktop method for this region or modify the existing system appropriately. Through this research programme not only will the existing tools used in wetland evaluations be tested, but new and critical baseline information on the functioning of these systems will be added. This baseline data will be able to assist in the prioritization of wetlands in the NMB metro for conservation, protection and rehabilitation. This work will help gain insight and improve understanding with regards to mitigating the challenges associated with climate change and important ecological drivers responsible for system alterations.

Estimated cost: R1 600 000
Expected term: 2012 - 2015

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

Develop and test a landscape-based multidisciplinary and multi-sectoral decision support system to support integrated water resource management in Mpumalanga
SANBI
No. 2281

The impacts of mining are felt by the natural environment as well as many stakeholders. In addition to non-

compliance with active mining licensing conditions, there are many abandoned mines that continue decanting mining-impacted water. The pollution load within catchments is aggravated by effluents from non-functional wastewater treatment plants. Mpumalanga, with the largest concentration of coal mines in the country, faces a considerable proportion of these challenges. Coal mining, in particular, poses serious threats to headwaters, wetlands, rivers, dams, groundwater, soil productivity, livestock production, grasslands, biodiversity, air quality, and human health. It is necessary first to determine the extent of water quality issues in Mpumalanga in preparation for integrated resource management. Existing mining licensing processes will be examined, to develop a decision support system (DSS) as well as a monitoring system which will ensure that mining and other land uses (as job creation and poverty alleviation) adhere to sustainable development requirements, while taking into consideration the complexities associated with natural, physical and societal needs. To build the capacity of communities, businesses and government officials, awareness-building and training tools are planned. Finally, proposals will be submitted about the resources required for ongoing implementation of the DSS and monitoring framework.

Estimated cost: R1 000 000
Expected 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 environments in densely industrialised and urbanised areas
University of KwaZulu-Natal (Chemistry)
No. 1977

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

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

Aquatic microbial diversity: A sensitive and robust tool for assessing ecosystem health and functioning
Rhodes University (Biochemistry)
No. 2038

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

Estimated cost: R800 000
Expected term: 2011 - 2014

Programme 5: Ecosystem risks and disaster management

Development of an ecosystem risk assessment model to determine the risk of EDCs in the water environment
University of Stellenbosch
No. 1712

Scientific research has shown that all major aquatic wildlife groups are experiencing endocrine disruption (ED). ED, at many sites, is caused by a complex mixture of substances, very often in low concentrations but acting in synergy with other compounds in the mixture. Imperfect knowledge about the effects of endocrine disrupting compounds (EDCs) on ecosystem structure has implications for environmental risk assessment for EDCs. An important emerging approach is to develop models for ED exposure in food chains, including pathways for human exposure. This study will research and design a conceptual risk assessment model related to the unique features of EDC dynamics in the aquatic environment in South Africa. This project aims to assess the advances made in the development of ecological-based risk assessment models and the use of the precautionary principle (vs. weight of evidence) in ecological risk assessments, as well as associated data requirements, with particular reference to EDCs. An appropriate ecological risk assessment model or framework for application in South Africa will then be recommended. The results will add value to the existing EDC programme and will provide guidance regarding future research.

Estimated cost: R370 000
Expected term: 2007 - 2013

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 - 2013

Programme 7: Ecosystem governance, legal framework and ethics

Nile crocodiles in north-eastern KwaZulu-Natal
University of KwaZulu-Natal
No. 2188

The recent die-off of crocodiles in the Kruger National Park (KNP) and at Loskop Dam have revealed the vulnerability of the species and highlighted the need for urgent study of Nile crocodile populations in Southern Africa. The KZN population is second in size only to the Kruger population, and the governing conservation organisation, EKZNW, has the obligation to conserve this important population effectively. As a top predator the Nile crocodile is a valuable ecosystem component but also a source of management concern, as individuals can cause problems when they leave protected areas. If crocodile populations are sick or in decline, it is a serious reflection on the health of their associated water bodies and other organisms in the food web. Mitigation of threats to crocodiles is important for protection of aquatic habitats at an ecosystem level and has a positive trickle-down effect on sympatric aquatic

species. Lake St. Lucia and environs represents one of only three major breeding areas for the Nile crocodile in South Africa. Crocodiles require large areas of undisturbed wetland (e.g., Lake St. Lucia) to maintain large, stable populations. As water levels fluctuate, movements of crocodiles within and out of particular areas become ecologically important to individuals and populations. Environmental fluctuations are suspected to affect the demographic stability of crocodile populations because of their direct and indirect influences on recruitment, mortality and food availability. This project aims to address the aforementioned conservation needs of Nile crocodiles in the study area by gathering sound data on a suite of ecological, physiological, epidemiological and genetic components for the species. Additionally, it aims to analyse the specific threats to crocodiles (human-, environmental- and disease-related) while simultaneously generating novel solutions of risk reduction for both sides of the crocodile-human interface. Information from field and laboratory studies will be used to produce predictive models of population viability and change that are needed to support proper long-term management of Nile crocodile populations in the study area.

Estimated cost: R884 000
Expected term: 2012 - 2015

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

Biology, ecology and management of indigenous and invasive alien fish species in the Groot Marico River and Sundays River catchments
Consortium: SA Institute for Aquatic Biodiversity (SAIAB); Golder Associates Africa (Pty) Ltd
No. 2039

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

Estimated cost: R1 600 000
Expected term: 2011 - 2013

Consolidation and optimization of wetland health assessment methods through development of a Decision Support Tree (DST) that will provide guidelines
Freshwater Consulting Group
No. 2192

There are currently two main wetland PES assessment methods that are being utilized interchangeably by the wetland assessment practitioners. Some wetland specialists have identified gaps in these methods and have subsequently supplemented the shortcomings by developing other tools. This is creating significant problems in maintaining consistent standards of data collection, reporting and confidence in the assessments and output PES scores and Ecological Categories which are derived. A support system, such as Decision Support Tree (DST), is required by different directorates within DWA and by other regulatory authorities (such as provincial environmental and conservation departments) for more effective and consistent decision-making with regards to the protection of wetlands. This project will deliver products that can support different end-user requirements, such as Reserve determinations, Recommended Ecological Category determinations, monitoring, WULAs, EIAs and rehabilitation plans. In particular, the outcomes of the research will provide a decision support system to assist DWA and other departments in selecting appropriate wetland health assessment techniques for different applications. The recommendations made regarding improvement of existing tools will also pave the way for improvement of existing methods.

Estimated cost: R300 000
Expected term: 2012 - 2014

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Estuarine, coastal and marine processes

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: R100 000
Expected term: 2013 - 2016

Programme 3: Aquatic, riparian and land connectivity

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 - 2015

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 Resource (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 increasing 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

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

Pollution mapping in freshwater systems: using aquatic plants to trace N-loading
Rhodes University, Zoology
No. 2262

The degradation of freshwater systems in South Africa has important implications for sustainable ecosystem usage in the long term. To achieve the DWA slogan 'some for all, forever' requires a clearer understanding and identification of nitrogen-pollution hotspots and the ecosystem-level effects already being experienced, before rehabilitation and water quality management plans can be designed. The proposed research aims to provide a temporal assessment of

anthropogenic N loading in the New Years and Bushmans River systems, with the aim of furthering the development of ecologically valid water quality monitoring techniques. Identification of pollution hotspots will encourage the development of sustainable management plans to provide clean, healthy water to local communities. The ecological integrity of South Africa's freshwater is directly related to the economy of the surrounding population, as high N levels and subsequent eutrophication of waterways negatively impacts surrounding communities. Excessive N loads affect subsistence and commercial fisheries, and irrigation farming, as well as plant, animal and human health. Understanding the degree of eutrophication in the New Years and Bushmans River systems will help to pinpoint pollution hotspots and develop more effective rehabilitation, conservation and management plans to maintain the availability of clean water in a sustainable fashion. The overall aim is to evaluate the potential of stable isotope techniques for water quality monitoring in natural systems.

Estimated cost: R275 000
Expected term: 2013 - 2014

Development of an immobilized receptor-based EDC detection kit
University of Stellenbosch (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

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

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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 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

Jay Bhagwan: Executive Manager

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.

The prioritised research areas which support Government Outcomes (6, 7, 9 and 9) and the WRC Knowledge Tree outcomes are:

- Improvement of water services institutions – institutional realignment
- Infrastructure – operations and maintenance; capacity and skills
- Water quality – emerging pollutants
- Financial sustainability of water services – cost recovery (tariffs, subsidy and financing)
- Climate change
- Water services landscape – informal areas and rural systems
- Industrial – brines, acid mine drainage and desalination
- Water-and-energy nexus (renewable energy and energy efficiency)
- Beneficiation – integrated technology use for water, energy, nutrient, and product recovery, and an industrial ecology approach for waste and water
- Water security – reclamation, 'new' water
- Water efficiency – reuse, multiple use systems and recycling

OBJECTIVES

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

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

THRUSTS AND PROGRAMMES

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.

STRATEGIC CONTEXT

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

Although the water requirements for the domestic (rural 4% and urban 23%), industrial (3.5%), power generation (2%) and mining (2.5%) sectors are a fraction compared to total water availability and water consumed, it is the assurance (98%) and continuation of the supply that dictates the high capital and infrastructure costs. Industrial and mining processes, though a small user of water, together contribute to the bulk of the pollution affecting our water environment. The commercial use of water in the domestic urban areas accounts for 20% of the total urban water use. With the increase in population and the economy, it is projected that by 2025 water demand in the domestic sector will increase to between 30 and 35%. Any future peaks in water demand will affect the assurance levels, resulting in demand being exceeded and vulnerability increasing.

Whereas the provision of water for human needs plays a cardinal socio-economic role in the upliftment of people and in promoting a healthy population, it is the industrial and mining sectors which play a primary role in the development of the South African economy and, hence, in the development of the country in terms of wealth creation, employment creation and export earnings. Sanitation and wastewater treatment are essential elements of service delivery that contribute to maintaining a healthy environment for our population. Environmentally, the mining

and industrial sectors have common features, such as an intensive demand on material and energy resources, a major impact on the landscape, a relatively low demand on the national water use and a proportionately much higher pollutant profile. This includes effluents of high concentration, contaminants that are difficult or expensive to remove, and with these the potential to degrade large volumes of water, thereby rendering them less fit for other beneficial uses. Effluents from all of these sources arise either as point sources (e.g. piped effluents from factories or sewers) or as non-point sources (e.g. runoff from un-ser¬viced high-density settlements and seepage from mine slimes dumps or mine workings).

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

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

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

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

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

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed funding budget of R34 843 582.

Research portfolio	Approved 2013/14 (R)
Current projects	17 596 030
New projects	17 247 552
Total	34 843 582

RESEARCH PORTFOLIO FOR 2013/14

Reviews have highlighted that the relative weight of this KSA's thrusts seem to be well-balanced regarding the needs of urban–industrial–mining and rural research needs. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. During 2013/14 the portfolio continued to build on the strategic changes from previous years, as well as being strengthened towards making greater impacts on the social and health aspects, environment and economy of the country. The primary objective of this KSA is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the DWA framework strategy, Water for Growth and Development (Version 6). We believe that the programmes and projects are strongly oriented to the challenges. The new portfolio of projects continued to provide solutions that support these directions in the following ways:

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

- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Management of brines
- Management of acid mine drainage
- Extending the implementation of water footprints, waste minimisation, cleaner production, cleaner consumption and clean technologies
- Climate change adaptation and mitigation
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including grey-water and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes
- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology
- Investing in emerging contaminants affecting water quality, especially trace organics
- Energy efficiency and generation, as well as the energy–water nexus
- Institutional strengthening – financing, regulation, etc.

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Mechanism for pricing and financing the implementation of the Green Drop Report to guide the strategic decrease of the risk factor of wastewater treatment works
Asset Research
No. 2085

The poor performance of wastewater treatment works (WWTWs) in protecting the health of the water resource has necessitated that the DWA take action to rectify the situation. Green Drop certification is part of a wider process aimed at ensuring compliance with the DWA's responsibility in terms of its constitutional mandate. The Green Drop is an incentive-based initiative aimed at improving the performance of municipal wastewater service providers. While the

Green Drop seeks to acknowledge excellence in wastewater quality management, it does not reflect on the financial cost and resources required for achieving this, or on the economic costs and implications of not achieving the desired turnaround in wastewater management and performance of the WWTW. This is an important gap in planning for remedial action and one taken up in the research project: what will it cost to improve the performance of WWTWs? This study found that the drivers of the Green Drop Report were:

- Skills availability
- Effluent treatment levels in relation to plant capacity
- Investment in refurbishment and improvements (R&I)
- The risk category of the plant

There is a substantial risk linked to non-improvement in performance of WWTWs. Not only is the current load on WWTWs already too great, hence their underperformance, adding additional loads that could logically be expected due to increases in both income and people, will only add to the already overburdened ecosystems to which the effluents are being discharged. This will add to the economic cost of such pollution. Not only is the economic cost a concern, but also the deteriorating ability of ecosystems to absorb/dilute the effluent loads. This places the entire water system in highly-populated places such as Gauteng at high risk, as the ecosystems are required to act as water purifier of last resort. A contaminated water system is akin to a contaminated socio-ecological and economic system as it affects each and every part of both economy and society.

Cost:	R597 500
Term:	2011 - 2014

Providing water services at tariff levels that cover cost and that are sensitive to demand
Nelson Mandela Metropolitan University; Nelson Mandela Metro
No. 2087

The sustainability of South Africa's municipal water services provision is being challenged by the desire of Government to extend high-quality services, currently only available to a relatively small portion of the population, to the whole. Evidence of failures in delivery are mounting and many reasons for this have been identified, including a lack of political will at local government levels, low budget priority, insufficient capital, lack of capacity and skill and flawed tariff and accounting structures. The project aims were to provide economic guidance to municipalities that they may wish to consider in determining the particular mix of water services they will provide and in the tariff structures they set, and to assess the extent of the under-recovery of financial costs at selected municipalities This study generates new perspectives by surveying selected, but representative, South African municipalities in their capacities as water services authorities (WSAs) on a range of financial sustainability issues – including cost burden on users, cross sub-subsidisation and cost calculations to set tariffs. The study is part of a wider WRC-funded investigation into the setting of tariffs that cover costs and satisfy demand. The study concludes that, in general, there is under-recovery of costs in

the water services sector and this occurs for many reasons. Inter alia, it occurs because there are insufficient transfers, from central Government grant assistance to the poor, to cover the costs of those who do not pay, there is inadequate provision for replacement and maintenance costs (also called rehabilitation cost or deferred maintenance), and external costs are being omitted.

Cost:	R1 250 000
Term:	2011 - 2014

Identifying efficiency and inefficiency in municipal water service provision
Nelson Mandela Metropolitan University
No. 2118

Discrete choice experimentation is one form of choice modelling. It utilises a stated preference survey technique to gather data for modelling choice. The aims of the study were to demonstrate that discrete choice experiment analysis and the survey instrument on which it is based could provide useful information about how consumer groups valued water service delivery and how they rated the water services that they were provided. The motivation for undertaking the study was that technical and cost considerations are inducing greater interest among South Africa's municipal providers of water services to adjust the levels of water services offered to various customer groups. Such adjustments have consumer welfare implications and potential impacts on the demand for water services and these implications and impacts need to be considered along with the technical and cost consequences. The scientific credibility of the discrete choice experiment method of analysis and its appropriateness for application to assess the welfare merit of the levels of water services provided is well established. Background on the science of choice experiment analysis and the steps in applying the methodology are found not to be overly complicated. By incorporating some consumer satisfaction questions in the survey instrument it was possible to analyse customer ratings and perspectives on the water services that are provided at three selected municipalities, namely: Breede Valley and Knysna in the Western Cape and Msunduzi in KwaZulu-Natal. The analysis of the customer satisfaction part of the survey yielded findings that were consistent with assessments reported in the form of Blue and Green Drop certification. Three water service consumer groups were identified for the purpose of this analysis – high income, low income and businesses. The different water service consumer groups in the different municipalities did not share a common perspective on the way water services were managed. It was concluded that the discrete choice experiment analysis and survey on which this is based has the potential to yield useful insights into the levels of attributes preferred in the water service mix provided by South African municipalities. Thereby it can inform water service management thinking and policy decision making on potential implications for water service consumer welfare of technological and cost-saving changes made to water service provision.

Cost:	R720 000
Term:	2012 - 2014

Programme 2: Institutional and management issues – Water services

A comparative analysis of water management devices in Cape Town and pre-payment meters in Johannesburg
University of the Western Cape
No. 2089

Water management devices (WMDs) have gained policy appeal as a regulated mode of water service delivery in South African municipal authorities and are becoming a prominent instrument for water management in urban low-income areas. Cape Town and eThekwini are two such municipalities that have rolled out these devices with the broad aim of charging viable user fees; enabling users to conserve water; managing consumer debt; providing free basic water and detection of leaks. This study provided an understanding of user perceptions of the usefulness of WMDs. It is a marked departure from previous research studies that have tended to focus on the supply side of water services by analysing the effectiveness of WMDs in promoting cost-recovery measures without seeking to understand how the recipients of the devices perceive them. The research indicates that users are satisfied that they will no longer be prone to debt and are guaranteed of FBW supply, and thus, in the light of the Technology Adoption Model (TAM) and the confirmation/disconfirmation model of consumer satisfaction, WMDs have delivered both acceptable technological innovation and fulfilled most consumer expectations. However, in some cases, water supply has been limited by the installation of the devices to the extent that residents have had to devise a wide range of coping mechanisms. Some of these coping mechanisms have potential or actual significant implications on health and hygiene. In some areas, devices are not functioning optimally as intended. In general, cost-recovery effects need to be better substantiated and communicated, as it is unclear how this forms part of broader consumption pattern restrictions.

Cost:	R500 000
Term:	2011 - 2013

Programme 3: Innovative management arrangements – Rural water supply

Capacity building for climate change adaptation and disaster risk reduction in rural South African Communities: Tsengiwe, Eastern Cape
Umvoto Africa; University of Fort Hare
No. 2126

In South Africa the most common natural hazards are floods, storms, wild fires and drought. The Southern African region is regarded as one of the most vulnerable regions in Africa to climate change and variability, in part, due to its low adaptive capacity and inherent vulnerability. If the changes in climate observed over the last century persist, the potential impacts on water resources are likely to become more diverse and severe. The extent and state of water infrastructure in South Africa varies widely across the country. Vast rural areas are still without access to an adequate,

safe water supply or proper sanitation and there is an urgent need for service delivery to address this backlog. The existing infrastructure in municipalities is under strain and can often not cope with the increasing demand. To sufficiently manage this vital resource, it is imperative to formulate a participatory approach, good governance and communication between all stakeholders. The purpose of the study was to gain an in-depth understanding of the rural challenges in adapting to climate change, to understand the role of community based organisations (CBOs) and community-level coping strategies, and how to cohere and optimise these with local and district municipal resources and initiatives and sustainable water services.
This study engaged with the rural Eastern Cape community of Tsengiwe in planning for climate change adaptation (CCA) at a local level. The study highlighted that DRR provides a useful and practical lens through which to view challenges that can affect water and sanitation services. According to this framework, potential threats to successful and sustainable service delivery are used as starting points for positive change or to initiate plans to mitigate the risks they pose. Tsengiwe was seen as a suitable case study for a follow-up study because the team was able to draw on established connections. A previous study gained an understanding of the institutional hazards and contextual issues faced by Tsengiwe. This information placed the study in a position to facilitate Participatory Rural Appraisal (PAR) processes to assess community perception of risk and deepen the community's understanding of DRR through catalysing community-led processes for CCA.

Cost:	R800 000
Term:	2012 - 2014

Sanitation subsidies in perspective: how to increase the effectiveness of sanitation subsidies in South Africa
Sustento Development Services; CSIR
No. 2136

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 < R1 100 per month) to gain access to a basic level of sanitation service, i.e., in the case of basic sanitation, at least a Ventilated Improved 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. The overarching objective of this research was to investigate the sanitation-related subsidies in South Africa, including economic and social cost issues, to determine overlaps and gaps in sources (MIG, Housing, Equitable Share) of subsidy and to determine what constitutes effective/efficient use of subsidies, with the key purpose to develop a guideline to guide future sanitation subsidy policy and interventions. The key conclusion which can be drawn from the above review is that the provision of sanitation services utilising subsidies may be one of the most difficult regulatory environments in which to operate in South Africa, largely due to the lack of clarity and often conflicting legislation, policies and strategies from national to local government levels. To meet their Constitutional mandates and be able to deliver effective and efficient basic sanitation services to all South Africans, all sectors of government

need to understand the interactions, overlaps, gaps and conflicts in subsidised sanitation-related policies, processes and procedures. The financial component of the basic sanitation service sector would benefit significantly from a set of guidelines which could bring all these confusing and contradictory policy documents and instruments under a single set of guidelines, bringing together water services, housing, indigent, municipal and financial requirements of the subsidised sanitation sector. These guidelines could provide significant support to the sector, at a national, provincial and local government level.

Cost:	R488 765
Term:	2012 - 2014

Programme 4: Regulation of water services

Municipal guidelines for implementing WDM
WRP Consulting Engineers (Pty) Ltd
No. 2130

There is no single water demand management (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 is not complicated but does require a dedicated and methodical approach if real and sustainable savings are to be achieved. It is often similar to detective work where the first step in the process is to identify and understand the problem before trying to solve it. Too often, water loss reduction interventions are introduced which are inappropriate to the problems experienced in the reticulation system. The interventions must be selected to address the most serious problems experienced in a specific area to have any chance of success. The key issue is to decide which interventions are the most appropriate to a specific area and how best to implement them. The most common mistake made by many municipalities throughout the world is to believe that water loss reduction is achieved only through leak detection and repair. In such cases, large budgets are often used to search for unreported leaks using the latest hi-tech and expensive equipment. If the water losses are due to inaccurate metering or even background leakage, the leak detection activities will yield little or no results. There are many excellent books and publications on the subject of reducing water losses from municipal water distribution systems. This book does not attempt to replicate or replace any of these previous publications but concentrates on highlighting the key issues in simple and straightforward terms in an attempt to explain what interventions can be undertaken in order to reduce water losses from municipal water supply networks and how best to implement them. The book is based on the extensive practical experience of the authors derived from the implementation of various WDM interventions in over 20 countries.

Cost:	R500 000
Term:	2012 - 2014

Programme 5: Water services education and awareness

Social norms and moderation of water consumption in a major South African city
EPRU
No. 2091

Behavioural economics is increasingly informing policy design around the world. In the utility space behavioural economics is being increasingly used to moderate the water and energy consumption of households. The attraction of these methods is that they are generally very cheap to deploy, require limited infrastructure and offer few, if any, opportunities for corruption. This project assessed whether there was scope to use feedback, informed by several principles derived from the behavioural economics literature, delivered in the post with the water bill to reduce household water consumption within a major South African city (Cape Town). The findings from this study strongly suggest that merely reporting tips about how to save water will not result in a noticeable reduction in household water usage. In contrast; raising the salience of a household's water consumption, either by reporting their consumption in a bar graph or by comparing their consumption to their neighbour via a bar graph, was found to result in water consumption that was lower by roughly 1%.

Cost:	R462 000
Term:	2011 - 2013

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Wastewater reclamation for potable reuse
Umgeni Water; Durban University of Technology; SSI
No. 1894

The main objective of this research project was to demonstrate the applicability of MBR technology for production of consistent, acceptable potable drinking water through domestic wastewater reclamation. The MBR system was evaluated as a pre-treatment process and advanced treatment processes were evaluated for producing water that meets potable standards. The project was divided into two phases. In the first phase, the performance of MBR technologies as pre-treatment step for advanced water treatment processes to produce potable water was evaluated. In the second phase; bench-scale evaluations of advanced water treatment technologies for the production of potable water using the following technologies: ozone (O3), granular activated carbon (GAC), nano-filtration (NF) / reverse

osmosis (RO) and advanced oxidation (hydrogen peroxide and ultra-violet radiation) were evaluated. From the findings recommendations for an effective wastewater reclamation treatment process train for the design of a full-scale reclamation plant at Darvill WWW were made, and the capital and operating cost estimates of the recommended process were presented.

Cost: R907600
Term: 2009 - 2014

Development of design and operating guidelines for high-rate clarifiers in the South African water treatment industry
Umgeni Water; Durban University of Technology; University of KwaZulu-Natal (Westville)
No. 1942

This project was initiated with the intention of contributing to bridging this knowledge gap on the operational, maintenance and process requirements and limitations for high-rate clarifiers. The study was undertaken by first conducting a literature review of the common high-rate clarification technologies being used. The high-rate clarifiers considered in this study were the HR-CSAV (a sludge blanket clarifier which uses a flocculant aid), ballasted sand processes and sludge recirculation processes. This was supported by plant visits undertaken to provide case studies for existing full-scale facilities using these technologies, both in South Africa and abroad. In this study, the high-rate clarification technology was evaluated based on investigations conducted on a 500 m^3/day demonstration model HR CSAV high-rate clarifier, a patented technology developed by Pavel Polasek and Associates. Basic practical guidelines on the selection, design considerations and operation and maintenance for high-rate clarifiers, based on the case study assessments, literature and on the outcome of investigations on the HR-CSAV clarifier, were developed. The report will assist water treatment designers and water treatment practitioners, particularly in South Africa, to make informed decisions on the appropriateness of high-rate clarification processes under local conditions.

Cost: R1 800 000
Term: 2009 - 2013

Decision-support model for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery (with focus on upgrading options, water reclamation and desalination)
Chris Swartz Water Utilisation Engineers; University of Stellenbosch
No. 2119

The initial aim of this project was to develop a decision-support model (DSM) for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery (with focus on upgrading options, water reclamation and desalination). After several discussions with reference group

members, a decision was taken to only concentrate on water reclamation projects for potable use, both indirect and direct water reuse. In addition, a user-friendly DSM based on Excel was developed, instead of the Eidos software. Thus the overall objective of this present study was to develop a decision-support model and provide guidance on the costing of water reuse projects as means for decision-makers to compare options for water reuse schemes. These tools are based on a number of drivers, such as technical, water quality, costing, environmental and social and cultural aspects. More specifically, the aims of the model are to collate existing expertise and information for planning and implementation of potable water supply and direct potable reuse projects, and to provide decision-support guidelines and methodologies in the form of a spreadsheet-based, multi-criteria decision support model. This will enable municipalities to identify, evaluate, compare, and select appropriate options for water reclamation and reuse.

Cost: R450 000
Term: 2012 - 2014

Programme 2: Water treatment for rural communities

Compilation of guidelines for the selection and use of home water treatment systems and devices
Tshwane University of Technology; University of KwaZulu-Natal (Howard College); Chris Swartz Water Utilisation Engineers; GO Water Managment; University of Johannesburg
No. 1884

A number of home water-treatment systems (HWTSs) are being used internationally by rural communities without access to potable water services. These HWTSs vary from the simplest, such as using cloth as filter, to the most sophisticated systems, able to treat grey-water to potable standards. Although various devices have been reported on extensively in the literature, little is known locally about the existing options and little has been done to assist local communities in making informed choices on whether a specific device should be selected. This project therefore aimed to evaluate HWTDs for local application and provide guidelines for the selection and use of appropriate HWTSs by rural households. Devices were then selected according to their water-treatment efficiency, local accessibility and availability of materials used in their design, their ease of construction and robustness, their ease of operation and maintenance, and their cost. An ideal rural HWTS should be able to provide water compliant with the prevailing South African National Standard for Drinking Water Quality (SANS 241) over extended periods, and produce at least 25 L of safe drinking water per person per day. Five types of low-cost filters were investigated: a conventional biosand filter (BSF-S), a biosand filter with zeolite (BSF-Z), a bucket filter (BF), a ceramic candle filter (CCF), and a silver-impregnated porous pot (SIPP) filter. Environmental water samples were collected, providing ground and surface waters with low and high turbidities. The flow rates and product water qualities were measured; the SIPP produced too little water (5 L/d) and the other HWTSs produced >20 L/d. The SIPP and BSF-Z filters produced the best quality product water, but only the SIPP consistently met the SANS 241 water quality targets. The costs of manufacture ranged from approximately R130 (for the BSF-S) to R500 for the CCF. The SIPP costs R290 and was the second-most expensive filter,

and the BSF-Z cost R165 to manufacture. The social acceptability of the two HWTSs that had produced safe water (SIPP and BSF-Z) was explored for residents of a rural village, in partnership with the project team. Most of the residents (93%) had never used any water-purification devices, but found the SIPP and BSF-Z convenient. However, while most participants thought the HWTSs were useful, many found them complicated to operate and/or risky to handle, and were afraid of breaking the devices (e.g. during cleaning). Neither of the HWTSs tested in the village was seen as being better than the other. The project demonstrated that HWTSs would be welcomed by rural households as long as they are not too much trouble to operate and maintain, and provided that they are affordable to the users. The SIPP produced reliable water quality but not enough quantity, and the BSF-Z produced a higher quantity of safe water than the SIPP, but required more knowledge in order to care for it.

Cost: R1 200 000
Term: 2009 - 2013

Point-of-use disinfection systems designed for domestic rainwater harvesting (DRWH) tanks for improved water quality in rural communities
University of Stellenbosch; Bergema Wholesale Retail
No. 2124

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 8 occasions from 29 tanks during the period of March to August 2012. The chemical and microbial parameters were compared to drinking water standards stipulated by the South African and Australian Quality Guidelines. A survey of users' perceptions on rainwater harvesting was conducted. The social research project was aimed at developing a better understanding of public perceptions, including the degree of acceptance of DRWH, and the way in which the harvested rainwater is utilised. More specifically, quantitative and qualitative data were collected in order to describe the following: (i) the condition of the tank; (ii) the users' knowledge of the DRWH system, including its operation and maintenance; (iii) whether the user would be willing to pay for repairs (if required); (iv) perceived benefits and risks associated with DRWH; (v) level of satisfaction with DRWH; (vi) and views on municipal water. In addition, demographic data on the respondents were gathered, viz., gender, age, highest level of education, household size and employment status, in order to provide a socio-economic background description of the study population. Finally, different point-of-use treatment systems (mainly filtration and solar pasteurization systems) were evaluated for their effectiveness in treating the harvested rainwater to produce water that meets drinking water quality standards.

Cost: R746 000
Term: 2012 - 2014

Programme 4: Water distribution and distribution systems

Energy generation from distribution systems
University of Pretoria; Bloem Water Board; City of Tshwane; eThekwini Municipality; Energy and Water Resources
No. 2095

An initial scoping investigation highlighted the potential hydropower generation at the inlets to storage reservoirs. In South Africa there are 284 municipalities and several water supply utilities, e.g. 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. The hydro-energy may be used on-site, supplied to the national electricity grid or feeding an isolated electricity demand cluster. Thus the objective of this study was to prove that it is feasible and technically possible to generate energy from distribution systems; and develop guidelines to identify locations which have potential for hydropower generation. In this regard, the application to install hydro-electric turbines in a water distribution system is fairly new in South Africa, and thus three pilot plants were constructed showcasing several of the intricacies in the development process and to demonstrate the technologies:

- Pierre van Reneveld (Tshwane Municipality) – 16 kW
- Brandkop Reservoir (Bloemwater) – 96 kW
- Newlands (eThekweni – pico units x 2)

Cost: R2 500 000
Term: 2011 - 2013

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Effects of urine separation and treatment on wastewater effluent quality
CSIR (Stellenbosch); University of Stellenbosch; Africon Engineering International (Pty) Ltd
No. 1824

The concept of urine separation is still in its early stages, but the prospects of achieving more sustainable urban water management are very good. Urine separation could lead to better wastewater treatment, e.g., increased plant

capacity, improved effluent quality and reduction in energy consumption. 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. Although urine makes up less than one percent of the volume of wastewater, it contains around 50% of the total phosphate load and up to 80% of the nitrogen load in wastewater. The impact of urine diversion on BNRAS processes was investigated in a laboratory-scale reactor with a University of Cape Town (UCT) BNR system configuration, receiving mixes of grey and brown wastewater collected separately at the CSIR in Stellenbosch. Interestingly, the grey-water and brown water collected for experiments had lower overall concentrations than that measured initially at CSIR. A series of batch tests were done, which pointed to 6 factors to prove the non-existence of nitrifiers in the system, which included (i) no nitrite or nitrate in the effluent (ii) no nitrate generation when fed with excess ammonium in batch tests (iii) no decrease in alkalinity (iv) phosphate release in the anoxic compartment (v) measure oxygen uptake rate yielded a good COD balance and (vi) a low nitrogen fraction of the sludge produced. This meant that nearly all N was used for biological growth and no nitrate was produced, and the P removal proceeded via the normal biological excess P removal (BEPR). Removal performances were all better than those achieved in a control system, with exact design parameters and an equivalent COD feed, from a real domestic wastewater treatment works. A second system was operated according to the Johannesburg (JHB) process configuration, which also received a 50:50 mixture of grey and brown water. The JHB process is similar to the UCT process, but includes an anoxic zone in the return activated sludge stream, to remove any nitrate before entering the anaerobic zone. The mass balances showed that if all the degradable COD was utilized, then the very low effluent standards of 0.1 mg P/L could be achieved in both UCT and JHB process configurations. Furthermore, based on the mass of the COD load on a wastewater treatment works, the reactor can be reduced by 50% if urine was collected separately. From the perspective of an existing system, an activated sludge reactor basin could treat double the design load if urine was collected separately at source!

Cost:	R1 200 000
Term:	2008 - 2013

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

γ-PGA, a polymer of D- and L-glutamic acid monomers connected by amide linkages, is a naturally occurring biopolymer, synthesized by a variety of micro-organisms. Most commonly, γ-PGA production has been studied in *Bacillus* species, such as *B. subtilis* and *B. licheniformis*. *Bacillus* is also associated with domestic wastewater treatment and its enrichment has been associated with improved treatment processes. Potential applications of γ-PGA are reported in the medical, food, cosmetic, wastewater treatment, plastic and agricultural and textile industries. In this project, we consider the production of γ-PGA by *Bacillus* species for the partial treatment of domestic wastewater and concomitant production of the polymer for soil improvement and water treatment. This system was selected to

ensure that natural selection within the wastewater ecology was achievable. A number of isolates, 19 in total, were obtained from the Mitchell's Plain WWTP and screened for their growth potential and potential to produce PGA. Isolates showing reproducible growth and evidence of polymer production were selected for further screening in terms of growth. The growth, substrate utilisation and PGA production of these were compared. A sub-set were selected for further research with specific emphasis on media composition in terms of C:N:P ratio and selection pressure of continuous culture under reduced substrate concentration. In parallel to this, the requirements of the wastewater biorefinery were assessed and nature of wastewater as a source of nutrients described. This formed the basis for the review of reactor design and selection of appropriate reactor types. Following a broad review of bioreactor types, reactors supporting biofilm or aggregated microbial growth are selected to allow decoupling of hydraulic and biomass residence time to facilitate growth on dilute media. The fluidised bed reactor with an aerobic granular sludge (AGS) and the rotating bed contactor were selected for further study, and were designed, built and commissioned with an emphasis on simple and cheap construction. These reactors were trialled in the laboratory, using synthetic media and a pure culture of isolate 1, a *Bacillus* species. They were also trialled in the field at Athlone WWTP using wastewater. The latter allowed many challenges to be identified. The review of industrial ecology and the importance of this paradigm in the design of the biorefinery are reported. Further, key features of the wastewater biorefinery in terms of the process flowsheet are described, as is the tension between the goals of bioprocess engineering for maximising product formation and environmental biotechnology for maximising remediation.

Cost:	R356 000
Term:	2010 - 2013

Integration of aquatic chemistry with bio-process models
University of KwaZulu-Natal (Westville); University of Cape Town; eThekwini Municipality; University of Queensland; Umgeni Water; Water & Wastewater Engineering, Stellenbosch University; Universite Laval; Sasol; CEIT; Paper Manufacturers of South Africa (PAMSA)
No. 2125

Advanced process modelling is increasingly being used to design and optimize the operation of wastewater treatment plants. Both bio-process modelling and aquatic chemistry modelling are mature technologies; however, up to now they have not been well integrated with each other. As a result, in 2011, the International Water Association set up the IWA Task Group on a Generalised Physico-Chemical Modelling Framework for water and wastewater treatment processes. The challenge for the task group is therefore to develop a framework for integrating this pre-existing knowledge with current approaches to modelling biological treatment processes. The task group includes two South African researchers, Prof GA Ekama (University of Cape Town) and Mr CJ Brouckaert (University of KwaZulu-Natal), who have extensive experience in speciation chemistry and who have developed a number of models, in particular, the UCTADM2 model of anaerobic digestion (Brouckaert et al, 2010) which already incorporates several features which are consistent with the goals of the task group. This project has supported their continued participation in the Task Group and builds on the results of several previous WRC projects. Thus, a theoretical framework for integrating a

rigorous representation of important physico-chemical processes into established bio-process modelling approaches has been developed. It is presented as a framework for organizing the relevant knowledge about the bio-kinetic system which must be included in the model. In general, speciation reactions, especially acid-base reactions, are orders of magnitude faster than bio-kinetic and phase transfer reactions. It is therefore reasonable to use an equilibrium speciation model to calculate the aqueous phase speciation at each time step in the bio-kinetic model. The recommended approach is the algebraic solution of the speciation equations in a separate sub-routine which is called the main bio-kinetic treatment model. The approach is general and applicable to a range of models and processes. However, its practical application has also been demonstrated in a set of didactic case studies focused on anaerobic digestion. This new approach constitutes a significant step forward in wastewater treatment modelling compared to the widely used IWA models, particularly for those processes where accurate pH prediction is essential. The work presented here also contributes to meeting the goals of the IWA Task Group on a Generalised Physico-Chemical Modelling Framework for water and wastewater treatment processes. The training materials developed are intended to address a critical gap in expertise in the water and wastewater sector. The development and implementation of more accurate and flexible process models can facilitate the improved design and operation of wastewater treatment facilities, resulting in better protection of water resources as well as potential economic benefits.

Cost:	R480 000
Term:	2012 - 2014

Programme 2: Application of appropriate technologies and tools

Denitrification in trickling filters
CSIR (Stellenbosch); Virtual Buro (Pty) Ltd; Tshwane University of Technology
No. 1825

Within South Africa, at least 130 municipal wastewater treatment works, and another 50 at government institutions, have trickling filters. Trickling filters are employed either as part of a process, or as the sole biological treatment process. These trickling filters are not only found at small towns or remote rural settlements, but are often part of large treatment works, such as Rooiwal Northern Works (220 ML/d), Olifantsfontein (105 ML/d), Daspoort (55 ML/d) and Paarl (25 ML/d). Amidst current concerns of under-investment in wastewater treatment infrastructure, always in competition with other services for funding, existing trickling filters deserve more attention. This study compromised three parts:

- An investigation of the historical data for the Daspoort trickling filters to understand N removal
- Changes to operating parameters (arm rotation and recycle ratios) to evaluate if the system could be improved
- Identification of the mechanisms and microbiological processes that play important roles in the nitrogen removal efficacy of the Daspoort trickling filters

The full-scale trickling filter experiments confirmed the historic data for the Daspoort Eastern Works in two respects: (i) nitrogen removal over the trickling filters is very good, with removal efficiencies up to 70%; there is often not enough COD removed to account for the good nitrogen removal in terms of ordinary heterotrophic denitrification. Aside from the observations of good nitrogen removal, it was not really possible to identify operational parameters that led to this performance. None of the experiments on effluent recycle, or distribution arm rotation speeds, improved effluent concentrations significantly, or consistently. It must therefore be concluded that the old trickling filters at Daspoort operated at their optimum already, regardless of this work. Bacteria closely related to anammox bacteria were detected through direct molecular screening of samples from the trickling filters of the Daspoort WWTW. Batch reactors filled with humus sludge demonstrated anaerobic ammonium removal with concomitant nitrite reduction, at a stoichiometric relationship close to that which characterizes known anammox bacteria. However, batch reaction rates decreased progressively over the successive experimental periods, indicating decay of the anammox-like process without growth during batch experiments. With the above as background, it is evident that nitrogen removal over Daspoort trickling filters is not only a function of conventional heterotrophic denitrification, but an anaerobic ammonium oxidation process also plays an important role. A conceptual biofilm process reaction model was developed and the mathematical model of Hao et al. (2001) was integrated into the biofilm compartment of the AQUASIM software. Because of their performance and proven potential low loaded trickling filters should be considered as both most sustainable and most appropriate technology in the right context.

Cost:	R930 500
Term:	2008 - 2013

Evaluation of the DEWATS process for decentralised wastewater treatment
University of KwaZulu-Natal; eThekwini Municipality; WAI; Bremen Overseas Research and Development Agency
No. 2002

eThekwini Municipality, in common with other municipalities in South Africa, is faced with the increasing challenge of providing housing and infrastructure to its population. EWS, as the unit responsible for the provision of water and sanitation, are investigating various sanitation technologies that meet the needs of the different communities, taking into account aspects such as access to the sewer system, terrain, housing density, compliance and availability of land. New housing developments are continuously being established within the urban and peri-urban areas in order to meet the housing backlog, many of which are not able to be connected to the main sewer line. The traditional approach for these developments was to provide septic tanks for the individual households, but this has led to a number of problems due to poor management by the households. EWS has therefore looked to the DEWATS approach as a possible sanitation solution for future housing developments as the DEWATS has been promoted by the NGO BORDA as having the following advantages:

- No energy requirements. The system works on gravitational flow and therefore maintenance of pumps, etc., would not be required; the process is largely anaerobic (lower sludge production, no aeration required) and can be operated without pumping.

- The potential for using the treated wastewater on agricultural land, thereby providing a possible source of income for the community; the ABR does not remove nitrogen and phosphorus and thus could serve as a fertiliser source.
- The possibility of generating biogas for use in the houses as an alternative energy source.

The construction of the pilot plant at Newlands Mashu therefore provided the opportunity to investigate the applicability of the DEWATS system to treat the wastewater from a small housing development, and to identify any operational problems and how these could be overcome. It was decided not to include a primary treatment process in the form of a septic (settler) tank at the head of the process as eThekwini wanted a process that was simple. Furthermore, a preliminary agricultural study was initiated to evaluate the potential of using the nitrogen and phosphorus for agricultural crops. The field trials highlighted several challenges and highlighted the importance of some of the initial design decisions and assumptions that were made. The outcomes from this project provided the following lessons:

- Operating a pilot plant such as Newlands Mashu requires dedicated management. Using students to manage and maintain such as plant is not a sustainable solution as they are present for a relatively short period of time, have specific research aims and are not equipped to deal with the 'bigger picture'. Where further test sites are to be installed and evaluated, it is essential to have a management team consisting of the key stakeholders (in this case EWS and BORDA).
- ABR effluent is more applicable as a source of water for irrigation than as a source of nutrients for crop growth. If used as a water source, the impact will be higher in winter than in summer (due to limited rainfall in winter). If used as a source of nutrients, the volume required would exceed the water requirements of the crop due to limited nutrient value.
- As the effect of using the ABR effluent on crops, soils and the environment will vary from region to region depending on prevailing circumstances, it is recommended that a model be used to simulate water and nutrient balances for different crops under different soil characteristics. This will provide information on the nutrient uptake and the possibility of nutrients leaching into surrounding rivers, and further indicate the sufficiency of the land being used and the ability of the soil to take up all the nutrients, allowing excess water to flow into hydrological systems.
- The effluent from the DEWATS process meets most of the irrigation standards, except for faecal coliforms where further analysis is required.

Cost:	R900 000
Term:	2010 - 2013

Microbial database – a tool for evaluating the BNR processes in KwaZulu-Natal
Durban University of Technology; Umgeni Water
No. 2003

Over a 20-month period, a critical evaluation of two BNR plants, treating domestic wastewater, was carried out with

the aim of establishing a microbial population database that can be used efficiently and easily as a tool for evaluating BNR processes in KwaZulu-Natal. This database was constructed by determining the relationships between plant operating parameters, process performance and the functional microbial populations. Even though the selected plants were initially designed based on the UCT and Johannesburg process configurations, a major deviation from the initial design was noticed. However, the typical and expected biochemical changes for nitrogen and phosphorus removal across the zones (anaerobic, anoxic and aerobic) were observed at both plants (Kingsburgh and Howick WWTWs). Hybridisation with group- and species-specific probes showed the presence of major functional groups such as nitrifiers, denitrifiers, PAOs and GAOs in abundance within these plants. The major operational problems observed were filamentous bulking/foaming and inconsistency in ammonia removal. Temperature, dissolved oxygen and COD: N level showed a significant relationship with the ammonia removal efficiency of the plants. Phosphorus and COD removal efficiencies however were not severely affected by the changes in the prevailing operational conditions. A cumulative logit model was developed during the course of this study to understand the significant relationships of the dominant filamentous bacteria to the prevailing plant operational conditions. Using this model, significant relationships were observed with the dominant filamentous bacteria and the operational conditions such as DO, COD, F/M ratios and NH_3 levels. Based on observations and knowledge gained during this study, the structure for the Microbial Population tool was constructed. This was accomplished using the Microsoft Office Access (2007) software, to create a user-friendly interface that details important plant operating controls in relation to operating conditions and the inherent effect on the microbial populations. The invaluable information and data generated in this project can be used as a basis to expand this research, to include a wider sample size, i.e., a larger number of BNR plants in KZN and nationally. Future research will also focus on the generation of an invaluable real time and interactive microbial population database, accessible online to assist plant operators with troubleshooting. Future research efforts will also determine how representative this database will be for all BNR plants in South Africa. The ultimate intention is to participate in the wider initiative and to lead the way to create a consolidated microbial fingerprint of BNR plants globally, in close consultation with Danish partners. A separate initiative of future research will include the training of plant operators on the application of the database to solve operational problems.

Cost:	R900 000
Term:	2010 - 2013

A gap analysis of technologies, techniques and capacity for the water and wastewater (domestic and industrial) sector in South Africa
University of Cape Town; University of Stellenbosch
No. 2258

Water innovation in South Africa takes place in a complex network of state and non-state actors, and is influenced by a wide range of different institutionary relationships and linkages. The diffusion of knowledge and technology and the translation of sciento-technological advancement into societal and economic benefit is not an uncomplicated or linear process – it is influenced by the cognitive or learning capacity of actors throughout the system, and by

the linkages and relationships that make up the system. A crucial distinction must be drawn between science-and-technology – the domain of research organisations and the focus of traditional R&D policy – and innovation, which includes a far broader array of actors and organisations. One of the outcomes of the study was a policy brief which suggests five opportunities for intervention followed by the inclusion of a modified Innovation Systems Framework applicable to South Africa.

In addition the following recommendations are offered for further discussion and investigation:

- Attract skilled and committed (so called 'right') individuals to career opportunities in the water sector using: (a) attractive marketing tools and programmes; (b) establishing further Centres of Excellence in water studies; and (c) offer attractive bursaries to attract the best school leavers into the water sector.
- Build a well-established STI system by paying particular attention to building linkages (partnership and co-operation), and in achieving desirable impacts.
- Implement successful funding models that offer retainer funds to give researchers a secure source of funding to think about specific and broader challenges faced by the society and local authorities, and the flexibility to develop and engage in multidisciplinary and trans-disciplinary projects.
- Research must increasingly draw on funding sources capable of supporting the various parts of the value chain with the intention of shifting research from the concept phase to commercialization and use value.
- Seed funding and tax incentives should become the norm in incentivising businesses and industries to develop water-related products.

Cost: R450 000
Term: 2012 - 2014

Programme 3: Stormwater and sewerage systems

Investigation into pumps and pressurised flow in separate sewer systems
University of Stellenbosch; BKS (Pty) Ltd; University of Johannesburg
No. 2007

Pumps are essential components in most sewer systems and are often considered by operators and managers to be the most problematic. The project sets out to address a number of pertinent issues with regards to pumps, pump stations, and related elements. This project was motivated by the general lack of published research into sewer pump stations and related problems, combined with the need for such knowledge during the planning, modelling, optimisation, design, operations and maintenance phases of these infrastructure elements. One of the key issues addressed by this research and the subsequent software tool revolves around improved communication between different levels of technical staff involved with sewer pumps, and basic training of operator-level staff.

This project aimed to conduct field research in South Africa, consolidate and organise the information and create a practical tool giving tips on pump station design and operation, as well as facilitating the flow of information between different levels of management. The SEWPUMP Tool developed follows the following broad specification:

- Identification: help to understand and identify problems at sewer pump stations
- Communication: facilitate communication between pump station operators and management
- Training: should transform to a training tool that could be used by individuals for self-study and by managers to facilitate training.

Therefore, the SewPump tool should be seen as a transformer, with three facets or functioning modes for (i) training (ii) operators and (iii) managers.

Cost: R1 000 000
Term: 2010 - 2013

Programme 4: Wastewater sludge and faecal sludge management

Investigation into the long-term risks associated with deep row entrenchment of pit latrine and wastewater treatment sludges for forestry and land rehabilitation purposes
Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); University of KwaZulu-Natal (Howard College); University of Kwazulu-Natal (Westville)
No. 2097

Municipalities in South Africa are used to dealing with wastewater treatment works sludge disposal. Very few, however, have to date tackled the disposal of pit latrine sludge at any scale, with eThekwini being the only notable exception. Wastewater treatment works sludges are generally disposed of in landfills, or are composted. In some cases they are irrigated or surface spread. Landfill and composting are fairly expensive processes, with costs in the order of R500/m^3 being reported. No other method of sludge disposal is more economical than simply burying it in the ground. In the ground, sludge decomposes by natural biological processes and after a few years is barely distinguishable from the surrounding soil. After three years even the hardiest pathogens such as *Ascaris* die off. Despite high loading rates no significant impact on groundwater has been observed in the trials to date over four years of monitoring. When sludge is buried in close proximity to Eucalyptus trees, which form a major part of the South African forestry plantations, growth is enhanced by up to 50% in terms of total timber volume, although it is too soon to say if the magnitude of this difference will be sustained over a full growth cycle.

Cost: R1 000 000
Term: 2011 - 2014

Investigation into pollution from on-site dry sanitation systems
University of KwaZulu-Natal (Pietermaritzburg); Partners in Development; eThekwini Municipality; University of KwaZulu-Natal (Howard College); University of the Free State
No. 2115

Many studies have been conducted on the widespread use of pit latrines. Regrettably, no consistent methodology has been used to monitor or report the extent of nutrient or pathogen movement. Very often, the studies comprise monitoring of local boreholes down-gradient of informal or peri-urban developments. Several case studies report incidences of nutrient and pathogen contamination as a result of on-site sanitation contaminating water resources. Elevated concentrations of nutrients and pathogens have been observed between 20 and 90 m from latrines. Studies also claim that observations from boreholes some 900 m downstream of developments where pit latrines are used have shown increases in pathogen abundance. Only one study warns that the rapid lateral subsurface flow from extreme events may move nutrients and pathogens from pit latrines, but no observations are evident in the literature. Four sites on two geologies were established in this study. A transect of four VIP latrines was monitored on a hillslope and an associated background site was coupled with this transect. Three other sites were established to monitor individual pour-flush latrines. The study found that, in comparison to previous studies, nitrate movement does not appear to be as significant at the KwaZulu-Natal study sites. However, the results are consistent with each other in terms of greatest mobility being during periods of high rainfall. The same can be said for the mobility of *E.coli*. However, at the Slangspruit site, a distinct *E. coli* plume extended to 26 m, whereas the nitrate was only clear up to 3 m. At this site, where the water table was consistently high (i.e. <1 m), it may be suggested that in these circumstances there is a great chance of faecal coliforms contaminating nearby water resources.

Cost: R1 500 000
Term: 2011 - 2014

Programme 5: Sanitation technology and innovations

An investigation into technical sanitation solutions for informal areas
Cape Peninsula University of Technology; City of Cape Town; eThekwini Municipality; Stellenbosch Municipality
No. 2098

Conventional approaches to environmental sanitation are unable to make a dent in existing service delivery backlogs, and are not able to cope with the new challenges arising from informal areas. Several sanitation technologies are being developed using available guidelines and compendiums that are often too general and not specific to informal areas. A number of emerging sanitation technologies provided to informal areas are not often documented or adequately established to ascertain their feasibility. In addition, the developed sanitation technologies are being provided without understanding the main sanitation issues in the context of particular informal areas. This research

was aimed at investigating technical sanitation solutions for informal settlements. The intention of the research was mainly to develop an approach for developing sanitation concepts and solutions that respond to particular conditions of informal settlements. The most important concepts of relevance to informal settlements were found to be those focusing on resource recovery and reuse, low O&M, zero waste generation and economic incentives for both users and service providers. This study has provided an overview of the development of sanitation concepts and solutions for informal areas. It is understood that sanitation technologies are developed to respond to particular sanitation challenges that can be viewed from social, institutional, economic or technical perspectives. From social and technical perspectives, sanitation challenges are related to the profile of the served community and the components of sanitation solutions respectively. These challenges include non-compliance with operational requirements, poverty, density, inadequate design, operation and maintenance.

Cost: R500 000
Term: 2011 - 2014

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

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

This project aimed to develop a continuous process to effect the depolymerisation of the lignocellulosic content of fruit waste using a selected group of enzymes in a bioreactor setup. An additional objective was to add value to the process of breakdown of the lignocellulose components, in the form of various products, bioenergy or biomass. The proposed system aims to address three major problems: (i) the increasing scarcity of clean water in South Africa; (ii) the production of large volumes of agri-industrial wastes; and (iii) the fact that these agri-industrial wastes contain lignocellulosics, which present a particular challenge in their disposal. In this project, fruit waste, called pomace, which has been generated from fruit and juice processing, was targeted for treatment. One of the main objectives of the TILE project was to scale up solid fruit waste hydrolysis to larger volumes using the optimum hydrolysis conditions obtained by running 1 L bioreactors. Initial studies developed a cocktail of commercial enzymes which could be used to realise the aims. The artificial neural network closely predicted the apple pomace hydrolysis in the 20 L and in 1 L optimised reactors. This observation is now further validated by showing that at various substrate loadings, of 5%, 10% and 20%, in the 20-L bioreactor displayed the same profile for glucose and other sugars as in the optimised 1-L bioreactor. The study showed that HMP solids can be efficiently reduced within 24 hours in a 20-L

stirred tank reactor system using a mix of commercial enzyme cocktails (Viscozyme, Celluclast and Novozymes 188). Thus, using the reactor format, enzyme cocktails and conditions previously employed efficiently reduced the bulk solids of two industrial apple pomace substrates (AFP-B and CFP), industrial peach and industrial pear pomace. In addition, it was also confirmed that the TILE system is able to hydrolyse HMP substrate loadings of up to 20% (wet w/v). Overall, this system has been shown to be flexible and robust as it can be used to effectively reduce the bulk solids and release sugars from different pomace substrates, i.e., the TILE system is 'tunable' to various fruit waste types.

Cost: R1 250 000
Term: 2011 - 2014

Programme 2: Integrated management

Adapting water footprints for South Africa and exploring the value of integrating water, carbon and energy (environmental) footprints for the South African industrial sector
Pegasys Strategy and Development (Pty) Ltd; WWF South Africa; University of Cape Town
No. 2099

A water footprint is an indicator of freshwater use that considers the direct and indirect water required to produce a product, measured over the full supply chain. Water footprint studies have been completed for a variety of entities, including countries, products, commodities and river basins. While water footprints have significant potential to contribute to corporate water management and to integrate water into decision-making, significant questions must still be addressed in order for water footprints to be a reliable and meaningful indicator. A range of case studies were conducted to understand the applicability of water footprinting to different sectors using different lenses. Using the WF design process, the water footprinting tool was applied to the following case studies: (i) irrigated carrots from the Ceres area, to represent a local irrigated crop; (ii) imported beans from Kenya, to represent an imported crop; (iii) cheese production in the Western Cape, to represent a livestock-based product with an operational water footprint component; (iv) dishwashing detergent produced in Johannesburg, to represent a consumer good with an operational and a downstream water footprint component; (v) manufactured fruit concentrate, to compare the water footprint associated with the growth and processing of different fruits (vi) extraction of coal from a mine, to represent the extractives industry and explore the grey water footprint; (vii) combustion of coal to represent the power generation industry and (viii) manufacture of products from a chemical facility in the Vaal to highlight the complexities of a large-scale chemical plant. Overall, it can be concluded that water footprinting is indeed a useful tool that companies can use as a first estimation of their water use and impact. The major pitfall is the lack of consensus on the use and reporting of the water footprint studies. In many cases there are no clear regulatory frameworks for disclosure and the reporting of water footprint assessment outcomes, In addition, there is no clarity on the application of water footprint tools; for example, a company that has undertaken an operational water footprint might report this as their sole water

footprint, even though it does not include their supply chains. Due to the disparity in the application of the water foot-print concept, there is a need to agree on an industry wide-approach. Furthermore, the study showed the water foot-print data and knowledge base for industries is not well developed, and more work is required to gain confidence in the tool. Going forward, a standardised guide on the use of the water footprint and its application needs to be developed.

Cost: R2 000 000
Term: 2011 - 2013

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

Valuing water for South African industries: A production function approach
CSIR
No. 2103

This study applied and tested the marginal productivity approach to estimate the marginal value of water to industrial users in South Africa, as well as the associated price elasticity of demand, based on a sample of 58 companies. The results indicate that the method is vulnerable to statistical issues such as multicollinearity, particularly in the presence of a relatively small sample size, which leads to unexpected results regarding the marginal value of water use. On the other hand, the estimated price elasticities of demand (in the range of –0.66 to –0.78) are in line with theoretical expectations and comparable to estimates for the industrial sector in other countries, and for other sectors in South Africa, and are fairly robust in response to changes in the specification of the model. The estimated elasticities suggest that, as expected, an increase in water prices would lead to a reduction in water use, all else being equal; although the percentage reduction in water use is comparatively lower than the percentage increase in price. This provides some evidence to suggest that an increase in water tariffs would lead to a reduction in water use among industrial users, although this reduction in water use would be outweighed by the increase in tariffs, such that total expenditure on water by industrial users (or total revenues received by the water services provider) would increase. However, water pricing is a sensitive issue, affecting various stakeholders. As such, policy recommendations cannot be made on the basis of this analysis alone; particularly given the limitations of the method (e.g. the possibility of multicollinearity), and of this study in particular (e.g. the relatively small sample size). Further research is therefore warranted. In particular, future research should be aimed at improving the method (e.g. by making adjustments to overcome the statistical issues, or making use of a larger sample size), or at identifying alternative methods. Furthermore, in addition to this purely micro-economic analysis, stakeholder consultation is essential, while the wider socio-economic and macroeconomic impacts of an increase in water prices need to be assessed.

Cost: R780 000
Term: 2011 - 2013

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 3: Minimising waste production

Investigation of carbon flux and sulphide oxidation kinetics during passive biotreatment of mine water
University of Cape Town
No. 2139

While acid waters emanating from groundwater rebound through the Witwatersrand gold basins has received the majority of the media attention and elicited the strongest response from the authorities, acid rock drainage (ARD) from diffuse sources, primarily associated with coal mining, is likely to impact a far larger area. The traditional chemical and physical interventions are not particularly well suited to these discharges. Research into passive and semi-passive systems has met with varying degrees of success. Typically, the processes that target sulphate salinity make use of biological sulphate reduction, often utilising complex organic carbon sources to provide the electron donor. The sulphide product is highly toxic and presents a significant risk to the environment and human health and needs to be carefully managed. The most attractive option is the partial oxidation of sulphide to elemental sulphur, which is stable and has commercial value. The primary aim of the research was to characterise the carbon flux through an integrated sulphate reduction/sulphide oxidation process and determine its effect on the recovery of sulphur in the floating sulphur biofilm. The second aim was to investigate oxygen mass transfer to the biofilm and use this information to inform optimal management of the system. Two packed bed columns were used to investigate the sulphate reduction efficiency and carbon flux. A series of linear flow channel reactors (LFCRs) was used to investigate the effect or residence time and acetate supplementation on sulphide oxidation rate and elemental sulphur yield. The oxygen mass transfer into the biofilm was investigated in a scaled-down reactor, using a dissolved oxygen microprobe. The composition and internal structure of the floating sulphur biofilm was analysed using scanning electron microscopy and elemental analysis. The structure of the biofilm informed the interpretation of the data. The data allowed the specific aims to be addressed and provided significant insights into the performance of the integrated system. The experiments showed that efficient sulphide oxidation was possible within the floating sulphur biofilm in the LFCR, provided the feed was supplemented with organic carbon. A hydraulic residence time of between 1 and 2 days was optimal. In order to sustain optimal performance the biofilm would need to be harvested every 2 to 3 residence times. Under these conditions sulphide oxidation rates of up to 5.5 mmol/L per day could be achieved, with at least 75% of the oxidised sulphide reporting to the biofilm as elemental sulphur. Conservatively, this represents a sulphur recovery of 13.5 g/m^2 per day, for the current reactor configuration. The experiments illustrated that organic carbon liberation from packed bed reactors is unlikely to be sufficient to sustain efficient levels of sulphate reduction beyond the short term, once the readily labile organic carbon has been liberated. Supplementation with relatively significant (1 g/L) concentrations of readily usable organic carbon, such as acetate, was needed to sustain sulphate reduction. While the majority of the sulphate reduction ($\pm$ 75%) was reliant on the acetate, continued hydrolysis of the lignocellulose was observed. Despite this, the VFA concentration in the effluent from the packed bed reactors was negligible after

the first four months. Therefore, further organic carbon supplementation (> 100 mg/L acetate) of the feed to the LFCR was necessary for biofilm development and efficient sulphide oxidation. Under optimal conditions the biofilm formed within 12 hours, following which the oxygen mass transfer into the liquid was significantly reduced. The reduced mass transfer prevented complete sulphide oxidation, so the majority of the sulphide was oxidised to sulphur within the biofilm.

Cost: R279 450
Term: 2012 - 2014

Programme 5: Low-volume mined products

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

This project set out to investigate the application of emulsion liquid membranes (ELMs) in recovering platinum group metals (PGMs) from the aqueous by-products of PGM refining. The by-products are generated as sidestreams which require storage and reprocessing. Of the PGMs, rhodium (Rh) is one of the more inert and therefore difficult to extract. Membranes have historically been viewed as semipermeable barriers between two adjacent phases. From the operational point of view, membranes are easy to bring to industrial scale for the following reasons: the underlying scientific concepts are relatively simple, their operation and scale-up is uncomplicated to achieve, and they are environmentally-friendly and low-cost in terms of energy. Membranes can consist of polymer films and liquids. If the membrane system is based on a liquid matrix, then it is called a liquid membrane. Liquid membrane systems involve contact of an immiscible organic liquid (named the diluent) with a feed phase (i.e. the wastewater or effluent of interest). The application of emulsion liquid membranes (ELMs) reduces energy and financial costs and the time for the metal solvent extraction. This is caused by the faster kinetics of extraction with ELMs and higher extraction yields in comparison with the classical solvent extraction. An ELM was prepared by using 28-30% solution of toluene in kerosene. This diluent phase was then mixed with a stripping phase. Extraction of Rh from aqueous matrices was tested and the results showed that the complete extraction of Rh was possible. This was achieved by the use of an optimised ELM. Carryover of the diluent components into the stripping phase and effluent was observed and further work is recommended to overcome this drawback

Cost: R337 450
Term: 2010 - 2013

THRUST 6: WATERSMART FUND

Development and testing of a water treatment bottle for use during emergency diarrhoeal outbreak conditions
University of Johannesburg
No. 2194

Although there are various commercial water treatment options available for the treatment of water under severe circumstances, most of these are dependent on a consumable(s) and equipment that needs to be delivered to the people. When the consumables run out the water treatment also comes to a standstill leaving the people without treated potable water. The ideal would be to provide a water treatment device that can be used with commercially available options, home-based chemicals or, in extreme situations, things that can be found in the environment. In an attempt to come up with a design that could provide an option to deal with all these situations, members of the Water and Health Research Centre designed a water bottle that can be used for the treatment of smaller volumes of water (< 1 L). The novelty of the water bottle lies in the fact that the design allows for various applications and adaptations without any structural changes needed. This literally means that the user can adapt the use to suit what he or she has available at that stage. The design now gives the user the freedom to transport treated drinking water while having the facility available to treat more water. It can be used by people living in areas without treated potable water, hikers or in emergency situations where treated water might not be available. The combined aim of this study was to produce the water bottle using injection moulding and to test the effectiveness of the water bottle using a variety of commercially available treatment options, household-derived treatment options and worst-case-scenario water treatment options. A prototype of the design has been produced and the preliminary testing was concluded. It was found that the technology is not effectively treating water for a variety of reasons. Further development and testing is required to ensure the robustness of the technology.

Cost:	R432 000
Term:	2012 - 2014

New housing unit designed for ceramic water filters to be more applicable in rural and peri-urban communities in South Africa
University of Venda; University of Johannesburg
No. 2195

The lack of access to safe, reliable water sources remains a problem for many people in developing countries. The Potters-for-Peace ceramic water filter (PFPCWF) has been successfully distributed as a point-of-use water treatment device in various countries around the world, and is intended to convert unsafe environmental water into potable water. A previous WRC study carried out in the Limpopo Province showed that the Potters-for-Peace ceramic filter (sourced from Ghana) is a viable option for use in South African conditions. Part of the study looked at how

rural communities accepted these filters and what possible changes could be made to increase the efficiency of the filters. It was found that if certain design aspects could be addressed, the water filter would be better accepted. The housing unit was successfully designed and developed and a total of 90 housing units were produced by rotor-moulding. These were assessed for user-friendliness and acceptability in a peri-urban and a rural community using the silver-impregnated ceramic POTPAC pot filter. In the assessment of user-friendliness and overall acceptance of the new housing unit by the peri-urban and rural households, the feedback showed an overall satisfaction with the new design, especially with the stability of the unit, the taste of the filtered water, the easy cleaning process, and the fact that the design provides enough water for a family.

Cost:	R500 000
Term:	2012 - 2014

Filter for the removal of suspended solids naturally found in harvested water
Durban University of Technology; independent consultant
No. 2197

In recent times, with the debatable exception of Australia, authorities worldwide have not been inclined to fully approve private rainwater harvesting (RWH) as an alternative to piped municipal water, due to the skills shortage, and reliance on the self-discipline required for adequate maintenance and water quality. What is evident is that very little research on RWH has sought alternatives to the conventional first-flush methods, relying instead on using either diverter or secondary settlement tanks or, in the case of industrial applications, pressure or sand filtration. The aim of this investigation was to evaluate the efficiency of the novel filter in the removal of suspended solids from harvested rainwater. A total of five test sites were selected for observation of the Zeo Xen-Filter Diverter performance within a RWH system. This selection was based on specific criteria such as accessibility, vegetation cover around buildings, average annual rainfall, geographic location, environment and positioning relative to the prevailing wind and sunlight. From microbiological analyses based at the field testing sites, it was evident that the ZX-FD-filtered water contained health-concerning levels of faecal contaminants at concentrations above those stipulated in the SANS 241 drinking water specifications. Thus, whilst the filter is able to remove suspended solids that may harbour pathogenic bacteria, the filter is incapable of removing 'free living' bacteria; therefore further tertiary disinfection of the harvested water is required for potable supplies.

Cost:	R426 400
Term:	2012 - 2013

Developing a low-flush latrine for application in public schools
Partners in Development; eThekwini Municipality; University of KwaZulu-Natal (Howard College)
No. 2198

The objective of this study was to design a robust low-flush system to contribute to the development of a range of on-site sanitation options which take into consideration all aspects of the life cycle of a system, including user behaviour, pit emptying and beneficial disposal of sludge. Building on research that began in 2010, which then led to the development of a pour-flush pedestal toilet and the testing of 20 units in households using 1 to 2 L, it was shown that the pour-flush systems performed well over their first two years of use. Based on this success, in May 2011 eThekwini Metro Municipality approached the research team to consider developing a low-flush latrine which could be used in public schools. eThekwini is increasingly taking over responsibility for sanitation in the rural public schools within the Metro, which number over 400. Some of the schools have VIP toilets, sometimes with a shared pit which has proven exceptionally difficult to empty. Others have full waterborne systems which result in a high level of water usage by the school. A low-flush system could provide the convenience of a flush system with minimal consumption of water. The study thus produced a 2-L mechanical flusher to be attached to the pour-flush pedestal. After the development of a prototype, the technology was piloted in two homes and two schools. The system has been found to be working very well over the testing period and there has been general acceptance of the system.

Cost:	R250 000
Term:	2012 - 2013

CURRENT 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) in the South African municipal environment
Cape Peninsula University of Technology
No. 2088

Community Led Total Sanitation (CLTS) focuses on behaviour change rather than toilet construction. CLTS mobilises a cooperative approach based on people deciding together how to create a hygienic environment that benefits everyone. Total sanitation ensures that everyone uses a hygienic toilet and safely disposes of their domestic waste,

creating a safe and clean environment. The CLTS approach encourages responsibility by the community, taking its own action. Cooperation among households is a key element, as is spontaneous emergence from within communities of 'natural leaders' (NLs) as facilitators. The objective of this study is to adapt and test the concepts of CLTS in the South African environment and context.

Expected cost: R2 500 000
Expected term: 2011 - 2014

Constraints on providing sewerage in South African informal settlements: A study of social and institutional management concerns
University of Cape Town
No. 2120

Full-flush toilets are generally preferred by residents and deemed by the National Government as being the most appropriate technology for dense urban settlements. Yet standard conventional (gravity) systems are costly to implement and sometimes impractical in flat terrains where residents, fearing increased marginalisation, have resisted relocation. Further challenges arise because informal settlements are often regarded by planners as temporary, with the result that sanitation services installed are not always of high quality. Municipal officials countrywide report a pattern of shared (communal) facilities in densely-populated informal areas deteriorating rapidly, allegedly a result of mismanagement and apparently senseless destruction. All of these situations are likely a consequence of residents' desire, and increasingly their demand, for security of tenure and a national policy for service delivery that is supply-side driven. While present policy is indeed supply-side driven, it makes no provision for sanitation management costs despite this being an expectation of residents who claim a right to free operation and maintenance of communal sanitation services (O&M). This study intends to analyse the social and municipal concerns with, and attempts to address, current sanitation planning and management processes. Many municipal officials question how to achieve this economically and rapidly, and on a large enough scale that it results in services which residents are satisfied with and will develop a sense of propriety over and therefore protect. The research hopes to assist municipal officials, and, by extension, residents, by first detailing the criteria whereby and reasons that officials and residents consider some sanitation projects 'successes' and others 'failures'.

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

Social protest and water service delivery in South Africa
University of the Western Cape
No. 2133

From a planning perspective, lack of simple correlations in the occurrence of water services related protests raises an

important methodological question about whether or not such unrest can be predicted and/or pre-empted. Although useful quantitative and qualitative insights on social protests are provided by Municipal IQ and by the Dialogue Unit of the Institute for Democracy in South Africa (IDASA), a major problem is that much of the evidence on social protests is based on media reports and anecdotal evidence, with a limited range of in-depth scientific analyses. Post-apartheid reforms have not only partially resolved these inequalities, but have also spawned unprecedented social challenges associated with societies in transition. For example, formal institutional responses to the mushrooming of urban informal settlements have often failed to keep pace with urban social change and many such settlements remain with insecure access to water. Similarly, formal institutional responses in rural areas have often fallen short of meeting newer social consumption patterns, livelihood aspirations and expectations for service delivery. A key question for further research is why water-related protests have largely been confined to urban areas, irrespective of socio-economic status. The study will provide for an in-depth scientific understanding of this development and a broadened focus to include both the lived realities of historically disadvantaged individuals (HDIs) in informal rural and urban economies as well as those of other socio-economic groups within South Africa.

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

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

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

Proper operation and maintenance procedures are key to ensuring that the investments in new infrastructure provide a continuous and sustainable high level of service. Components of water distribution systems do not last forever, and need to be operated within their design parameters and inspected, repaired and replaced at appropriate times to ensure that the integrity of the infrastructure is maintained. Lack of proper operation and maintenance invariably leads to faster degradation of the infrastructure, with an associated decrease in service levels of both quantity and quality of water supplied. If this process is not checked, it eventually leads to complete breakdown of the system integrity, which requires the infrastructure to be replaced at huge cost. This project will provide clear and practical guidance on the operation and maintenance of water distribution systems. The focus of the project will be on applying current knowledge on water distribution management to South African conditions, and to make this information accessible to South African engineers and managers.

Estimated cost: R757 000
Expected term: 2012 - 2014

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

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

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

Estimated cost:	R1 050 000
Expected term:	2010 - 2014

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

Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream

of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see highly variable flow rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material are selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

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

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

Polysulphone (PSF) membranes are the most common membranes used in ultrafiltration of wastewater due to their mechanical robustness and structural- and chemical stability. Unfortunately PSF is a hydrophobic material, making its surface prone to fouling due to adsorptive mechanisms. Fouling can either be caused by cake formation on the surface of the membrane, or by adsorption of the foulants both on the surface and in the membrane pores. Cake fouling is generally reversible and can be removed by backwashing or water flushing. Foulant adsorption however is irreversible and can only be remedied by very harsh chemical cleaning. Many studies have been conducted to increase the hydrophilic properties of the polysulphone membrane surface. These studies can be divided into three categories: 1) blending PSF with hydrophilic nanoparticles such as SiO_2, ZrO_2 and TiO_2; 2) grafting with hydrophilic polymers, monomers or functional groups; and 3) coating with hydrophilic polymers. Despite these efforts to minimise fouling of PSF membranes during wastewater treatment, there are still many unanswered questions regarding the mechanisms involved. This study will attempt to develop a novel PSF nanocomposite membrane with minimised foulingproperties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 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

Characterization of indigenous anaerobic ammonium oxidizing (anammox) bacteria grown in microaerobic environments
University of Pretoria
No. 2117

The project builds on the lessons learned in an earlier WRC-funded project conducted By Stellenbosch University entitled 'Fishing for indigenous anammox bacteria'. The main goal of the study was to find out if anammox bacteria exist in some South African anaerobic environments. The study has shown some impressive results with regards to the existence of these bacteria from various habitats. However, the researchers had difficulty in obtaining sufficient biomass to sustain the anammox process using the gas-lift reactors. In addition, the study also showed that oxygen is very inhibitory to the growth of anammox. Furthermore the constant feeding and mixing of the reactor contents resulted in biomass washout thereby hampering the progress of the enrichment process. Based on the abovementioned findings, the principal objective of this proposed study will be to develop an anammox enrichment system that will be designed to endure microaerobic conditions

Estimated cost: R460 400
Expected term: 2012 - 2014

Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems
CSIR
No. 2122

In contributing towards our collective understanding on the fate, behaviour and transportation of engineered nanomaterials, ENMs, in WWTP processes. This study will be to establish possible mechanisms of ENM accumulation and/or degradation in wastewater sludge, as well as the potential effects of ENMs on the microbial population which could be useful in current wastewater treatment processes. To understand the fate, behaviour and transportation of ENMs in the environment, the following processes, viz: aggregation, adsorption, complexation, entrapment,

degradation, reactivity, mobility or degree of stability, given the size of ENMs which is within the colloidal region, will be carefully investigated. The derived knowledge will provide sound evidence to allow for the search for technologies that can remove ENMs from wastewater efficiently.

Estimated cost: R680 000
Expected term: 2012 - 2014

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
University of Stellenbosch
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

Programme 2: Application of appropriate technologies and tools

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

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

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

Self-regulation of the package plants/small wastewater treatment industry: Development of a framework of standards, a conceptual model for a test facility and an accreditation system for each technology provided by suppliers
Royal Haskoning DHV
No. 2193

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. Most of the suppliers are not process experts but rather entrepreneurs who have funded the development of their product using limited resources. Furthermore, SWWTW's are often purchased on the basis of purchase cost which means that at present product costs have to be minimized. This is achieved by omitting any form of redundancy in the plant such as aerators and pumps, overloading media, and using optimistic upflow rates in settlers. Lack of regulation of the SWWTW sector has led to a number of problems in terms of performance, durability and reliability. This project aims to use the experience gained locally, together with international standards and practices to develop:

- A framework of appropriate standards for the SWWTW industry
- Implementation of the standards in a simple manner without duplication
- A conceptual model with key criteria for an independent testing facility for the different technologies
- An accreditation system for the various technologies which will encompass technical and managerial aspects. This would be based along the lines of the Green Drop system, but taking into consideration the fragmented roles of the sector stakeholders. The study will also evaluate who should manage and audit the accreditation process, the cost of the process and who bears the cost.

Estimated cost: R800 000
Expected term: 2012 - 2014

Programme 4: Wastewater sludge and faecal sludge management

Quantifying the fertilizer value of wastewater sludges for agriculture
University of Pretoria
No. 2131

This study follows on from a previous WRC project (K5/1724/3) on the sustainable agricultural use of sludge. The previous project included a local field-scale study, conducted across a range of cropping systems using anaerobically-

digested air-dried sludge and incubation trials for model N and P parameterization. This study highlighted that sludge application rates that attempt to match nutrient supply to crop demand depend on cropping intensity, availability of water, management practices, and sludge N and P content. In order to accommodate such complex interactions between sludges, soils, climate, and cropping systems, a mechanistic nutrient (N and P) balance cropping-systems model (SWBSci) was developed for use as a reasoning support tool to guide decision makers with the responsible use of municipal sludges in agriculture. The model was calibrated and validated under various cropping systems, proving its potential as such a reasoning support tool. This model is a fairly complex scientific research tool, and requires detailed weather, soil, crop, and sludge parameters in order to be deployed. Interest in using the model to assist with the development of sludge management strategies for different wastewater care works has been expressed on several occasions by industry partners. However, in its current form, routine use of this reasoning support tool by industry part-ners or extension officers is highly unlikely, as parameterization is not completely trivial, and there is a definite need to simplify the procedure to follow in running simulations. In order to render this tool more usable, the model needs to be populated with soils, crops, and long-term weather data parameters around the perimeter of wastewater care works, as well as sludge parameters. Sludge parameterization for the various N and P pools relies on a long-term incubation trial which is tedious, time consuming and impractical in real life. Therefore, practical and affordable methods are required to identify the various N and P pools for model parameterization. It is also vital to add a simple heavy metal module into the model to estimate the accumulation of heavy metals in the soil profile across time. The long-term trial could be continued for another three years to validate and calibrate the heavy metal model. This is because beneficial agricultural use of sludge is prohibited if the concentration of heavy metals in the soil profile exceeds a certain threshold value. The model can then be run for various scenarios for several local cropping systems to generate a database of options.

Estimated cost: R2 100 000
Expected term: 2012 - 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

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
No. 2134

There is strong growing evidence that the methods used to empty the pits of on-site sanitation systems result in transmission of disease from sludge to workers or householders. This undermines the impact of basic sanitation and health objectives of breaking the cycle of faecal-oral disease transmission. This study aims to investigate the risks of transmission of pathogens to workers or householders through current emptying methods and to develop guidelines for institutional support to minimise these risks.

Estimated cost: R1 200 000
Expected term: 2012 - 2015

Pour-flush and Portapotty sanitation systems
University of KwaZulu-Natal (Durban)
No. 2137

The nature of the waste material from a pour-flush system is different to that of a pit latrine (in that it has a higher moisture content and contains all the urine) and that of a septic tank (in that it is much more concentrated and does not contain any grey-water).It is believed that moisture content and ammonia concentration affect the rate of biological degradation of any waste stream, but these effects have not been clearly established for pit toilet, pour-flush toilet and septic tank contents. This study will investigate the nature of the feed (specific loading and composition), the extent and kinetics of biodegradation, which need to be determined in order that a rational design procedure can be proposed.

Estimated cost: R1 281 500
Expected term: 2012 - 2015

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

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 hypersaline effluents
University of the Western Cape
No. 2100

Brines are a major waste by-product from industrial activities. This study aims to understand and provide solutions for the efficient minimisation of industrial brines. The study will evaluate evaporation rates and design and assemble climate-controlled enclosures for the study of evaporation processes of brines. The data will result in the development of protocols for the measurement of evaporation rates from brines which will lead to the development of empirical models for determining evaporation processes of industrial brines under controlled laboratory conditions and the development of theoretical models for determining evaporation rates of brines. Finally, it is envisaged that this understanding will result in the development of novel textured surfaces and absorbents for enhanced evaporation of industrial brines.

Estimated cost:	R1 500 000
Expected term:	2011 - 2014

Evaluation of forward osmosis technology for the treatment of concentrated brines
University of KwaZulu-Natal (Durban)
No. 2101

Forward osmosis is a new technology for industry in South Africa and this scoping project is to assess the applicability for further application of concentrated inorganic brines. The study will aim to evaluate whether forward osmosis can be used as a lower energy consuming technology compared to reverse osmosis. It will evaluate the advantages, limitations and feasibility of using forward osmosis technology to concentrate various high ionic strength wastewaters and to assess the fouling characteristics of forward osmosis on various high ionic strength industrial streams which are known to be badly fouling.

Estimated cost:	R354 000
Expected term:	2011 – 2014

Application of mineral carbonation processes for brine remediation
University of the Western Cape
No. 2128

Currently the typical method of brine disposal is the use of evaporation ponds, which is aimed at reducing the volume of the brine and providing a manageable solid product. Unfortunately, this approach does not stabilize the brine and the cost of long-term storage is still very expensive. Fly ash is another waste material that is being produced in huge amounts by coal-fired power plants. Eskom for instance produces 36.7 Mt of fly ash per annum. The majority of this ash is disposed of in ash dumps while only 5% is applied in the making of building and construction materials. This fly ash presents a major resource that can be utilized in the carbonation of brine, thereby leading to the formation of carbonates which are benign and can be applied as mine backfill. This project proposes to utilize fly ash through mineral carbonation to remediate the effluent brine, which would lead to potable water that can be reused in the power generation process as well as domestic and agricultural purposes. Moreover, this will also lead to reduction of the carbon emissions from power plants.

Estimated cost:	R1 362 750
Expected term:	2012 - 2015

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

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

Adapting constructed wetlands for real-world applications
Cape Peninsula University of Technology
No. 2104

This project builds on previous research and will use the new fingerprinting techniques that have been developed and customised to define the parameters which will allow the effective use of constructed wetlands to treat wastewaters using natural processes. It will also investigate the reproducibility of constructed wetlands adapted for specific waste-containing waters in varied environments by characterising the microbial communities in these environments, and to understand the extent to which microbial communities in constructed wetlands can accommodate changes in waste impacts and the rates at which they can adapt. Finally it will develop a matrix of

parameters and thus guidelines to use to adapt wetlands.

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

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

This project aims to test, at a laboratory scale, the use of zeolite as a support material to improve biogas production and anaerobic reactor stability. In addition, the study will concentrate on synthetic industrial effluents and use a photocatalyst (titanium dioxide) to break down these complex chemicals to simpler ones and evaluate the anaerobic reactor efficiency. Knowledge from these tests can be used in future to improve anaerobic digestion efficiencies by allowing microorganisms to come into contact with simpler compounds and prevent washout of the sensitive methanogenic bacteria.

Estimated cost:	R500 000
Expected term:	2011 - 2013

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Toxicity evaluation of metals and metal oxides nanoparticles to aquatic invertebrates and algal species
CSIR
No. 2107

Since the beginning of the 1990s, nanotechnology has matured from a laboratory-based research and development phase into full commercialisation of nanoproducts. For example, there are numerous novel consumer products and industrial applications of nanotechnology including: nanoelectronics, molecular assemblies, tissue engineering, biomedicine, nanocomposites, cosmetics, paints, pesticides and water purification modules. Among the nanomaterials, used in the nanoproducts reported above, with high potential of release in large quantities into aquatic environments are metals and metal oxides. In view of the rapidly increasing quantities of nanomaterials released into different environmental compartments – especially water and sediments – it is imperative that the potential risks that may be associated with nanomaterials attract attention, to ensure long-term safe, responsible, and sustainable

development of this novel technology for optimal benefit of society. Due to the limited data, on potential risks of nanomaterials to aquatic organisms, which could support practical risk assessment and risk management after entry into the environment, this project will investigate the effects of nanomaterials on organisms at different trophic levels. Secondly, the mechanism by which nanomaterials cause toxic effects to the receptor organisms will be explored through use of DNA, reactive oxygen species (ROS) generation techniques.

Estimated cost:	R495 000
Expected term:	2011 - 2014

Programme 2: Regulatory, management and institutional arrangements

Development of risk criteria for water management aspects of mine closure
Golder Associates Africa
No. 2127

The DWA recently produced a series of Best Practice Guidelines that give specific guidance on procedures to be adopted in the development of mine closure plans (BPG G5) and in the prediction of future impacts that are associated with mine closure (BPG G4). While the BPGs provide clear methodologies for undertaking the assessments required to support a mine closure application, they do not provide any practical guidance on how issues such as: agreement on the acceptable levels of confidence for the prediction that will limit the State's liability to acceptable levels; statistical representivity of the datasets used in the prediction and their suitability for addressing the issues that pertain to the particular closure application; the definition and descriptions of uncertainty inherent in the predictions and acceptance that the defined uncertainty meets the requirements of the regulator; and the suitability and adequacy of financial provisions to cater for uncertainties and risks for post-closure water management and treatment. This project will address the above issues through review of international best practice on these topics and engagement with all stakeholders (DWA, DEA, DMR, mining industry and consultants) in order to provide guidance on how to address these issues when considering impact predictions and mine closure applications.

Estimated cost:	R535 000
Expected term:	2012 - 2014

Programme 3: Minimising waste production

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation
University of Cape Town
No. 2108

The main aim of this research is to further the understanding of the precipitation of metal sulphides in the treatment of acid mine drainage via sulphate reduction and metal precipitation. The project will characterise the effect of operating conditions on the physical characteristics of the formed metal sulphide precipitate by investigating the effect of metal to sulphide ratio on precipitation behaviour, the effect of the operating pH on the precipitation process and using a technique based on moment transformations of the number density function n(L) to make inferences about the mechanisms involved in the particle formation processes. The project will also investigate the factors affecting the solid-liquid separation characteristics of the formed particles. The effects of the processing conditions on solid-liquid separation characteristics of the formed precipitates will be quantified using particle size distribution measurements, settling characteristics and zeta potential measurements for surface charge determination. These studies will be carried out on a number of model metal systems. Finally, the project will investigate factors that potentially influence the solid-liquid separation characteristics of the formed particles. As a result of the investigations carried out, it should be possible to identify a number of factors, possibly different additives, which would influence the separation characteristics of the formed precipitates. Thus the effect of these ions (as well as other additives) on the coagulation and aggregation phenomenon will be quantified by measuring their effect on particle size distribution, surface charge and settling characteristics of the precipitate.

Estimated cost:	R884 820
Expected term:	2011 - 2014

Development of a toolkit to enable quantitative microbial ecology studies of sulphate-reducing and sulphide-oxidising systems
University of Cape Town
No. 2109

The catastrophic effects of untreated mine-water discharges are well known and several high profile events have been documented. Mine-water has traditionally been treated using oxidation-neutralisation-precipitation which effectively removes metal, but the treated stream still contains sulphate. Biological treatment systems, based on the activity of sulphate-reducing bacteria have received considerable attention. Their widespread application has been constrained by the provision of a carbon source/electron donor and the management of the sulphide-containing effluent. Both these issues are addressed in the Integrated Passive Treatment System (IMPI) technology which makes use of a mixture of complex, lignocellulosic carbon sources and incorporates a sulphide oxidation step. Both the sulphide oxidation and sulphate reduction processes are catalysed by a consortium of different microorganisms. Different components of the consortium have different tolerances to sulphate, sulphide and heavy metals. As a consequence, changes in feedstock can lead to major changes in the microbial community. This may have catastrophic effects on system performance. Until recently these changes were poorly understood and system management was based on empirical rules of thumb. The advent of molecular biology techniques has facilitated qualitative microbial ecology studies. While these have been useful in confirming the presence or absence of species or groups of species they provide limited information on dynamic changes in population structure, which could be extremely useful

in predicting the response of a system to specific perturbations. This project will develop a molecular toolkit for performing quantitative microbial ecology work in sulphate-reducing and sulphide-oxidising systems. The toolkit will initially be used to characterise the microbial populations in the IMPI demonstration plant at Middleburg Mine. This technology has the potential to treat mine-water effectively and economically over a sustained period of time.

Estimated cost:	R487 500
Expected term:	2011 - 2013

Addressing the challenges facing biological sulphate reduction as a strategy for AMD treatment through analysis of the reactor stage: raw materials, products and process kinetics
University of Cape Town
No. 2110

Mine-waters generated during active mining or resulting from groundwater rebound at abandoned sites have major environmental and economic implications. Active chemical treatment of the waters is the most widely employed technology. Recently there has been increasing interest in active and passive biological treatment processes. These systems rely on naturally-occurring biological and geochemical processes to improve water quality with minimal operational and maintenance requirements. Biological sulphate reduction is a well understood and efficient process that has been frequently demonstrated at laboratory and pilot scale. However, its full-scale implementation has been limited. The challenges facing sulphate reduction systems have been identified as: provision of a cost-effective carbon source; enhancing reaction kinetics when complex carbon sources are used; and management of the resulting sulphide. This study will undertake a critical review of existing technologies, from a technological and economic perspective. Furthermore the feasibility of using microalgal biomass as a carbon source/electron donor will be investigated. The study will also evaluate the requirements for algal cultivation at the scale required to sustain the SRB process. To address the issue of enhanced reaction kinetics the effect of decoupling the hydrolysis and acidogenesis reactions from the sulphate reduction will be investigated. The study will include a review of available technologies and investigate the application of cross-flow microfiltration membranes to recover and recycle biomass to both the hydrolysis/acidogensis and sulphate reduction reactors.

Estimated cost:	R1 050 000
Expected term:	2011 - 2014

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

A detailed acid-base accounting study of the Karoo formations in the Waterberg coalfield
University of the Free State (Institute for Groundwater Studies)
No. 2142

Coal mining has a pronounced impact on surface and groundwater quality and quantity. Local experience indicates that the influx of water may be as low as 1% of rainfall for deep bord and pillar mines with no subsidence, to as much as 20% for some opencast mines. Such differences have significant impacts on the quantity and quality of surface and groundwater resources in a local area and further afield. The Waterberg is the only remaining large area with proven coal reserves in South Africa and they are being targeted for large-scale mining in the foreseeable future. Most of this will be opencast mining, resulting in large volumes of spoils and also discards (due to the fact that a number of coal seams will be mined with approximately 50 m of interburden between the coal layers) being handled on surface. This project will provide detailed in-depth acid-base potential studies in the area in order to determine how spoils should be handled in future by the mining companies, due to the complexity and volume of the spoils and discards. If handled correctly, acid generation can be minimized. This study will consolidate the existing information, and obtain new information regarding the possibility of acid generation of the overburden, interburden and discards.

Estimated cost: R1 775 000
Expected term: 2012 - 2014

NEW PROJECTS

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

Development of a framework for sanitation governance in South Africa
Hlathi Development Services
No. 2206

South Africa is fast becoming the world's capital of service delivery protests. Municipal IQ, a local government data and intelligence service institution, recorded 372 service delivery protests between January 2012 and the end of May 2012. Poor sanitation service delivery featured strongly in most of these service delivery protests. Several studies have identified poor governance as the underlying cause of poor basic service delivery. A report on the civil society perspective of local governance in South Africa recommended that the problem of poor governance should be addressed by a combination of institutional, political and community-focused interventions. A COGTA report

of 2009 identified weak national regulations and provincial oversight of service delivery as a problem. The Local Government Turnaround Strategy which was launched in 2009 has so far not made any visible improvements in the performance of local government as shown by the increase in the number of service delivery protests. The 2012 SA Medium Term Review of the priorities of Government identified poor governance of municipal service delivery as a major concern. The participatory local governance envisaged in the Constitution of SA and local government legislation was non-existent; communities were disconnected from decision making processes. They have been disempowered and turned into passive spectators of their development which is driven by external consultants. Good sanitation governance depends on effective engagement between government, institutions and stakeholders, transparency and accountability within the rules of engagement. The main goal of the proposed study is to develop a framework for effective sanitation governance in South Africa. It will provide government with a tool for facilitating the implementation of good sanitation governance in all spheres of government while also ensuring accountability to citizens through the building of appropriate stakeholder platforms for facilitation of partnerships for sustainable sanitation service delivery that involve municipal councils, communities and civil society organizations. The study will investigate sanitation governance at national, provincial and local government levels. An in-depth analysis of selected case study municipalities that demonstrate elements of good governance will be conducted to document good practice which will inform the development of a framework for sanitation governance in South Africa.

Estimated cost:	R700 000
Expected term:	2013 - 2015

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 Affairs
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 3: Drinking water quality

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

A national water R&D and innovation roadmap for South Africa
Mutualfruit Limited
No. 2305

Project aims:

- Identify the completeness of the inputs required for Roadmap development
- Baseline South Africa's Water RDI landscape
- Select a set of attractive and addressable market opportunities.
- Establish HCD requirements
- Define scope and principles for implementation framework
- Define RDI response (policy, financial, institutional) for attractive and addressable market opportunities
- Shape outline for HCD programme
- Design an implementation mechanism to ensure successful delivery of the plans

Estimated cost: R1 898 300
Expected term: 2013 - 2014

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

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

Development of web-enabled (and supportive spreadsheet-based) wastewater risk abatement planning tools
Emanti Management
No. 2217

With the release of DWA Green Drop Certification 2012 requirements, it is clear that DWA is moving towards a risk-assessment based regulatory approach, and that the Wastewater Risk Abatement Plan (commonly referred to as W2RAP, and very similar to the water safety planning approach used for drinking-water quality risk assessments) is the primary tool with which it will assess and monitor the performance of wastewater services at Water Services Authorities (WSAs). The W2RAP process assists WSAs by (i) evaluating and documenting wastewater processes and (ii) prioritising wastewater services risks and therefore providing targeted support to address gaps and weaknesses. The project aims to use the principles and approach outlined in the WRC-developed W2RAP guideline document 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)
- Wastewater Risk Abatement Planning Status Checklist Tool (web-based and supportive spreadsheet-based tools, and allows the user to determine status of W2RAP processes)

Estimated cost: R511 600
Expected term: 2013 - 2014

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

Best practice in wastewater treatment in small to medium sized municipalities in South Africa – roadmaps to Green Drop excellence
Sarah Slabbert and Associates; Water Group Holdings (Pty) Ltd
No. 2304

Traditionally, 50% of municipalities used pond systems. Equating excellence in wastewater management with an activated sludge system was one of the unintended consequences of the Green Drop regulation. As a result, municipalities that previously had pond systems, invested in an activated sludge system and decommissioned their pond systems. In many instances, especially with influent volumes of less than 1 ML per day, the result is 'overkill', which is unnecessary, expensive and requires skills that many of these municipalities do not have. If the correct design principles are followed, ponds are still a relevant technology for small wastewater volumes, as are sequencing batch reactor (SBR) and rotating biological contactor (RBC) systems. The focus of this project will be on key aspects such as: ponds as technology of choice, appropriate design, the importance of desludging and the ability of the plant to meet different effluent compliance standards.

Estimated cost: R500 000
Expected term: 2013 - 2014

Programme 3: Stormwater and sewerage systems

Pressure drop prediction for efficient sludge pipeline design
Cape Peninsula University of Technology
No. 2216

There is still no widely accepted design correlation of sludge viscous properties as a function of solids content, causing frustration to design engineers, who, in the absence of obtaining costly rheological data, have to make estimates which could compromise efficient design of pump and pipe systems. During wastewater treatment operations the objective is to remove solids such as grit and naturally floating materials, and the remaining solids are called sludge. The sludge needs then to be dewatered to be efficiently transported by pumping through pipelines. Measurement of the sludge rheology in-line and real-time has been attempted by many with varied success. A patented system using ultrasound has been developed using velocity profiling and pressure drop measurements to achieve this. The addition of real-time, in-line viscometry measurements will reconcile the differences that exist between rotational and tube viscometry

which caused the delay in the development of a more widely-accepted model. With water becoming scarcer it will become important to pump sludges at higher concentrations which will necessitate a better understanding of the flow properties of such viscous non-Newtonian fluids (sludges). This project aims to:

- Expand the existing sludge database obtained from tube viscometer measurements to validate/improve the pressure drop–flow rate predictions developed and published previously
- To measure the pressure drop versus flow rate for the wastewater plants, in existing pipes as well as the concentration of the sludges to independently test the design protocol developed
- To test the application of the in-house developed UVP viscometer over a range of sludge concentrations

Estimated cost: R224 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

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

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 2: Integrated management

Effluent treatment: retrofitting of integrated algal pond system (IAPS) to existing conventional ponds as well as combination of industrial and domestic effluent treatment
JR Muller & Associates
No. 2227

The Algal Integrated Waste Pond System (AIWPS) for treatment of effluent was originally developed by Professor Oswald of the University of Berkeley, California. This technology was pioneered in South Africa by the Water Research Commission, when Oswald visited South Africa as their guest in 1994. The AIWPS technology is deemed to be appropriate for Southern African conditions, due to SA weather conditions (i.e., high levels of sunshine), simplicity of operation, low installation costs, low operational costs and ease of installation at source of effluent generation. The AIWPS system was adapted, and is locally known as the Integrated Algal Ponding System (IAPS). It is considered to be the ideal treatment system for rural areas and for small- to medium-sized local authorities. An opportunity has been identified at Reitz Municipality, where a conventional ponding system is presently in operation and a new abattoir has started operation. Thus, the pond capacity has to be vastly increased to accept the increased load and volume from the abattoir. The loads are complementary:

(i) town: high volume, low load (CDD); (ii) abattoir: low volume, high load. This combination of the two effluent streams represents the ideal transfer of technology of the IAPS-system, i.e., in the design of the Reitz system, the technology from TT191/01 and TT191/02 has been incorporated into the Oswald AIWPS-system design and provision has further been made for recirculation and changes to effluent flows to the individual ponds. The performance of the retrofitted and combined domestic/industrial IAPS-system is to be monitored over a two-year period to afford the bacteriological systems the opportunity to stabilise and adapt over two periods of seasonal climatic changes.

Estimated cost:	R1 150 000
Expected term:	2013 - 2016

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

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)
University of Stellenbosch
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 (PMB)
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:	R850000
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

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

Water resource planners within DWA foresee that the salt load associated with the AMD from the Witwatersrand gold mines will have to be reduced significantly or prevented from contaminating existing supplies. Otherwise large quantities of good quality water will be required (in essence wasted) to dilute the salinity to an acceptable level within the Vaal River system. The water quality decanting from these mines can be highly acidic or alkaline, very saline, and dominated by calcium sulphate, sodium sulphate, magnesium sulphate or sodium bicarbonate. Technologies exist to neutralise and remove these salts from water, preventing environmental degradation following its release, but the techniques are expensive and energy intensive, and create high volumes of brine. Work done in the early 1980s showed that when calcium sulphate–rich mine water is used in irrigation a significant quantity of gypsum precipitates (becomes insoluble) in the soil, effectively reducing salt loads in the irrigation return flows. The more soluble sodium-based salts do not precipitate. In subsequent WRC-supported research, this gypsum precipitation mechanism was confirmed in commercial-scale systems under pivot irrigation with coal mine water. Multiple crop species grown under sprinkler did not show foliar injury symptoms and yields were higher than for dryland production. Furthermore, gypsum precipitation did not result in any observable physical or chemical changes that would adversely affect soil productivity. Following these findings, the team concluded that there are four components to consider in managing irrigation with saline water: the chemical quality of the irrigation water, the hydrological setting of the irrigated area, the management of the leaching fraction, and the fate of the AMD. The AMD issue in the western, central and eastern basins has now reached a critical point requiring short- and long-term mitigation measures. Issues of a similar nature in the Mpumalanga coal fields and elsewhere are anticipated in the near future. This project aims to build on previous WRC research on the feasibility of using irrigation to remove salts from neutralised AMD through gypsum precipitation in soil, by assessing whether irrigation can be a feasible component in an integrated AMD management plan, as a cost-effective and sustainable method to prevent a significant salt load from neutralised AMD from ending up in the Vaal River System, while also utilising the water in an economically productive way. This work will assist in identifying whether irrigation can be part of an integrated solution to the AMD problem in the Vaal Basin as well as other basins with AMD issues. Decision makers will be provided with better information on the feasibility of using a potentially

more cost-effective and environmentally-sustainable way of reducing the salt loads from AMD. The use of irrigation to remove salts from neutralised AMD will potentially reduce the financial and environmental burden resulting from other treatment options, for example, reverse osmosis plants. Using neutralised AMD productively will result in income for farmers, job opportunities and increased agricultural production in the region, which will be especially beneficial in regions with scarce irrigation water resources.

Estimated cost:	R600 000
Expected term:	2013 - 2014

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

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

Water quiz development
Overstrand Conservation Foundation
No. 2290

The aim of this project is to develop and implement a cellphone-based water quiz linked to an information database designed to stimulate school pupils throughout Southern Africa to spontaneously learn about the value, sources, conservation and sustainable use of water resources, as well as threats to water security.

Estimated cost:	R500 000
Expected term:	2013 -2014

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

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.

Estimated cost:	R313 531
Expected term:	2013 - 2014

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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 are addressed through creation and application of water-efficient production technologies, models and information systems within the following interrelated sub-sectors of agriculture:

- 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 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 representation by Black and female researchers, postgraduate students are trained to improve the expertise of human capital, with research empowering individuals and groups in rural communities.

Gerhard Backeberg: Executive Manager

Water users in all of the above-mentioned subsectors, as well as organisations such as WUAs, cooperatives, agri-businesses and government departments serving water users, are the clients or target groups of the research output. The point of departure of applied research is therefore the real-life opportunities and problems experienced primarily by water users and related organisations, for irrigated and rain-fed crop production, fuel-wood and timber production as well

as livestock and fish production. The problems which may be experienced in practice for any aspect of water use on the farm, irrigation scheme or river catchment vary from non-existence of knowledge, doubt regarding the applicability of existing knowledge, deviation of empirical observations from some relevant theoretical optimum, to an unclear outcome of possible alternative decisions and actions.

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

OBJECTIVES

The primary objective is to increase national and household food security and to improve the livelihoods of people on a farming, community and regional level through efficient and sustainable utilisation and development of water resources in agriculture.
The secondary objectives are to:

- Increase biological, technical and economic efficiency and productivity of water use
- Reduce poverty through water-based agricultural activities
- Increase profitability of water-based farming systems
- Ensure sustainable water resource use through protection, restoration and reclamation practices

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.

STRATEGIC CONTEXT

The National Water Resource Strategy 2 (2012) includes the following critical thrusts under 11 different core water strategies, with emphasis on those in which the Water Research Commission (WRC) has functions to perform:

- Fostering innovation and knowledge management, investing in people's capabilities, cultivating a more water educated and literate society, as well as increasing economic growth and social development
- Enhancing indigenous knowledge systems to meet the challenges of globalisation, focusing on the role of women and the youth
- Developing a knowledge-based water sector as a strategic move to raise the value added of all water use activities and optimising empowerment of people in society
- Strengthening human resource development to produce an efficient, effective and knowledgeable workforce
- Pursuing water security and environmentally sustainable development to re-enforce long-term growth
- Ensuring sound investment policies and infrastructure management as well as enhancing efforts to develop a knowledge-based water economy
- Improving user's knowledge, skills and expertise as well as upgrading innovation, science and technology

Key strategic actions which require inputs by the WRC and which are most relevant to the KSA: Water Utilisation in Agriculture are the following:

- Investment in the development of 'smart' solutions for water use efficiency, research of appropriate technologies, management solutions and appropriate institutional as well as organisational arrangements
- Development of a programme for investment in research and development of water efficient technologies and management systems

- Co-ordinate a skills development programme to build capacity in water management, including investment in education and youth development programmes, together with DWA and Universities

The National Planning Commission released the National Development Plan and Vision for 2030 on 11 November 2011. The most relevant sections which direct the Research and Development (R&D) Strategy of the Key Strategic Area (KSA) on Water Utilisation in Agriculture are first, 'Key drivers for change' of science and technology; second, 'Economy and employment' in relation to the National System of Innovation and Learning that permeates society and business; third, 'Economic infrastructure', in particular water resources and services; fourth, 'Inclusive rural economy', regarding trade-offs and risks for agricultural expansion; and fifth 'Improving education, innovation and training', with a focus on achieving the vision for 2030.

According to the New Growth Path (2011) measures must be taken to address income inequality in society, including skills enhancement and small enterprise development. Efforts to support employment creation will be given priority, with key sectors including, amongst others, the agricultural value chain. This includes measures to encourage growth in commercial farming for improved national food security. The agricultural value chain also offers employment opportunities through smallholder schemes and beneficiation with processing of agricultural products. Furthermore, improvement of rural livelihoods is possible by upgrading farmworkers' living conditions and by enabling rural households to increase food production. However, the growth path also requires a radical review of the training system to improve skills development and address shortfalls in technical skills. It is 'critical to ensure a space for smaller enterprise in the value chain' and promoting small business and entrepreneurship.

In the Programme of Action of The Presidency (2010), there are two outcomes which give further strategic direction to research in the KSA. Under Outcomes 7 and 10, the following outputs are specifically relevant:

Outcome 7: Vibrant, equitable and sustainable rural communities and food security for all:
- Output 1: Sustainable agrarian reform
- Output 2: Improved access to affordable and diverse food
- Output 4: Improved employment opportunities and promotion of economic livelihoods
- Output 5: Enabling institutional environment for sustainable and inclusive growth

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced:
- Output 1: Enhanced quality and quantity of water resources
- Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmosphere quality
- Output 3: Sustainable environmental management

Furthermore, the Green Paper on National Strategic Planning (2009) seeks to answer, amongst others, how to reduce poverty and what capacity is needed to ensure availability of water, energy and food in the future. The intention is to articulate a vision and strategy for the next 15 years, to which all organisations of Government are aligned.

In this regard the South Africa Vision 2025 of the Medium Term Strategic Framework projects a society in which, inter alia:

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

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

The water resource base is therefore of key importance in agriculture. Together with other renewable and interdependent natural resources, it forms the ultimate support of the productive economic activity of people. Water utilisation can best be quantified as rainfall-dependent, surface water- and groundwater-dependent use. Approximately 12% and 62% of rainwater in South Africa is used annually for dry-land cropping and by natural grasslands, woodlands and forests respectively. Rainwater runoff and deep percolation become available as surface water and groundwater of which approximately 62% is used for irrigation. It is abundantly clear that the biggest share of water is used for both extensive and intensive production in agriculture. The significance of agriculture and the impact of research in the development process encompass the following:

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

As is typical of an industrialised economy, the relative contribution of agriculture, forestry, hunting and fishing is low, at between 2 to 3% of gross domestic product (GDP). The forward linkages to processing industries and backward linkages to input suppliers in agriculture are, however, of considerable importance for economic activity in urban and rural areas, increasing the contribution to 20 to 30% of GDP. Until 2006 agriculture was also a net exporter of food,

contributing 10% of total exports of which 50% are processed products. During 2007, imports exceeded exports, mainly due to import of processed food products. Since 2008 the trade balance is again positive.

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

Critical issues in the forthcoming years and the next two decades are increasing pressure on agriculture and forestry, in particular food and fuel-wood production, due to population growth, urbanisation and increasing consumer income levels. Expansion of agricultural production on land suitable for cultivation will be increasingly constrained by the availability of water. Increasing hazards of rainfall variability, with western parts of South Africa getting drier and eastern parts wetter, over the long-term, are caused by climate change. This requires adaptive management practices to reduce the vulnerability of people in rural areas and prevent disasters of crop failures, income loss and widespread famine. At the same time, there is a relatively high ratio of people to cultivated land and a larger dependence on agriculture in rural areas to increase the material income and improve the social wellbeing, particularly of the poor. All of this will bring pressure on the water resource base.

It must be recognised that the use and development of water resources by people have both beneficial consequences, as mentioned above, and detrimental consequences. Negative impacts of water use include soil erosion, sedimentation, water-logging and salinisation. Important issues, which must receive attention, are the nature of resource degradation, underlying causes and feasible restoration and reclamation practices. Consequently, although the quantity and quality of water resources available for agricultural use are limited, it is important to note that this is not a constraint for economic development. The requirement is that water resources must be utilised productively and greater efforts with research and development must be made to increase productivity growth and thereby the competitiveness of agriculture.

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed funding budget of R30 507 464.

Research portfolio	Approved 2013/14 (R)
Current projects	27 507 464
New projects	3 000 000
Total	30 507 464

RESEARCH PORTFOLIO FOR 2013/14

In this KSA a holistic systems approach is followed for knowledge creation and dissemination to enable people to utilise water in a sustainable way for food production and improved livelihoods. Research projects are managed within the innovation cycle to ensure that scientific research is applicable and socially beneficial. Key issues being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas and prevention of resource degradation. These efforts are aligned to the Vision for 2030 of the National Development Plan; the outputs for Outcomes 7 and 10 in the Programme of Action announced by the Presidency; core water strategies of the NWRS-2; measures in the framework for the New Growth Path; the Green Paper on National Strategic Planning; the DWA framework on Water for Growth and Development; the DAFF Integrated Growth and Development Plan; the National Agricultural Research and Development Strategy; and the Comprehensive Africa Agricultural Development Programme of NEPAD. Work continues to fill knowledge gaps that exist in the utilisation of water in agriculture, under the following key activities of the research portfolio:

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

Over the past 11 years a strategic shift has been made to achieve a balance between research projects in irrigated

and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities through participatory action research; and to take research projects further toward practical application of results with technology transfer projects. The baseline of completed projects and stakeholder requirements indicates the direction and priorities for future research. In the next two years emphasis will be placed, through new projects, on quantification of the water use of indigenous field crops; determining the water footprint of selected food crops; measurement and modelling of fruit orchard water use; technology transfer for water quality management in aquaculture; rehabilitation of grasslands after eradication of invasive trees; evaluation of the water use and nutritional productivity of food crops in the diet of rural poor people; contribution of inland freshwater fisheries to rural livelihoods; action oriented knowledge transfer for training of productive water use in homestead food gardening and cropland rainwater harvesting; wide-scale modelling of water use and water availability with earth observation/satellite imagery; investigating entrepreneurial development paths of smallholder farmers; optimisation of electricity cost for sustainable irrigation water use; impact assessment of sedimentation on water flow and salinisation of irrigated land; revision of the 1996 water quality guidelines for agricultural water uses; and vulnerability analysis for drought impact assessment and resilience related to climate change. The output of these projects will mainly contribute to the flagship initiatives of the water, energy and nutrition/food nexus as well as the green village and model catchment.

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 drought-tolerant food crops
University of KwaZulu-Natal (Crop Science); University of KwaZulu-Natal (Howard College); South African Sugar Association Experiment Station
No. 1771

The initial task of the project was to identify and characterise indigenous and conventional food crops with application potential in South Africa. This was done taking into consideration, inter alia, (i) what can grow where under water-scarce conditions, (ii) water requirements and crop responses to water stress, and (iii) production and yield under water-stress conditions. A series of trials, including controlled, field and rainshelter experiments, were conducted in three provinces of South Africa – KwaZulu-Natal, Free State and Gauteng. The overall objective of the experiments was to understand the agronomy of selected crops and to determine whether or not they were drought tolerant. This included understanding their water use and water productivity. Modelling of the selected crops to

determine performance under dryland conditions was a secondary objective. A novel approach of the project was to select at least four crops that could be used to develop a crop model for indigenous crops. Over a period of five years, this study achieved the overall objective of providing agronomic information about the response of selected indigenous crops, indigenised taro and traditional maize, to management under field and controlled environmental conditions when water is limited.

Cost: R4 350 000 (incl. leverage)
Term: 2007 - 2013

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

Interaction between aquaculture and water quality in on-farm irrigation dams: Extended monitoring and mitigating procedures to manage environmental impact
University of Stellenbosch (Division of Aquaculture)
No. 1802

Irrigation dams in the Western Cape Province have a history of enrichment through external factors such as agriculture (fertilizers and pesticides), runoff and stormwater from the surrounding areas and effluent from infrastructure extension (housing and informal settlements). The incorporation of aquaculture into such dams adds additional nutrients to the water column and sediment, although the nutrients are not very concentrated. Irrigation dams can play a role in providing water bodies for floating net cage farming systems. However, water quality analyses over the research period indicated that farm dams in the Western Cape, overall, had good water quality, indicating that commercial crop farmers are exercising better management practices. The water quality was generally within the South African Water Quality Guidelines for agriculture, aquaculture and recreational use. The introduction of aquaculture under the prevailing farm-dam water quality guidelines generally did not pollute the water to such an extent that crop farming was compromised. Thus, there is a case to be made for promoting integrated aquaculture-agriculture farming. Sustainability for both uses can be maintained through robust site selection and diligent hands-on management of both fish- and crop-farming operations. This approach will ensure that commercial crop farmers' irrigation regimes and yield quality is not negatively affected. Recommendations include prevention or minimisation of pollution through aquaculture in irrigation farm dams by means of effective technology transfer and knowledge dissemination.

Cost: R1 680 000
Term: 2008 - 2013

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

The impact of re-establishing indigenous plants and restoring the natural landscape on sustainable rural employment and land productivity through payment for environmental services
ASSET Research; University of Stellenbosch; independent consultants
No. 1803

The specific objectives of this study were to conduct ecological, hydrological, and socio-economic assessments to determine the impact of restoration at several existing, and ecologically and socio-economically different, restoration sites by comparing them with degraded or un-restored areas in close proximity. The outputs from these studies were used to develop an integrated system dynamics model on the likely impact of restoration on the ecology, hydrology and economy of, notably, agriculture. The research team identified eight existing restoration sites that were well established and that had significant/sufficient supporting data. An ecological, hydrological and economic assessment of the impact of restoration on ecosystem function was done. A summary of the classification of projects suggests that those with the highest potential payoffs (the pearl projects) are the water projects, in other words those projects where downstream water consumers benefit from the restoration project. The Agulhas, Beaufort West, Kromme and Sand study sites are all examples of this. This study provided unique perspectives in that it was reflective, and multi-disciplinary. The study demonstrated that standard economic evaluation methods have limited ability to take system dynamics into account and could, therefore, easily misdirect or reject investment in restoration, potentially leading to disastrous social and ecological consequences. Using the proposed decision-making framework with respect to the development of markets/payment systems for ecosystem goods and services following restoration, decisions can now be taken against the backdrop of the risk involved in achieving such rewards or benefits. Neither systems dynamic approaches nor risk quantification in themselves are new, but applications to existing and on-going restoration projects are novel. This study has contributed to the science and practice of restoration through such an evidence-based approach to integrating economic evaluation and ecosystems dynamics. The report makes various technical and policy recommendations.

Cost:	R3 450 000 (incl. leverage)
Term:	2008 - 2013

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

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

Rainwater harvesting and conservation (RWH&C) for rangeland and cropland productivity in communal areas in selected provinces in the semi-arid area of South Africa
ARC (Institute for Soil, Climate and Water); ARC (Livestock Business Division); Department of Agriculture Forestry & Fisheries
No. 1775

Extensive research in South Africa has gone into developing a water harvesting system for growing crops in homestead gardens, although focus is shifting to implementing water harvesting in croplands at a much larger scale. Various techniques were identified, of which only few were deemed appropriate for use in this project. It was decided to concentrate on-farm micro-catchment techniques including contour ridging, tied ridging, tied furrows, strip catchment tillage, mechanized basins and stone terracing. The in-field rainwater harvesting technique was originally proposed in South Africa in 2000 as an alternative to conventional crop production. The technique was designed to maximize productive losses of rainwater. By combining the advantages of water harvesting, no-till, basin tillage and mulching on high drought-risk duplex and clay soils, the integrated rainwater harvesting technique reduced runoff to zero and considerably reduced evaporation. The general aim of this research was to assess rainwater harvesting and conservation (RWH &C) techniques/practices and related institutional arrangements for improved rangeland and cropland productivity in communal areas through on-station (controlled) and on-farm (participative) research.

Cost: R4 728 500 (incl. leverage)
Term: 2007 - 2013

Improving plotholder livelihood and scheme productivity on smallholder canal irrigation schemes in Limpopo Province
Tshwane University of Technology; ARC; Wageningen University; PANNAR
No. 1804

The main thrust of the work was the testing of a number of farming system innovations, but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes. The case study of Dzindi provides detailed evidence

of a rapidly decaying water distribution system, which is at least partially due to neglect on the part of plotholders, who have allowed the collective organisation that was responsible for routine maintenance of the system to collapse. For this reason, establishment of an effective routine maintenance system was identified as a critical condition for the sustainability of canal schemes. The empirical work identified the lack of a comprehensive legal framework that enables plotholder communities to assert their land rights as an important weakness of the current tenure system on smallholder irrigation schemes in Vhembe. The report covers issues of production, particularly dealing with irrigation scheduling of Chinese cabbage and green maize. The findings of the project have important implications for the improvement of smallholder irrigation schemes in South Africa, as a rural development option. The report contains recommendations derived from the project, with specific reference to policy. These recommendations have a significant bearing on policies such as the National Development Plan 2030 and the Limpopo Department of Agriculture's RESIS recharge programme, among others. Three guidelines were developed for use by development practitioners.

Cost:	R1 890 000
Term:	2008 - 2013

CURRENT PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

Water use of fruit tree/orchard crops
CSIR (Natural Resources and the Environment)
No. 1770

In summer and winter rainfall areas, water stress in river catchments is increasing. Limited water resources can constrain development if productivity is not improved. This is particularly important for the fruit tree industry where at least 90% of production is dependent on irrigation. However, there is a lack of comprehensive information of the water use of fruit trees or available information on water use is incomplete and contradictory. Correct knowledge is absolutely essential for drawing up on-farm water management plans for fruit production. The recently-published research reports on water use of citrus and deciduous fruit trees did not provide conclusive results. More specifically it is clear that soil-based measurements present a challenge to obtain accurate and reliable information on water use. Existing models in South Africa can also not confidently simulate water use of fruit trees for different climate,

soil, water and management conditions. Therefore, the definite need exists to do intensive research on the tree-based measurements and to design tree-specific models. The purpose of this project is to develop comprehensive knowledge of water-use characteristics and the water use of selected fruit tree/orchard crops for application in fruit tree/orchard management in South Africa. This will require a review of available knowledge on water use of tropical, sub-tropical and deciduous fruit trees/orchard crops. It will be followed by the assessment, ranking and selection of fruit trees/orchard crops in terms of economic importance, current hectarage, geographic distribution and gaps in knowledge on water use. The main outputs will be reports on the empirical measurement of water use at the selected sites and the development, verification and validation of models for the selected fruit trees/orchard crops. More precise modelling approaches and knowledge of water use will improve management advice to farmers on the productive water use of fruit trees within and between seasons over the productive life of the orchard.

Estimated cost: R5 567 500 (incl. leverage)
Expected term: 2007 - 2014

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

Water use efficiency of irrigated agricultural crops determined with satellite imagery
UKZN (Bioresources Engineering and Environmental Hydrology)
No. 2079

Advances in recent years in the use of remote sensing (RS) information now make it possible to assess crop water use, biomass and yield production (and WUE) spatially for each pixel (< 30 to 250 m) of a satellite image. For agricultural (field-scale) applications a number of models have been developed, including the Surface Energy Balance Algorithm for Land (SEBAL) model. Assessing the spatial WUE data over time can help farmers to detect, e.g., an uneven application of irrigation water (in a field or across a farm or irrigation scheme), a mismatch between irrigation water supply and that actually required (indicating over- or under-irrigation), potential seepage losses or drainage problems and other resources (e.g. fertiliser and energy) wastage. This project will build on research projects conducted in South Africa in recent years where the use of spatially-explicit data (from the SEBAL model) in irrigated agricultural water management has been evaluated. In South Africa, there is a need for information to be available operationally, so that WUE at field, farm and irrigation scheme level can be evaluated regularly, problems detected and addressed swiftly, crop WUE and other resource use (fertiliser, electricity, etc.) optimised, and water wastage minimised. This project will aim at conclusively confirming the degree of accuracy of the SEBAL model (when compared to traditional methods) for estimating ET and WUE of selected agricultural crops. This project should therefore pave the way for the operational near real-time application of RS data in agricultural water management. There will be collaboration with potential users of the data (researchers, farmers, irrigation advisors, water managers on irrigation schemes) and the project will continue to build capacity (students, extension officers, researchers) in generating and using this data.

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2011 - 2014

Investigating the possibility to improve water use efficiency and reduce canopy management inputs of wine grapes through deficit irrigation
ARC Infruitec-Nietvoorbij
No. 2080

At present, wine grape farmers are advised by viticulturists to follow certain canopy management practices, such as suckering, tucking in and topping of shoots. This is done to ensure that the grapes fall within a prescribed quality class. Under current economic circumstances, as well as with the rising cost of labour and fuel prices, these practices are becoming increasingly expensive to maintain, as farmers are not necessarily compensated for the additional expenses. Knowledge of how different canopy management practices at different deficit irrigation strategies will influence the combination of vegetative growth, production and wine quality is limited. A completed Winetech project investigated the effect of different deficit irrigation strategies on the water usage, production, growth, plant water potentials and overall wine quality, and crop factors were determined for a range of irrigations at different soil water depletion levels. The same canopy management was applied to the grapevines of all the treatments (two-spur winter pruning,

suckering twice during spring and the tucking in of shoots into trellis wires). The cost of these different management practice inputs has not been investigated. In previous irrigation trials conducted on wine grapes, a blanket standard canopy management was done on all the treatments as the object of these trials was to investigate the effect of the different irrigation strategies on the grapevines' yield and wine quality. In previous canopy management research, the same irrigation volumes were applied to the various treatments while their canopies were manipulated. The effect of different canopy management inputs in combination with different irrigation strategies, and the water requirements of these different canopies, has thus not previously been investigated. Depending on the outcome of the trial, the results could be used as subroutines in future economic models to calculate the profitability of wine grape vineyards.

Estimated cost: R2 072 000
Expected term: 2011 - 2015

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 (Department of 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

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 (Department of Microbiology and Plant Pathology)
No. 1875

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

in the context of South Africa as a developing country, will support accurate health risk assessment and subsequent community health management.

Estimated cost: R6 219 200 (incl. leverage)
Expected term: 2009 - 2015

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
University of Stellenbosch (Department of 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 (Department 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

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: R4 900 000
Expected term: 2011 - 2016

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

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

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

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

Estimated cost: R4 000 000 (incl. leverage)
Expected term: 2010 - 2014

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 woman 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 (Department of 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 (Department of 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:	R2 864 465
Expected term:	2012 - 2016

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
University of KwaZulu-Natal (Institute of Natural Resources)
No. 1879

The inclusion of subsistence and emerging farmers in the mainstream of the economy is a nationally identified priority. Structural and cyclical obstacles must be overcome to accomplish this. These are mainly the dualistic nature of the agricultural economy and the recent occurrence of food shortages with high input costs. Although expectations are high for subsistence farmers to enter the market, experience shows that technical and business skills are required to obtain access to assets in agriculture by entering food-value chains. With high poverty levels and increasing unemployment, there is also a need to ensure growth with equity and therefore impacting on a wider group of people to promote rural economic development. Achieving this is a real possibility, since on the demand side there are different value chains, with consumers demanding food in different marketing outlets. On the supply side there are a large number of rural inhabitants, which includes groups who can be broadly categorised as subsistence, emerging and commercial farmers, who can potentially respond and enter any one or a combination of these value chains.

The productive use of water in the value chain for both rain-fed and irrigated food production is of particular importance. The project will investigate factors such as needs and aspirations, technical capabilities, risks of crop production, food price expectations, water use security and incentives to increase water productivity which influence the decision of what value chain to enter and the degree of success obtained. The report will highlight innovative ways to promote integration of subsistence, emerging and commercial farming in food-value chains for crop and animal products with use of rain- and irrigation water.

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

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

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

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

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 (Department of 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
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: R1 950 000
Expected term: 2012 - 2016

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

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

The Department of Water Affairs is considering the issuing of a general authorisation (GA) for the irrigation of

agricultural crops, e.g. vineyards, with treated and augmented winery wastewater. This GA entails that the wastewater be treated to a specified quality standard, before storage in irrigation dams and mixing with raw irrigation water. In order to attain the specified wastewater quality standards, it is envisaged that wineries will adopt cleaner production approaches and replace chemicals that are detrimental to soils and crops with chemicals that will produce a wastewater rich in essential plant nutrients. Irrigation with the wastewater would thus be comparable to fertigation. While the effects of most of the winery constituents on soils and crops are fairly well known and their effect on soils and crops can thus be predicted with a fair degree of confidence, the same cannot be said for the organic content of wastewater, as measured by its chemical oxygen demand (COD). This project will consequently investigate the sustainable use of winery wastewater for irrigation of vineyards with respect to the effect it will have on soils, vineyard performance and wine quality. While the study will focus specifically on the effect of COD, it will also consider the effect of salinity, pH, sodium adsorption ratio (SAR), nitrogen, phosphorus and potassium contained in the wastewater. The research output will promote the beneficial reuse of winery wastewater, and the reclamation and protection of soil and water resources. This will inform legislation on wastewater management regarding regulations that promote the beneficial use of wastewater for productive purposes and lead to improved industry guidelines and practices for managing winery wastewater.

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

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

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

farming households and enterprises; identify and suggest appropriate adaptive techniques and practices in selected catchments and farming areas. The report will provide an assessment of the vulnerability of different farming systems to climate change. It will evaluate alternative adaptation practices and techniques (indigenous and science-based knowledge) and if necessary develop and test innovative, appropriate and sustainable interventions, including internal management measures and external policy measures.

Estimated cost: R4 300 000 (incl. leverage)
Expected term: 2009 - 2016

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

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

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

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

Agricultural activity is potentially a source of a number of hazardous chemicals in water resources. Concerns have been expressed that some of the pesticides used in agricultural practice for crop spraying and animal disease control may enter and pollute the rivers and dams and cause endocrine disrupter effects in animals and humans that use the water for drinking and recreational purposes. A scoping study (WRC Report No. 1774/1/08) indicated that there is no clarity on the extent and level of contamination of water resources by agricultural products with ED (endocrine disrupting) properties. However, a number of WRC studies have been done identifying different chemicals in different areas that are hazardous as well as having ED properties. Some studies identified EDCs in water resources and indicated ED effects in sentinel species in and around contaminated water resources. Most of these studies in South Africa are not specifically focused on the link between the chemicals used in agricultural practices and the impact on human health with water as a pathway. This research report will document the impact which agricultural chemicals have on human and animal health. Guidelines will be compiled for South African authorities to direct the safe use of agricultural chemicals in water resource management.

Estimated cost: R4 109 825 (Incl. leverage)
Expected term: 2010 - 2015

Insights into indigenous coping strategies to drought for drought adaptation in agriculture: The Southern Cape scenario
Cape Peninsula University of Technology (Centre for Water and Sanitation Research)
No. 2084

Drought is a normal, recurrent feature of South African climate. In the past, droughts have resulted in significant economic, social and environmental impacts on the country. South Africa will continue to experience droughts and the likelihood of serious drought is greater with climate change. In the Western Cape Province, for example, climate change projections indicate that the province can expect less rainfall, particularly to the eastern parts of the province. Thus the future climate change projections mentioned indicate that droughts will become a more regular phenomenon. The Southern Cape is the area most vulnerable to such extreme events and therefore the area of investigation. To develop drought preparedness strategies it is critical to capture local experiences. There have been limited studies capturing indigenous local knowledge of the impacts and experiences of past and current droughts in South Africa. Completed studies recommend three groups of drought mitigation measures –supply-orientated, demand-orientated and minimisation of impacts and losses. However, these coping strategies and mitigation measures are not concerned with local practices, and certainly do not incorporate indigenous knowledge and practice. In any case, these concern drought experiences of two to three decades ago. It is therefore critical that the experience of the current drought in the Southern Cape be captured to adequately prepare and mitigate against future anticipated droughts in the region. The research is intended to capture and assess local coping strategies and experiences of a current drought within the agricultural sector to inform preparedness planning for future droughts. In this respect the research would contribute to an indigenous knowledge base for informing mitigation and preparedness planning in both disaster risk management and climate change adaptation for the agricultural sector.

Estimated cost: R812 000 (incl. leverage)
Expected term: 2011 - 2014

NEW PROJECTS

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

Programme 1: Water-efficient production methods in relation to soils, crops and technology in rain-fed and irrigated agriculture

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 intercropping 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

Knowledge transfer on water quality management for improved integrated aquaculture and agriculture systems
University of Stellenbosch (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 3: WATER UTILISATION FOR POVERTY REDUCTION AND WEALTH CREATION IN AGRICULTURE

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

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
Umhlaba Consulting (Pty) Ltd
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 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 - 2017

The optimisation of electricity and water use for sustainable management of irrigation farming systems
University of the Free State (Department of 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 2: Impact assessment and environmental management of agricultural production

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

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KSA 5:
BUSINESS DEVELOPMENT, MARKETING AND COMMUNICATIONS

SCOPE

Globally, the scientific community agrees that knowledge use and uptake is challenging. The path from research to policy formulation is no longer a causal linear process where 'research results in a product which is passed from the researcher to the policy maker'. Policy formulation is a complex interaction of actors and includes several advocacy coalitions and networks. As other science councils and research organisations in the country, the WRC too has to try to narrow the 'knowledge chasm' between practitioners and the scientific research community by improving collaboration and strengthening partnerships.

The WRC research portfolio addresses the full water cycle through the four research KSAs and links this to the knowledge cycle. KSA 5: Business Development, Marketing and Communications supports and continues the knowledge cycle, with the support from KSA 5 contributing to the production and dissemination of research outputs, testing and demonstration, feedback and implementation.. Additionally, this KSA is in the process of undergoing significant transformation in terms of stakeholder communication and marketing, uptake of WRC-funded knowledge, the streamlining of WRC business processes, and, in so doing, changing from a reactive to proactive working modality.

Inga Jacobs: Executive Manager

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
- 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 as well as partners
- 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 led by the WRC
- Supporting knowledge creation by providing appropriate research management tools and logistic support
- Sharing and disseminating water-centred knowledge internally and externally
- Providing strategic research advice to decision-makers and other stakeholder groups

OBJECTIVES

In execution of the WRC's mandate and functions, the objectives for KSA 5 are as follows:

- To position the WRC as a premier knowledge resource for all water-related issues, locally and internationally
- To effectively manage the WRC research cycle
- To provide strategic research advice to the water science and technology sector

THRUSTS AND PROGRAMMES

THRUST 1: RESEARCH – WATER-CENTRED KNOWLEDGE

Aim:
• 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.

This KSA focuses on researching various elements, drivers and trends affecting the dynamics of the water-centred knowledge cycle, from issues related to research capacity and overall funding of research by the sector to the effectiveness of research and its impact on policy and technology used by the sector. 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

THRUST 2: TECHNOLOGY TRANSFER AND IP MANAGEMENT

• To demonstrate technologies and solutions through scale-up and demonstration facilities
• To manage the WRC patent portfolio and intellectual property according to the WRC IP Policy

This thrust 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. The thrust also includes the management of intellectual property.

THRUST 3: STRATEGIC POSITIONING AND PARTNERSHIPS

Aims:
- To enhance the credibility and relevance of the WRC locally and globally
- 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

This initiative has in the past been decentralised in the WRC. This caused, to an extent, individuals rather than the organisation to be recognised. This thrust was created to coordinate national, continental and global initiatives and to formalise strategic partnerships without compromising the individual efforts of our Research Managers and Executive Managers. It provides the golden thread for key selected dialogues and partnerships in which the WRC wants to play a major leading role.

Another major initiative is the establishment of the Water Knowledge and Capacity Advancement Programme (WaterKCAP), in partnership with the DWA. The aim of the WaterKCAP is to provide a dedicated programme of support that enables research supervisors to provide higher numbers of high-quality Doctorate and Masters level graduates in priority water-relevant disciplines.

The WRC also continues to establish strategic partnerships with large industry, local government as well as national government departments and their agencies.

Other initiatives addressed in this thrust are:

- Establishing and strengthening of relationships with government departments and a number of portfolio committees
  - Establish and maintain relationships with the National Planning Commission, portfolio committees, and various departments including Department of Water Affairs, Department of Health, Department of Science and Technology, Department of Agriculture, Forestry and Fisheries, Department of Cooperative Governance and Traditional Affairs, Department of Human Settlements
  - Provide interactive information sessions to the portfolio committees and respond to their knowledge requirements

- Supporting national, African and global initiatives
  - Support national initiatives of key importance to the water and other related sectors where the WRC plays a significant role
  - Support other KSA initiatives through providing support related to exhibitions, media briefings, events management, etc.
  - Support African initiatives for building water science and technology in the continent (example: NEPAD)

- Establish and maintain bilateral relationships
- Support global initiatives and partnerships, for example, through:
  - Linking to international associations such as the International Water Association, World Water Forum, etc.
  - Linking with the global research community through *Water SA*

• Prepare positioning material such as the WRC Annual Report, strategic messages, ministerial and policy briefs

THRUST 4: PUBLIC RELATIONS AND COMMUNICATIONS

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
• To market the WRC effectively

This thrust complements the objectives of Thrust 3 utilising public relations, marketing and communication mechanisms. The KSA 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 acting as a resource centre to meet the information requirements of the WRC and the water sector in general. It includes:

• 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

• Establishing working relationships with industry, decision makers and key stakeholders
  - Strengthening relationships through formal memoranda of understanding
  - Providing knowledge in a format that is fit-for-use
  - Delivering multimedia presentations to inform various target groups about the WRC and its accomplishments

• Supporting water-related youth and learner awareness programmes

• Knowledge sharing (external)
  - 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
- Developing and maintaining an Electronic Water Knowledge Hub for easy access to all WRC publications and resources
- Developing mechanisms for effective knowledge sharing and information transfer
- 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

• Enhancing the effectiveness of knowledge dissemination

• Supporting the research community
- 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

THRUST 5: BUSINESS SYSTEMS MANAGEMENT

Aim:
To coordinate the research funding cycle and provide effective tools, systems and procedures to support the core business of the WRC.

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

• Coordinate the annual funding cycle
• Provide the logistics required for the flow of research-related information into and out of the WRC
• Increasing the user-friendliness of the WRC Fund Management System (FMS) for both external and internal users

- 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

THRUST 6: PRODUCTION AND KNOWLEDGE PACKAGING

Aims:
- To provide an effective printing and distribution service
- To package water-centred knowledge for different users

This KSA manages the production of WRC-funded research reports, technology transfer reports, *the Water Wheel*, *Water SA*, brochures and briefs. It includes:

- Printing and distribution
  - Manage the quality-control process of WRC technical and technology transfer final reports
  - Manage the process of layout and printing of the WRC reports and other publications
  - Manage the effective distribution of research reports
  - Manage effective report distribution facilities (manual and electronic)

- Knowledge packaging
  - Develop and maintain innovative ways to share and disseminate WRC products, e.g. brochures, project briefing notes, Knowledge Review, media briefings.
  - Support KSAs 1 to 4 with the production of technology transfer documents

- Promote the public understanding of science
  - Produce and publish *the Water Wheel*
  - Produce and publish special publications such as books and learning material

- Ensure that scientific knowledge is globally recognised and exchanged
  - Manage the production and publication of *Water SA*

STRATEGIC CONTEXT

Globally, the scientific community is in agreement that knowledge use and uptake is challenging. The path from research to policy formulation is no longer a causal linear process where 'research results in a product which is passed from the researcher to the policy maker' (Whitty, 2008). Policy formulation is a complex interaction of actors and includes several advocacy coalitions and networks. Similarly to other science councils and research organisations in the country, the WRC has to try to narrow the institutional gap between policy-makers and the scientific research community by improving collaboration and strengthening partnerships.

In the South African water sector, the challenge is compounded by the constant change in the institutional and political environment. The organisations tasked with implementing legal and policy frameworks are constantly faced with a change in leadership, institutional changes and instability, high staff turnover, declining institutional memory and a highly-regulated environment which hinders the testing of developing concepts and technologies.

However, the outcome-based strategic approach developed by the South African Government provides a conducive environment for knowledge uptake as the sector gears itself to improve the impact of its efforts. This KSA will support the research KSAs in clearly communicating the link between research outputs and how these can assist Government in achieving the desired outputs. This KSA also coordinates the local and international dialogues aimed at firmly positioning the WRC in carefully selected themes such as adaptation to climate change.

Sector threats

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

- Functioning and pursuing continuous development in a resource-constrained environment
- The desperate and urgent need for solutions in the sector
- Working in a complex and multidisciplinary environment and often across institutions and disciplines
- Human resource capacity in the public sector – often qualified but less experienced people need to acquire a level of competence in a short period of time without the luxury of continuous mentorship
- Limited research capacity in certain of the water-related research areas and reduced ability to deliver on research contracts
- Shortage of South African students studying towards a higher degree in water-related disciplines – a balance is required between the need to continue research (creating knowledge) to ensure a sustainable water sector and the need to build capacity to export to other African states

- Relevance of the WRC; ability to provide South Africa with the knowledge required in the right format to improve service delivery and policy formulation

Relevance and impact

The relevance of the WRC depends in part on the organisation's ability to be the preferred supplier of knowledge to the sector. The absorptive capacity for knowledge generated by WRC-funded research is dependent on the manner in which it is packaged, understanding the complexity of the sector as well as the image of the WRC. The WRC, through this KSA, has started to place more emphasis on understanding and enabling knowledge uptake rather than focusing purely on knowledge dissemination.

Van Ryneveld and Sproule (2009) defined knowledge uptake as 'the active acquisition of disseminated information, the comprehension of the information and the ability of practitioners to apply the information in the field'. While the WRC continues to generate water-related knowledge-based products which contribute to addressing the knowledge gaps in the water sector, it also seeks to understand the mechanisms of knowledge uptake.

The role of KSA 5 is therefore important for the continued relevance of the WRC and for the sustainability of a knowledge-based water sector. The emphasis has now moved to better understanding knowledge flow and developing and applying methodologies to enhance the uptake and application of the water-related knowledge generated by the WRC to solve the water challenges that South Africa faces. KSA 5 therefore aims to lead a consultative knowledge flows programme to create a better understanding of what the knowledge uptake drivers are.

It also strives to assist the research KSAs to enhance and encourage sector involvement from the early stages of appropriate research projects/programmes to:

- Improve knowledge sharing with the aim to increase implementation
- Enhance sector involvement in the WRC research processes

This KSA continues to support the organisation with knowledge creation and sharing through:

- Supporting research management and providing logistic support
- Developing effective internal and external knowledge sharing and dissemination mechanisms/instruments
- Enhancing the credibility and relevance of the WRC, locally, in the rest of the African continent, and globally
- Ensuring the appropriate management of intellectual property
- Supporting the WRC with advice on research contract matters

KNOWLEDGE DISSEMINATION

The WRC aims to constantly improve its contribution towards knowledge as well as to enhance the sharing and dissemination of WRC-funded research findings. This is also linked to Government Outcomes/Outputs related to building skills, by addressing the building of future research capacity and improving knowledge dissemination. The WRC strives to improve its contribution towards the water-centred knowledge base in South Africa by enhancing the WRC knowledge-sharing activities and positioning.

Enhancing public understanding of water research: *the 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 as well as a special edition of *the Water Wheel* in 2013/14.

Briefs

The WRC technical, policy and ministerial briefs are communication tools that aim to communicate, in a clear and brief format, the outcome of various research studies to the water sector, with special emphasis on non-technical professionals, policy- and decision-makers. For all finalised research projects, one- to two-page briefing notes are produced, which are short communiques highlighting research outcomes and sharing pertinent messages and recommendations. Another 89 technical and policy briefing notes were produced in 2013/14. All technical and policy briefs and reports are available electronically on the WRC website: www.wrc.org.za.

Ministerial briefs are targeted messages aimed at communicating very specific research findings or knowledge generated from WRC research to Governmental ministers, most particularly, the Minister of Water and Environmental Affairs. Seven (7) ministerial briefs were produced in 2013/14.

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 2013/14, 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 2013/14. Table 2 lists the ten most popular reports in 2013/14 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 2013/14, and Table 4 lists the most popular reports in 2013/14 in terms of number of downloads from the WRC website.

Table 1: Reports distributed in 2013/14

Client	No. of Reports
Foundation for Water Research	244
Institutes	8 013
Municipalities	680
Private	7 187
Schools	21
State Library	138
University/University of Technology	1 011
WRC	1 064
TOTAL (print)	18 358

Table 2: Most popular reports (print copies) distributed in 2013/14

Report no.	Title	KSA	Total
KV309/12	Soil-plant carbon stocks in the Weatherley Catchment	1	347
TT 522/12	The state of non-revenue water in South Africa	3	346
TT 540/4/12	Training material for extension advisors in irrigation water management	4	243

1856/1/12	Development of a revised desktop model for the determination of the ecological reserve for rivers	2	231
2087/1/P/13	Trends in the insight into the growing South African municipal water service delivery problem	3	215
TT 565/13	Energy efficiency in the South African Water Industry: A compendium of best practices and case studies	3	214
1648/1/12	Assessment of the social and economic acceptability of rainwater harvesting and conservation	4	205
TT 568/13	Production guidelines for small-scale broiler enterprises	4	184
TT 566/13	Improving plot holder livelihood on smallholder canal irrigation	4	167
2087/2/P/13	Perspectives on the market processes followed in setting South African water services tariffs	3	163

Table 3: Downloads and e-reads of research reports from the WRC website in 2013/14

	Downloads	E-reads
WRC research reports	22 239	3 773

Table 4: Most popular reports (downloads from website) in 2013/14

Report title	Downloads
Water purification works design	735
Guideline for the inspection of wastewater treatment works	545
National standards for drinking water treatment chemicals	402
A simple guide to the chemistry, selection and use of chemicals for water and wastewater treatment	380
The state of non-revenue water in South Africa	223

Guidelines and training aids for the sustainable operation and maintenance of small water treatment plants	218
Easy identification of some South African wetland plants	171
State of the art: fracking for shale gas exploration in South Africa and the impact on water resources	158
Drivers for wastewater technology selection – Assessment of the selection of wastewater technology by municipalities in relation to the management capability and legislative requirements	151
Compendium of water conservation and water demand management interventions and measures at the municipal level in South Africa	119
Water use and nutrient content of crop and animal food products for improved household food security: A scoping study	116
Energy efficiency in the South African water industry: A compendium of best practices and case studies	103
A 2011 perspective on climate change and the South African water sector	100
Guides to the freshwater invertebrates of SA: Volume 8: Insecta II	94
Guideline document: Package plants for the treatment of domestic wastewater	90
Theory, design and operation of nutrient removal activated sludge processes	90
Water resources of South Africa, 2005 study (WR2005) - 2011 Update: Executive Summary (version 2, 2011)	89
WET-RehabMethods national guidelines and methods for wetland rehabilitation	82
Handbook for the operation of water treatment works	80
Quality of domestic water supplies Volume 1: Assessment Guide	79

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NEW TT REPORTS 2013/14

Hydrogeology of Groundwater Region 10: Karst Belt

Reinhard Meyer

This report forms part of a series on the hydrogeology of the various groundwater regions in South Africa. Region 10 (Karst Belt) is the sixth region that will be published; there are 64 Groundwater Regions. The Regions previously published are: 1 (Makoppa dome), 3 (Limpopo Granulite-Gneiss belt), 7 (Polokwane/Pietersburg Plateau), 19 (Lowveld) and region 26 (Bushmanland). The hydrogeology of the Karst Belt is described using available data and gives a good overview of the groundwater conditions in this region.

TT 553/13 *ISBN: 9781431203918* *Overseas Price: $35.00*

Vadose Zone Hydrology: Concepts and Techniques

Matthys A Dippenaar, J Louis van Rooy, Nelda Breedt, Altus Huisamen, SE Muravha, Sarah Mahlangu & JA Mulders

The vadose zone can also be considered as "the zone between the land surface and the water table" which includes the plant root and intermediate zones and the capillary fringe, representing that portion of the crust where the pore spaces contain water at pressures below atmospheric, air and other gases. The vadose zone falls within a framework overlapping between and combining the specialisation of many different disciplines. Vadose zone hydrology includes the specialist input of notably soil scientists, surface water hydrologists, hydrogeologists and engineering geologists, but such collaborative efforts are still mostly limited to the implications of soil water on biodiversity or the protection offered to the aquifer by the overlying unsaturated media, and hence closely linked with studies in geotechnical engineering and ecology.

TT 584/13 *ISBN: 9781431205073* *Overseas Price: $35.00*

Optimal utilisation of thermal springs in South Africa

Jana Olivier & Nelia Jonker

The aim of the project was to identify the optimal uses of thermal springs in South Africa. The objectives were three-fold, including the determination of the geological, biological, physical and chemical characteristics of the thermal springs in South Africa; their fitness for current use; and their suitability for alternative uses. Countries around the world have recognised alternative uses for waters and heat generated from thermal springs. Currently, the South African thermal springs are under-utilized.

TT 577/13 *ISBN: 9781431204816* *Overseas Price: $30.00*

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

Tamiru Abiye (editor)

Environmental isotopes are routinely employed world-wide in the study of groundwater and surface water, as they provide unique information on transport and interconnectivity of water resources and reservoirs. The term environmental isotope embraces the measurement of isotope ratios of the elements making up the water molecule and of substances dissolved in water. These are subject to environmental processes and undergo changes, for example during evaporation.

TT 570/13 *ISBN: 9781431204601* *Overseas Price: $35.00*

Groundwater governance: A global framework for action (2011-2014) - Regional diagnosis for the Sub-Saharan Africa Region

Eberhard Braune & Shafick Adams

The Groundwater Governance - A Global Framework for Action (2011-2014) is a joint project supported by the Global Environment Facility (GEF) and implemented by the Food and Agriculture Organisation of the United Nations (FAO), jointly with UNESCO's International Hydrological Programme (UNESCO-IHP), the International Association of Hydrologists (IAH) and the World Bank.

TT 578/13 *ISBN: 9781431204823* *Overseas Price: $30.00*

Linking property rights, ecosystem services and water resources

Duncan Hay, Bimo Nkhata, Melanie Wilkinson, Kyle Harris,Charles Breen & Jackie Crafford

"What is often referred to as property is really the access right to a stream of benefits from a given set of resources." Neil Meyer. A team of researchers recently conducted a research project for the Water Research Commission. It was entitled 'Embedding Property Rights Theory in Cooperative Approaches to the Management of Aquatic Ecosystem Services in South Africa'.

TT 554/13 ISBN: 9781431203994 Overseas Price: $32.00

Introduction to the management of EDCs Volume I

Ralph Gregory Melville Heath, Lee Ann Boyd, Oliver Obakeng Malete and Didimalang Masoabi

The aims of this project were to develop a guide to correct sampling and sample preparation in the context of endocrine disrupting chemicals (EDCs). This project also produced the overall introductory chapter for the current

series of EDC management volumes (of which the sampling guide is one). The sampling guide provides an overview of the issues that should be considered when designing a sampling programme (i.e., the how, when, and where). The guide addresses four media, namely, water, sediment, air and biota (typically fish). Quality assurance and quality control are described.

TT 560/13 *ISBN: 9781431204213* *Overseas Price: $10.00*

Endocrine-Disrupting Compounds: Sampling Guide. Volume II

Didimalang Masoabi, Lee Ann Boyd, Thomas Coughlin, Ralph Gregory Melville Heath

The aims of this project were to develop a guide to correct sampling and sample preparation in the context of endocrine disrupting chemicals (EDCs). This project also produced the overall introductory chapter for the current series of EDC management volumes (of which the sampling guide is one). The sampling guide provides an overview of the issues that should be considered when designing a sampling programme (i.e., the how, when, and where). The guide addresses four media, namely, water, sediment, air and biota (typically fish). Quality assurance and quality control are described.

TT 561/13 *ISBN: 9781431204229* *Overseas Price: $10.00*

Guideline for the management of EDCs in a catchment Volume IV

The aims of this project were to develop a guide to correct sampling and sample preparation in the context of endocrine disrupting chemicals (EDCs). This project also produced the overall introductory chapter for the current series of EDC management volumes (of which the sampling guide is one). The sampling guide provides an overview of the issues that should be considered when designing a sampling programme (i.e., the how, when, and where). The guide addresses four media, namely, water, sediment, air and biota (typically fish). Quality assurance and quality control are described.

TT 562/13 *ISBN: 9781431204236* *Overseas Price: $10.00*

Status review and requirements of overhauling flood determination methods in South Africa

Stefanus Johannes van Vuuren, Marco van Dijk and Gert Louis Coetzee

This project was undertaken to review the current flood calculations methods and to provide some guidance on the research focus to improve, extend and update the Flood Determination Procedures. The aim of the study is to reflect on the current state of flood determination methods used in South Africa and the short-comings in the existing methods. This then provides the basis to identify the specific research areas and prioritization of research and required updates for flood determination procedures in South Africa.

TT 563/13 *ISBN: 9781431204199* *Overseas Price: $35.00*

ECOMAG Model: an evaluation for use in South Africa

Evison Kapangaziwiri, Jean-Marc Mwenge-Kahinda, Denis Arthur Hughes and Moipone Precious Mokoena

The Russian ECOMAG model has been suggested as a possible candidate for use in South Africa, and this aims to evaluate its suitability for use under South African conditions. In the absence of the software code, the ECOMAG Model was evaluated qualitatively (without setting up and running it) against the South African equivalent models such as the Pitman and the ACRU. Naturally, each model is constructed to solve practical problems in a particular environment. The ECOMAG was developed specifically for the boreal environment, which is completely different from the South African environment.

TT 555/13 *ISBN: 9781431204083* *Overseas Price: $20.00*

Testing a Methodology for Environmental Water Requirements in Non-perennial Rivers: The Mokolo River Case Study

MT Seaman, M Watson, MF Avenant, AR Joubert, JM King, CH Barker, S Esterhuyse, D Graham, ME Kemp, PA le Roux, B Prucha, N Redelinghuys, L Rossouw, K Rowntree, F Sokolic, L van Rensburg, B van der Waal, J van Tol & AT Vos

This research has contributed considerably to the knowledge of the ecological functioning of non-perennial rivers and the testing of a method to determine the Environmental Water Requirements (EWRs) for non-perennial rivers. This report should be read in conjunction with the WRC report no TT459/10 (Seaman et al., 2010) where the ecological functioning of non-perennial rivers and the prototype methodology is explained.

TT 579/13 *ISBN: 9781431204854* *Overseas Price: $40.00*

St Lucia 2001 to 2012: A Decade of Drought

RH Taylor and JB Adams

This document is a record of the impacts of the 2001 - 2012 droughts on the St Lucia estuarine system. In addition to documenting the impacts of the drought on the estuarine system, details of the management interventions are provided.

TT 576/13 *ISBN: 9781431204755* *Overseas Price: $30.00*

DRIFT: DSS Software Development for Integrated Flow Assessments

CA Brown, AR Joubert, J Beuster, A Greyling & JM King

The previous version of the Reserve Desktop model was based on hydrology and regional parameters, which were largely based on seasonal distributions of stream flow. One recent development in Environmental Water Resource methodology is the flow stressor response method, which links the hydraulic habitat requirements of biota to the hydraulic characteristics of a channel cross-section, to specify the ecological stress conditions that will occur under different flow regimes. The core component of the model uses a desktop approach to define the characteristics of a

representative channel cross-section in the absence of any detailed field surveys. Components of the model deal with hydrology, hydraulics and ecological requirements.

TT 575/13 *ISBN: 9781431204182* *Overseas Price: $30.00*

Manual for Ecostatus determination (Version 2) MODULE B Geomorphology Driver Assessment Index (GAI)
KM Rowntree, with L Kelly and M Rountree
EcoStatus is defined as "the totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and its capacity to provide a variety of goods and services". In essence the EcoStatus represents an ecologically integrated state of the drivers (hydrology, geomorphology, physico-chemical) and responses (fish, aquatic invertebrates and riparian vegetation).

TT 551/13 *ISBN: 9781431204052* *Overseas Price: $30.00*

The Shared River Initiative Phase II - Part 3 - Development of a participatory framework for understanding water-related ecosystem services within the context of classification and the reserve
Sharon Pollard, Alyona Rydannykh, Derick du Toit and Ariane Laporte-Bisquit
The findings of Phase 1 of the Shared Rivers Initiative (SRI) prompted a second phase.
The aim was to assess the sustainability of the water resources of the six major Lowveld river systems, and the factors that constrain or contribute to this, in order to provide a grounding from which to design and implement real change.

TT 574/13 *ISBN: 9781431204700* *Overseas Price: $35.00*

The Shared River Initiative Phase II - Part 2 - Legal competence and regulation
Ramin Pejan, Alexandra Robertson, Jonathan Cogger, Dimakatso Sefatsa
The findings of Phase 1 of the Shared Rivers Initiative (SRI) prompted a second phase. The aim was to assess the sustainability of the water resources of the six major Lowveld river systems, and the factors that constrain or contribute to this, in order to provide a grounding from which to design and implement real change.

TT 573/13 *ISBN: 9781431204695* *Overseas Price: $35.00*

The Shared River Initiative Phase II - Part 1 - Collective action for improved water resources management
Derick du Toit, Sharon Pollard, Jane Burton & Madeleine von Balkom
The findings of Phase 1 of the Shared Rivers Initiative (SRI) prompted a second phase. The aim was to assess the sustainability of the water resources of the six major Lowveld river systems, and the factors that constrain or contribute to this, in order to provide a grounding from which to design and implement real change.

TT 572/13 *ISBN: 9781431204687* *Overseas Price: $35.00*

Social franchising partnerships for operation and maintenance of water services:Lessons and experiences from an Eastern Cape pilot

Kevin Wall & Oliver Ive

Year after year, the operation and maintenance of too much of South Africa's water services infrastructure has been found to not comply with the required standards. Breakdown of service delivery is too often the outcome. The primary objectives of the Butterworth schools sanitation and water servicing pilot project was the demonstration of the suitability of social franchising partnerships under these circumstances, and the development of a model which can be used for rolling out similar services to the rest of the more than 4000 rural schools across the Eastern Cape.

TT 564/13 *ISBN: 9781431204168* *Overseas Price: $25.00*

ICTs in the water sector – where do we stand?

Michael Champanis, Ulrike Rivett, Saaligha Gool, and Mphatso Nyemba-Mudenda

Over the last decade ICT systems have become known as a potential solution for developing countries and their information needs. The wide distribution of mobile phones in even the most rural environments has created the suggestion that cellphones are far more than a mere communication tool. Cell-phone systems used for data collection, mobile payment and crowd-sourcing initiative to improve governance and other applications are offering a new way of using technology to improve access and might have the potential to improve service delivery.

TT 571/13 *ISBN: 9781431204052* *Overseas Price: $25.00*

Guideline for the utilisation and disposal of water treatment residues

Jacoba Elizabeth Herselman

This project is the third in a series of projects undertaken by the WRC to deal with the utilisation and disposal of water treatment residues (WTR). It was undertaken with the specific aim to develop Guidelines that describe the requirements for the disposal and/or use of WTR. The Technical Support Document records the assessment and review of the legislation governing the utilization and disposal of WTR, the international and local literature that assisted in the development of the Guideline and the rationale that was followed to develop the South African WTR Guideline, the associated limits for South African conditions and the outcomes of the risk assessments.

TT 559/13 *ISBN: 9781431204090* *Overseas Price: $25.00*

WATCOST: Manual for a costing model for drinking water supply systems

Chris D Swartz, Peter Thompson, Presantha Maduray, Gerhard Offringa and Godfrey Mwiinga

This project developed a user-friendly costing model, "WATCOST", for estimating costs of drinking water supply systems. This allows economic comparison between different water treatment and supply options being considered for a water supply scheme(s). It further also allows costing reports to be done for existing water treatment systems, which assists with budgeting and asset management processes. The aim of WATCOST is two-fold: firstly, the manual

can be used as a reference document for information on costing data for water supply projects, with actual costing figures that can be obtained from the tables and graphs in the document.

TT 552/13 *ISBN: 9781431204014* *Overseas Price: $35.00*

Guidelines for the Selection and Use of Appropriate Home Water-Treatment Systems by Rural Households
Maggy NB Momba, Jocelyne K Mwabi, Bhekie B Mamba, Barbara M Brouckaert, Chris D Swartz, Gerhard Offringa & Robert O Rugimbana
A number of home water-treatment systems (HWTSs) are being used internationally by rural communities without access to potable water services. These HWTSs vary from the simplest, such as using cloth as filter, to the most sophisticated systems treating greywater to potable standards. Although various devices have been reported on extensively in the literature, little is known locally about the existing options and little has been done to assist local communities in making informed choices on whether a specific device should be selected. This project therefore aimed to evaluate HWTDs for local application and provide guidelines for the selection and use of appropriate HWTSs by rural households.

TT 580/13 *ISBN: 9781431504892* *Overseas Price: $35.00*

Guidelines on using the refined and translated web-enabled Water Safety Plan Tool (2013 version)
Unathi Jack and Philip de Souza
Water Safety Planning is a systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery. In so doing the process allows for better understanding of water supply systems. Once the risk has been identified, control measures can be put into place to mitigate these risks.

TT 581/13 *ISBN: 9781431204953* *Overseas Price: $35.00*

Energy Efficiency in the South African Water Industry: A Compendium of Best Practices and Case Studies
Chris Daniel Swartz, Marlene van der Merwe-Botha, Susan Delia Freese
Energy will in future become a high cost item for municipalities and utilities which operate and maintain water and wastewater processes. Energy consumption will continue to increase as more people are provided with water and sanitation and new technologies are implemented to meet stricter effluent and potable water quality requirements. To position the water sector globally with regard to energy consumption, the Global Water Research Coalition (GWRC) embarked on a project entitled Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies, which looks at these best practices worldwide.

TT 565/13 *ISBN: 9781431204304* *Overseas Price: $30.00*

Stasoft V user manual

JFC Friend

Stasoft was developed by JFC Friend under the leadership of the late Prof Loewenthal at the University of Cape Town during the late 1980s, early 1990s. Unfortunately the software was not designed at that stage for the current new Windows-based environment present on all computing platforms, as that only happened years later. However, the original program was developed in Turbo Pascal. The new Stasoft V program was developed to be functional on new operating platforms (Windows 7 and higher). The program has the same calculation functions that were available in Stasoft III, with enhanced menu and help facilities

TT 585/13 *ISBN: 9781431205127* *Overseas Price: $35.00*

Community engagement in drinking water supply management: A review

Ulrike Rivett, Derek Taylor, Chenai Chair, Bianca Forlee, Mandisi Mrwebi,Jean-Paul van Belle, Wallace Chigona

This study provides the necessary background information on community engagement in drinking water services delivery and the role of ICTs in incentivising public participation. This study is based on the notion that an increase in community engagement – particularly in rural areas – would result in an increased understanding of the current shortcomings of drinking water supplies, an increased understanding of the communication challenges between communities, Water Service Authorities (WSA) and Water Service Providers (WSP) as well as an improved experience of greater transparency and accountability for all stakeholders.

TT 583/13 *ISBN: 9781431205068* *Overseas Price: $20.00*

TIPS for Sewering Informal Settlements

Lina Taing, Neil Philip Armitage, Nangolo Ashipala & Andrew Spiegel

Informal dwellings tend to be laid out in a manner that is not conducive for retrofitting drainage according to conventional engineering standards. Coupled with unfavourable ground conditions (ranging from settlements in flood-prone areas to discontinued landfills), retrofitting and/or installing conventional sewerage in such conditions is inherently problematic, particularly in situations where residents refuse to relocate (even temporarily) for fear of further marginalisation.

TT 557/13 *ISBN: 9781431204120* *Overseas Price: $30.00*

The South African Guidelines for Sustainable Drainage Systems

Neil Philip Armitage, Michael Vice, Lloyd Fisher-Jeffes, Kevin Winter, Andrew Spiegel & Jessica Dunstan

Stormwater management in the urban areas of South Africa has and continues to predominantly focus on collecting runoff and channeling it to the nearest watercourse. This means that stormwater drainage currently prioritises quantity (flow) management with little or no emphasis on the preservation of the environment. The result has been a significant impact on the environment through the resulting erosion, siltation and pollution. An alternative approach

is to consider stormwater as part of the urban water cycle, a strategy which is being increasingly known as Water Sensitive Urban Design (WSUD) with the stormwater management component being known as Sustainable Drainage Systems (SuDS).

TT 558/13 *ISBN: 9781431204137* *Overseas Price: $35.00*

Water Reuse for Industrial Wastewater

Wade Edwards, Marshall Sheerene Sheldon, Petrus Jacobus Zeelie, Debbie De Jagers, Leendert Gideon Dekker and Cornelius Carlos Bezuidenhout

This project investigated the application of the dual stage operations strategy in a pilot plant evaluation of a MBR (dsMBR) for the on-site treatment and recovery (reuse) of industrial trade effluent. The goal of the study was to use the MBR system as a pre-treatment for the reduction of the wastewater pollution load so that a downstream reverse osmosis (RO) system can be incorporated to facilitate a zero liquid discharge strategy as well as effluent reuse potential for the industrial partner.

TT 556/13 *ISBN: 9781431204113* *Overseas Price: $35.00*

Improving Plot Holder Livelihood on Smallholder Canal Irrigation Schemes

Wim van Averbeke

The main thrust of the work was aimed at testing a number of farming system innovations but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes.

TT 566/13 *ISBN: 9781431204441* *Overseas Price: $40.00*

Growing Green Maize on Canal Schemes in Vhembe: Production Guidelines

W van Averbeke, Khathutshelo Ralivhesa, Sibonelo Mbuli, Tsunduka Khosa, Kgabo Manyelo

The main thrust of the work was aimed at testing a number of farming system innovations but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes.

TT 567/13 *ISBN: 9781431204458* *Overseas Price: $20.00*

Production Guidelines for Small-Scale Broiler Enterprises

Khathutshelo Ralivhesa, Wim van Averbeke & Francois Siebrits

The main thrust of the work was aimed at testing a number of farming system innovations but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes.

TT 568/13 ISBN: 9781431204465 Overseas Price: $25.00

Guidelines on Management of Working Animals

Timothy Simalenga, Sipho Sibanda, Peta Jones

The main thrust of the work was aimed at testing a number of farming system innovations but attention was also given to social resource constraints. The research was conducted in the Limpopo Province, which is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of schemes to be constructed. A survey of all registered smallholder irrigation schemes in the Vhembe District was conducted. The findings confirm the continued relevance of canal irrigation and show that gravity-fed canal schemes are more likely to be operational and to last longer than pumped schemes.

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