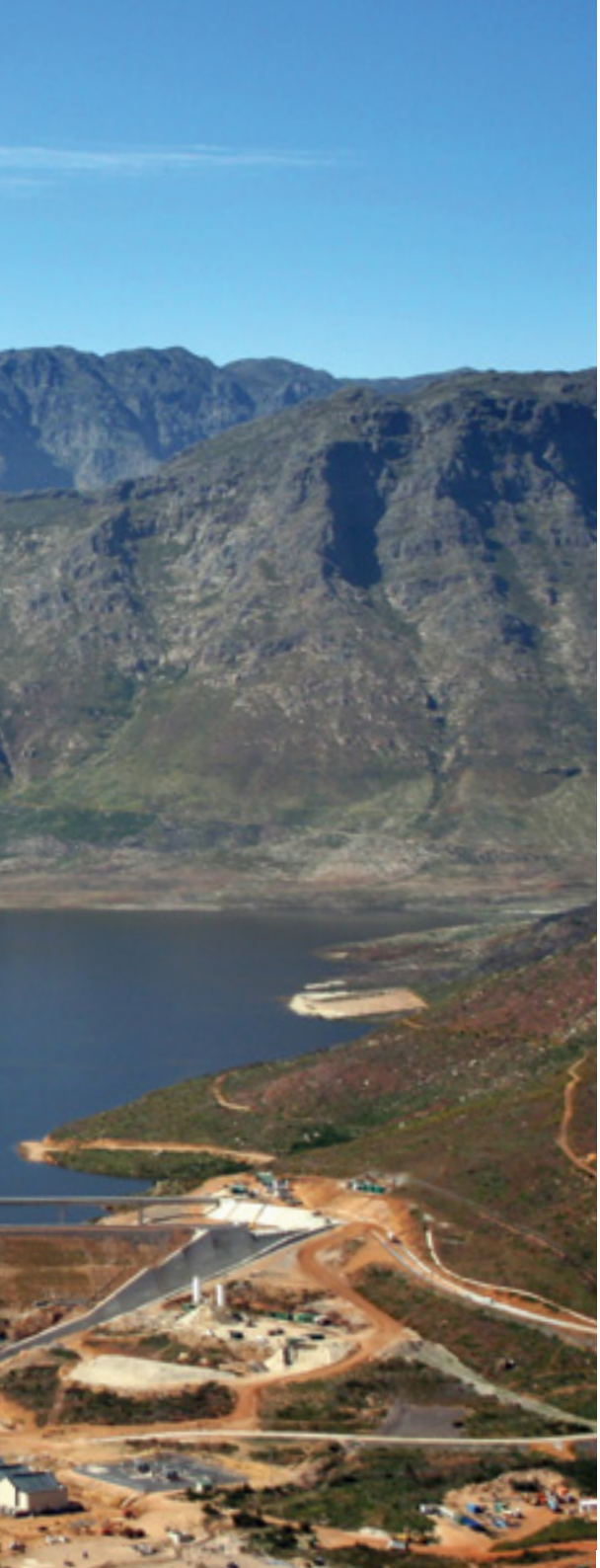

KSA 1: WATER RESOURCE MANAGEMENT

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KSA 1: WATER RESOURCE MANAGEMENT

SCOPE

Demands placed on water resources arise from a combination of factors: growth and development, increased human and animal populations, increased urbanisation, and climate change and variability. Strategies for reducing demand, increasing efficiency on a catchment basis, and creating new sources of water resources from, for example, desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., provide complementary strategies within the National Water Resource Strategy that can form part of Outcome 6 of Government's key focus for 2014, namely, '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', is directly addressed by these strategies.

Climate change can exacerbate competition over scarce or inequitably allocated resources. This leads to tension and conflicts such as those seen in some parts of Darfur. The agreements reached in COP17 and subsequent COPs will have direct implications for how water will need to be central to climate change discussions beyond the Nairobi Programme. South Africa has brought water into the National Climate Change Response White Paper and aspires to streamline water in the South African Climate Change Response Strategy. This will highlight the need for good climate projections, especially relating to rainfall. Enhanced downscaled models from the Global Circulation Models and the use of new technological advancements for remotely-sensed data will be central in adapting to climate change.

A solution proffered by a recent study shows that to achieve a balance in water allocations, scaling up the water development process to a river basin level will require stronger integration of national processes with regional economic and social growth and development to meet the projected temporal and spatial water decline challenges; in effect the convergence of national and regional economic processes is a key step towards stronger shared river basin management. As the African Development Bank's Regional Paper for Africa (2009) notes, "regional integration is essential not desirable".

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 as well as other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes will depend heavily on accurate and reliable data at appropriate spatial and temporal scales. The KSA has invested considerably in enhancing the estimates for quantifying water use and water availability, and has contributed to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the national information system on water resources. Furthermore, the need for integrating surface water and groundwater models has been highlighted. A concerted effort has been made to bridge this gap, starting with improved evapotranspiration estimates which take into account the unsaturated zone, informed by groundwater dynamics.

The bulk of the research in this KSA is in support of Outcome 10: 'Environmental assets and natural resources that are well protected and continually enhanced'. Output 1: 'Enhanced quality and quantity of water resources' is largely supported by Thrusts 1, 2, 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'. Further details will be provided in the respective thrusts and programmes.

OBJECTIVES

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

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

THRUSTS AND PROGRAMMES

The research portfolio for 2012/13 was organised within the following thrusts:
Thrust 1: Water Resource Institutional Arrangements
Thrust 2: Water Resource Assessment and Planning
Thrust 3: Water Quality Management
Thrust 4: Water Resource Protection
Thrust 5: Water Resources and Climate
The scope of the strategic thrusts and programmes within KSA1 is as follows:

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

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

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

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

Programme 3: Water resource planning	Scope: This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps such as the absence of reliable information in ungauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water system plans that will benefit from real-time, historic and stochastic data on a countrywide basis. Impacts of climate change on water resources and the planning processes will be accounted for so as to ensure a proactive approach and allow for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs as expressed in the objectives of Water for Growth and Development as well as through accounting for other factors, which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals. Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water uses will be investigated and included as part of future water resource plans.
Programme 4: Water resource infrastructure	Scope: There is an increasing need to develop systems for the efficient maintenance of the aging water infrastructure as the demand for the development of new and expensive water resource infrastructure is increasing due to the growing economy and population growth. This programme will seek to develop strategies and priorities for water resource infrastructure development and management to address the uncertainties and risks associated with climate change. While built infrastructure development such as dams, reservoirs, irrigation and flood barriers, are important options for addressing these issues, this programme will also explore the potential use of natural infrastructure such as wetlands, floodplains, artificial recharge (to aquifers), etc., to complement built infrastructure (but with an added advantage of healthy ecosystems).

Programme 5: New water	Scope: This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges and economic growth target of 6% of GDP per year will require thorough understanding and assessments of alternative sources of water. Such sources could be built into future projections for new water, virtual water and water transfers, be they national or international, from desalinisation, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. The initial development of research under the new theme of Water and Energy will be initiated through this programme. Within this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention, to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.

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 within 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 therefore 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 organisational 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. The following programmes support this thrust:

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.

Programme 1: Predictive tools (continued)	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: Climate change risk management seeks to promote sustainable development by reducing vulnerability associated with climate risks. The approach involves a range of actions including reduction of vulnerabilities or enhancement of resilience amongst people and societies, protection of ecosystem goods and services, early response systems, strategic diversification, and improved institutional capacities. Climate adaptation refers to the ability of the system to adjust to climate change, variability or extreme to moderate potential damage or to cope with the consequences. This programme is aimed at reducing vulnerabilities among communities and people through development or implementation of systems, tools, approaches and strategies (some of which would have been developed under Programme 1, such as modification of structures or implementation of early preparedness programme for extreme events). Protection or restoration of ecosystem goods and services that are vulnerable to climate variability and change as well as strengthening capacity of people and institutions are some of the techniques that will be investigated under this programme.

Programme 2: Climate change risk, vulnerability and adaptation (continued)	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.

BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed and approved funding budget, inclusive of roll-over, of R31 619 133. Available funding to support running projects within the five thrusts in 2012/13 was R 22 816 533. The committed and approved budget for new projects was R8 802 600. The consolidated budget for the research portfolio is presented below:

Research portfolio	Approved 2012/13 (R)
Current projects	22 816 533
New projects	8 802 600
Total	31 619 133

CORE STRATEGY

Strategic context

The 'water crisis' the world community faces today is largely a governance crisis, according to the OECD, in a comment made in late 2011: "The real challenge is 'implementing' the existing solutions on the ground, tailoring them to local contexts and engaging all stakeholders. Well-functioning institutions underpin increased and more effective investments in water development, hence the importance of the governance-financing nexus. Concrete and pragmatic tools can help diagnose governance challenges *ex ante* and design adequate responses to address the complexity in the water sector." These issues are by no means different to what South Africa faces in the water sector. Similar 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 known that there is no one-size-fits-all answer or magic blueprint to respond to governance challenges in the water sector; rather, 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 will be 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 verifications. The KSA has invested heavily in enhancing the estimates for quantifying water use and water availability. This year, the KSA also contributed to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the national information system for water resources. Furthermore, the need for integrating surface water and groundwater models has been highlighted. Concerted effort was 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 remains a challenge, mainly to the poor and the disempowered majority whose ability to pay for water is limited. Delivering water services to this majority and ensuring that there are adequate water resources for new productive users, such as emerging farmers in rural areas, is a main target of Outcome 7: 'Vibrant and sustainable rural communities and food security for all'. Output 1: 'Sustainable agrarian reform' is a major focus for the KSA dealing with Water and Agriculture, but in this KSA the main focus is from the perspectives of climate change and adaptation, resource assessment and the institutional arrangements pertaining to addressing equity aspects. In all of the above, the need to safeguard society and the economy through early-warning systems has been identified. Research results need to be shared and communicated effectively to be optimally used for the benefit of South Africa and further afield.

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

Thrust 3, which deals with water quality, identifies eutrophication as being of most concern, followed by increasing salinity. If only two high-priority problems were to be identified to focus immediate research efforts (in the next year or two), they would be microbial pollution and eutrophication. However, all of the main water quality problems would need some attention over the next five years to ensure their current research bases do not stagnate.

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 i**mproved water allocation and optimisation of water use between social development, economic growth and environmental sustainability.**

Water and society

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

Water and the economy

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

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

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

Water and the environment

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

The impact on the environment from the release of energy and the resulting impact thereof on water

resources have formed part of a long-term discussion between WRC and ESKOM, and an agreement has been signed between the two parties to conduct joint research into alternative energies and the international benchmarking of the latest technologies.

Needs analysis

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

- Promoting proactive research which anticipates the nation's water needs and the environmental impacts of management options
- Encouraging multidisciplinary and interdisciplinary research
- An effective alliance with, and active participation of, water resource research stakeholders
- A systematic, strategic, and balanced agenda of both core- and problem-driven research priorities set to meet short- and long-term needs
- Creation of partnerships with national and international role players in the water management field
- The South African public is the prime beneficiary of research investments with relevance to regional, continental and international benchmarking of the latest technologies.

In continuation from the previous business plan and based on the consultative processes, the research focus of this KSA continued to support policy-making by: developing tools and technologies for overall water resource management, supporting decision making by reviewing existing policies and strategies, providing quick responses to immediate and specific research questions in support of national initiatives, providing platforms for debate, building capacity in project teams and steering committees disseminating resultant information as widely as possible and encouraging partnerships through joint projects with key stakeholders.

The KSA deals with freshwater resources and their management. In 2012/13, the strategic intent of this KSA continued to be informed by regular interaction with numerous stakeholders. During its formal and informal consultation with the various stakeholders, mainly the board of the WRC, and based on new international research and major global investigations, the following broad categories were identified from the previous cycle and continue to be relevant:

Business and the human right to water

The Office of the United Nations High Commissioner for Human Rights' statement in relation to the right to water stresses a number of key factors: sufficiency, accessibility, safety, acceptability, and affordability. In South Africa, the idea of human rights informed the development of the **Freedom Charter**, which in turn greatly influenced the development of the **Bill of Rights** that forms Chapter 2 of the **Constitution.** This sets out the citizen's rights and commits Government to fulfilling them. The right to water requires that states give priority in water distribution and management to water for personal and domestic uses. This prioritization has implications for water management and may require specific systems to manage competing demands. Industrial bodies (including both private corporations and state-owned enterprises) are often major consumers of water. It is predicted that in 2025, industry, rather than agriculture,

will account for most of the projected increase in water use. As a result, industries may substantially affect the availability of water if their water use curtails access to safe-drinking water for personal and domestic uses, either through over-abstraction or pollution of water sources. Building on the significant commitment to action contained in the CEO Water Mandate, it is recommended that industrial water users endeavour to ensure their activities have a favourable impact on the right to water. The CEO Mandate commits signatories to action in the following six areas: direct operations; supply chain and watershed management; collective action; public policy; community engagement; and transparency.

There is a need to help develop a fuller understanding of how a rights-based approach can inform management of all water-related issues. This understanding would better define what it would mean for a business to go beyond a 'do no harm' approach while also building or influencing the capacity and willingness of governments to uphold their position as the primary duty bearer for protecting and fulfilling the right to water.

Climate change

South Africa is a water-stressed country and by 2050 the effects of climate change will be evident. However, each province is unique and the models addressing climate change should be disaggregated to provincial level. There will be a need for interventions regarding adaptation at provincial and local levels. At the same time, agriculture (the biggest user of water) needs to be more efficient in using water and technologies are needed to improve agricultural productivity. **Uncertainty and climate change** go hand in hand. Small uncertainties in the physical processes are amplified into large uncertainties in the climate response. The challenge for policy-makers, planners and environmental decision makers is to understand how the timing and magnitude of impacts may be affected by changes in climate and sea-level rise associated with differing amounts and rates of change in global average temperature. The challenge for climate change research is to develop monitoring and observation systems; refine models to determine the impacts of climate change in a specific area; identify measures to enhance our capacity to adapt (building adaptive capacity) and take advantage of the opportunities presented by climate change; and make information available for those responsible for policy, planning and environmental decision making.

Water pollution and regulation

The Minister of Water and Environmental Affairs has stated that South Africa needs both technology-based solutions and a change in public attitude which can be achieved through education and awareness. Creative programmes are needed to address this at community level. The Minister also maintains that compliance and enforcement are critical. The Department has to bring back the polluter-pays practice and to establish a new guard with a clear mandate, i.e. the blue scorpions, which will control pollution with a heavy hand. Wetland protection is also of utmost importance as wetlands play a major role in sustaining the resource and combating pollution.

Monitoring

The state of monitoring infrastructure and its implications for water resource assessment and management was stated as one of the important issues which could have serious implications for research and research findings. Mapping of water footprints in the whole value chain, and their impact for specific use, is a new water accounting methodology gaining popularity here in South Africa. Application of real-time water assessment models and tools, water security (quality and quantity) to support growth, and targets for 2030 are also

important issues. The large water footprint associated with energy production is gaining importance as water scarcity continues to become more obvious. New energy technologies – from advanced methods of extracting fossil fuels to low-carbon renewable energy – may look appealing, but they exacerbate water concerns, creating unfavourable trade-offs between carbon and water. However, a myriad of technologies – including water reuse and recycling, increases in energy production efficiency, and large-scale distribution – can help with addressing these trade-offs. Going forward, energy technologies' water intensity will often play as great a role as their carbon footprint in determining the future makeup of the global energy mix.

Water scarcity

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

Water quality

Water quality has been a concern for many decades, be it urban, environmental (groundwater, surface, and estuarine), or drinking water. The water quality research portfolio has been diverse and has grown considerably over the years. While all KSAs have had, and still have, water quality-related projects, this KSA has focused mainly on monitoring (from analytical methods through to monitoring system design) and 'status quo' surveys involving direct measurement of water quality in our water resources. However, there has also been some water quality modelling and management-related research. Water quality problems that have been addressed have included eutrophication, microbial contamination, acid mine drainage, increasing salinity, sedimentation, and endocrine system disruption (potentially affecting many animal species). A document produced by the Fund for Research into Industrial Development, Growth and Equity (with government, big business and labour inputs) prioritised microbial pollution as posing "very high" human health, economic and social risks followed by eutrophication and acid mine drainage which each pose "high" economic and social risks. A DWA planning-level review of chemical water quality (it did not consider microbial pollution) noted eutrophication as being of most concern, followed by increasing salinity. If only two high-priority problems were to be identified to focus immediate research efforts (in the next year or two), they would be microbial pollution and eutrophication. However, all of the main water quality problems would need some attention over the next five years to ensure their current research bases do not stagnate. Notwithstanding the historical and current broad research base, all of the above water quality problems remain, and indeed it is widely held that some are worsening. Consolidation of existing research findings and effective knowledge transfer that complements good existing initiatives (like Green Drop certification) is now necessary. Particular cognisance should be taken of the required 'enhanced quality and quantity of water resources' output of government Outcome 10 which attributes the deterioration of water quality to a "systematic eroding of management". This clearly-stated priority should also guide, and indeed strongly influence, further water quality research. Notwithstanding the need for consolidation, the changing natural environment, as well as the fast pace of international technological development in some contexts, and development of management ideologies,

also requires continued alertness to emerging issues. These may range from newly-identified chemicals hazardous to human or animal health, microorganisms, laboratory analytical methods, and so-called 'earth observation' techniques, to novel management approaches (e.g., those that address social issues, social learning, complexity, transdisciplinarity, etc.).

Sectoral and political cooperation

The realisation that water is an embedded sector and needs to be outward-focused emphasises that many decisions around water lie outside the water sector and hence expansion of the stakeholder base is important to affect decisions made around water. Alignment of powers and functions between the three spheres of Government is defined in the respective laws and legislation. However, the complexity inherent in the management of water and other resources in an integrated manner is proving to be a challenge. This requires a cooperative government functioning seamlessly between national, provincial and local spheres. However, the delineation, coordination and support in this value chain have created some blind spots, mainly from a planning and financial point of view. The reform of water allocations can only be successful if there is complete alignment between the responsible Government departments, viz, Trade and Industry, Rural Development and Land Reform, Cooperative Governance and Traditional Affairs, Agriculture, Forestry and Fisheries, Labour, Treasury, the Land Bank, etc. The new National Planning Commission calls for futuristic studies which are able to project alternatives in future scenarios. This KSA is investing in research efforts to further define available options in support of national sustainable growth and development, including a variety of technical, institutional and policy options for improved water allocation and optimization of water use – developed and adapted for basin-level water management.

Overview of technological trends

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

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

- Difficulties in the measurements calculated from parameters such as solar radiation, relative humidity and wind speed. Records are often very short, and available for only a few regions, which impedes complete analysis of changes in droughts.
- There may be opportunities for river flow data rescue in some regions. Where no observations are available, the construction of new observing networks should be considered.
- Groundwater is not well monitored, and the processes of groundwater depletion and recharge are not well modelled in many regions.
- Monitoring data are needed on water quality, water use and sediment transport.
- There is a general lack of data from the southern hemisphere.

- More information is needed on plant evapotranspiration responses to the combined effects of rising atmospheric CO_2, rising temperature and rising atmospheric water vapour concentration, in order to better understand the relationship between the direct effects of atmospheric CO_2 enrichment and changes in the hydrological cycle.
- Quality assurance, homogenisation of data sets, and inter-calibration of methods and procedures could be important whenever different agencies, countries, etc., maintain monitoring within one region or catchment. Better observational data and data access are necessary to improve understanding of ongoing changes, to better constrain model projections, and are a prerequisite for adaptive management required under conditions of climate change. Progress in knowledge depends on improved data availability. Shrinkage of some observational networks is occurring. Relatively short records may not reveal the full extent of natural variability and confound detection studies, while long-term reconstruction can place recent trends and extremes in a broader context.

Satellite radar tools and applications

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

Data monitoring using remote sensing is undergoing a revolution in terms of technical monitoring capabilities through the advances in spatial and spectral resolution of new sensors. The continuing improvements to the analysis are also expanding the level of detail that can be extracted from imagery. One of our research projects has applied hyperspectral imagery to accurately estimate evapotranspiration, plant water content, water stress and plant- or soil-water availability. Unlike low-spectral resolution imagery which covers only selected regions of the electromagnetic spectrum, thus giving more generalised products, high-spectral resolution imagery covers a wide region of the electromagnetic spectrum (approximately 400 to 2 500 nm). This gives more spectral bands with finer bandwidths (generally less than 10 nm). The finer spectral resolution allows for detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

Futurist techniques as a tool in water management

Successful management of complex social-ecological systems requires adaptive approaches and a system of continuous learning for building knowledge and effective management practices to interpret and respond to ecological feedbacks. Knowledge generation of such complex systems is an ongoing process which typically takes years to accumulate. Learning is essential for individuals, communities, other stakeholders and

agencies to develop their ability to deal effectively with new situations and to prepare for change and surprise. In addition the cumulative knowledge should be embedded in the management process.

Water-related multidisciplinary complex social ecological systems are all long-term issues, ranging from several decades to centuries. Delayed policies result in very high costs or the loss of mitigation feasibility. Long-term viewpoints and long-term policy are quite important in these cases, e.g., U.N. Millennium Development Goals (MDG). While forecasting – i.e., attempts to predict future states from current trends – is a common methodology, professional scenarios often rely on 'backcasting': asking what changes in the present would be required to arrive at envisioned alternative future states, e.g., the 'Water sector Institutional landscape by 2025' project.

Futurists use a diverse range of forecasting methods including: anticipatory thinking protocols, causal layered analysis (CLA), environmental scanning, scenario method, Delphi method, future history, backcasting (eco-history), back-view mirror analysis, futures workshops, failure mode and effects analysis, futures biographies, futures wheel, technology roadmapping, relevance tree, simulation and modelling, social network analysis, systems engineering, trend analysis, morphological analysis, etc.

These tools can be explored to assist in making the right choice between different management regimes. Plausible descriptions of how the future may develop based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Futurist predictions may be derived from projections, but are often based on additional information from other sources, sometimes combined with a narrative storyline.

Water accounting

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

Key stakeholders

The major stakeholders remained to be the following five groups:

- The Minister of Water and Environmental Affairs; shareholder
- The Parliamentary Portfolio Committee on Water and Environmental Affairs

- Government departments representing a major group that has a large stake in the research conducted, especially DWA which represents the water resource managers and planners, i.e., all those entrusted with developing and allocating water resources to meet the needs of the environment and various users according to the National Water Act
- Other departments such as the Department of Mineral Resources, the Department of Energy, the Department of Science and Technology, the Department of Cooperative Governance and Traditional Affairs, the Department of Agriculture, Forestry and Fisheries, the Department of Health, the Department of Rural Development and Land Reform, Working for Water, the National Planning Commission in the Presidency and the related Portfolio Committees of Parliament represent the other stakeholder groups
- Major water users including farmers, mines, industries, energy, water service providers and civil society
- Academy of Science of South Africa (ASSAf) is a long standing partner to the WRC. The KSA supports ASSAf in water resource matters and is a Deputy Chair of the National African Academies of Sciences Water Working Group.
- Orange-Senqu River Commission (ORASECOM), a partner on the Organising Committee of the International Water Conference to take place in November, 2012
- South Africa shares many rivers with its neighbouring countries; therefore, the governments and major water-user groups from these countries constitute the fifth group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.
- Water use communities at large

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

Other stakeholders

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

International players

As in previous years, the WRC maintained its peer review and best practice through continuous interactions with international role-players. Some of its major international partners include:

- CapNet, and a number of their extended networks
- The World Water Council, of which the WRC is a member
- United Nations Agencies such as the UN Environment Programme
- The WRC is the Chair of the Southern Africa Regional office of TIGER which is an initiative of the European Space Agency (ESA) in collaboration with SANSA, the South African National Space Agency, and DWA

- The WRC is the Secretariat of the UNESCO International Hydrological Programme (IHP) National Committee
- The WRC is the Chair of the SANCHIAS 2012 Conference Organising Committee
- Together with GWP Southern Africa, the WRC is reviving the Country Water Partnership and is a member of the SATAC, the GWP Southern Africa Technical Advisory Committee
- The WRC is also a partner in the IWA as the chair of their Groundwater Working Group
- In WISA, the WRC is the Chair of the Legal Subcommittee of the Management Division
- Numerous partnerships, at a project level, exist with the World Bank, the UNESCO IHE, University of Osnabrück, United States Geological Survey

KSA members are invited internationally to make technical contributions in most of the fields relevant to this KSA, mainly institutional governance, climate change, water quality, water resource protection and groundwater and hydrology research.

RESEARCH PORTFOLIO FOR 2012/13

During the past funding cycle the research community was given the opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. The 2012/13 plan was informed by the needs expressed by the board of the WRC and the Minister's committee on improving business processes within the DWA, as well as by the 50-year planning horizon of the National Planning Commission. Broad stakeholder inputs, as well as continuous interactions with various strategic partners, have informed the portfolios.

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 2012/13 addresses this primary objective through the Government delivery Outcomes 6, 7, 9 and 10, and as reflected by the following secondary aims to:

- 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
- Create focus for water quality research by prioritising two crucial concerns: eutrophication and microbial contamination while dedicating attention to implementation challenges
- Protect water sources in a comprehensive and integrated manner by focusing on supporting implementers
- Mainstream climate change discourse to pay closer attention to water

COMPLETED PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 2: Compliance and enforcement

Embedding property rights theory in cooperative approaches to the management of aquatic ecosystem services in South Africa
Duncan Hay and Associates; SANParks; Monash University South Africa; Prime Africa Consultants
No. 2073

In South Africa, with a growing appreciation of water scarcity, we have seen a shift away from the notion of ownership to rights of use. This shift marks explicit acknowledgement that water and the associated ecosystems need to be understood and managed as common pool resources. As our understanding of the links between ecosystems and society has developed we are encouraged to view ecosystems as providers of services from which we can derive benefits. Society's interest in aquatic ecosystems is thus focused on how the benefits of access to and use of services should be apportioned, a process that requires trade-offs and collective decision making. The need to allocate rights to benefit from ecosystem services that are highly variable in time and space stresses the central importance of understanding the concept of property rights in the context of common pool resources and embedding this in dialogue addressing the sharing of benefits. A scan of the international literature indicated that well developed and specifically detailed property rights regimes might contribute significantly to the equitable and efficient governance of common pool resources. With this in mind, this report:

- Explores the salient attributes of property rights regimes, particularly common property regimes that sustain cooperative approaches to management over long periods of time
- Identifies property rights knowledge gaps in the management of water resources in South Africa
- Analyses national policy and legislation with a view to assess the extent to which property rights theory and understanding have been integrated
- Develops a collective understanding of how property rights regimes, particularly common property theory, influences the management of aquatic ecosystem services in South Africa
- Services the WRC knowledge hub and those who benefit from it, by contextualizing property rights within the water sector

Cost: R600 000
Term: 2011 - 2013

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Management of human-induced salinization in the Berg River catchment and development of criteria for regulating land use in terms of salt-generating capacity
University of Stellenbosch; University of the Western Cape; CSIR; Department of Agriculture, Forestry and Fisheries
No. 1849

The objectives of this work were to (a) quantify water and salt balances for various land uses and farm management practices, (b) set up a hydrological model of the Sandspruit catchment for predictions of salt loads to the Berg River, and (c) develop land use regulation guidelines in terms of salt generation capacity. Results showed much higher evapotranspiration in the Renosterveld than in the wheatfield. This explained the lower water table levels in this area and why rising water tables in the cultivated land increased saline seep into the river. Although salt is still being naturally imported into the catchment via rainfall and wind, this increased saline seep has been increasing the salinity in the Berg River for decades. Guidelines for managing land use involved the following main factors: the ratio of area covered by perennials (like Resnosterveld) versus annuals (like wheat); the cultivation practice; the presence of contour banks; the occurrence of salinity in the landscape; accumulation of water in the landscape; and the routes water uses to reach the river.

Cost: R2 964 000
Term: 2008 - 2012

Development and application of global navigational satellite systems methodology for groundwater resource assessment
Umvoto Africa; Department of Rural Development and Land Reform; Overstrand Municipality; Purdue University
No. 1851

This study, through its involvement in particular aspects of global navigation satellite system (GNSS) technology related to water resources, contributes substantially to a broadening of the vision in the South African Earth Observation Strategy (SAEOS) framework for coordinating and integrating South Africa's Earth Observation capacities through the full spectrum of geosphere levels, from lithosphere to hydrosphere, atmosphere and ionosphere. The specific aims of the project were: (1) to demonstrate the use of high-precision GNSS technology as a tool for groundwater resource monitoring and assessment; (2) to develop the methodology for relating GNSS measurements of natural or abstraction-induced surface deformation and conjunctive hydrogeological data in order to derive the in-situ, bulk elastic properties (e.g. skeletal compressibility) of an underlying confined fractured-rock aquifer; and (3) to build South African capacity to establish the hydro-geodetic technical infrastructure and implement the data-processing methods required for groundwater resource monitoring. The study methodology had three main components, namely: (1) hydrogeological monitoring network (including borehole network with logged water levels, pumping regimes and water chemistry monitoring, pumping test results and weather station); (2) geodetic monitoring network (including TrigNet site HERM, later becoming International GNSS Service (IGS) site HNUS, three global positioning system (GPS) monitoring sites installed on the sites of production boreholes and the establishment of GPS data-processing infrastructure and software); and (3) combined hydrogeodetic synthesis of cGPS-derived deformation and hydrogeological forcing factors in order to establish elastic compressibility properties of the Gateway aquifer relevant to the improved calculation of groundwater storage and yield. The hydro-geodetic analysis in the case study area showed that the horizontal displacements at the Hermanus GPS sites are closely aligned with the calculated horizontal velocity components of the Nubia plate relative to the International Terrestrial Reference Frames (ITRF) reference frame. The vertical displacements at the Hermanus GPS sites show varying long-term trends (upwards at HGW1, downwards at HGW2 and flat at

HGW3) with a high frequency of peaks and troughs that correlate between sites but do not have a clear link to pumping or atmospheric phenomenon at a daily (one session per day) time-scale. At a shorter time-scale (eight sessions a day) the vertical movement at HGW3 (relative to HNUS) shows a clear downward movement followed by an upward movement in response to a pump switch off at GWE06. This may be due to a stress effect in the aquifer after pumping that could be explained by the Noordergum Effect.

Cost: R1 000 000
Term: 2008 - 2012

A comprehensive short- term heavy rainfall forecasting system for South Africa with first implementation over the Gauteng Province (SHORTRAIN)
University of Pretoria; Agricultural Research Council, Bureau of Meteorology, EUMETSAT; Finnish Meteorological Institute; South African Weather Service
No.1906

The aim of this project was to develop an ingredients-based rainfall forecasting system for the summer rainfall areas of South Africa and specifically the Gauteng Province in order to better understand heavy rainfall occurrence over the province. The methodology involved investigation of the thermodynamic conditions associated with heavy rainfall over Gauteng, construction of lightning climatology over Gauteng, identification of the lightning characteristics associated with heavy rainfall and development of a map which indicates convective initiation over South Africa using lightning data. A short-term rainfall ensemble for verification of results using a summer rainfall season was then constructed. The findings were that the January months have the highest monthly average rainfall as well as the highest number of heavy and very heavy rainfall days. The central and north-western parts of the province experience the most events in which the rainfall at a single station surpasses 75 and 115 mm. Significantly high seasonal rainfall is associated with above-normal rainfall in late summer. December is the month with the highest number of lightning strikes and March is the month with the lowest number of strikes. When an average number of heavy rainfall events occurs over Gauteng there is significantly more lightning than the average value.

Cost: R965 900
Term: 2009 - 2012

The hydrogeology of Groundwater Region 10: Karst belt
Dr JP Venter Consulting Services; Engineering and Exploration Geophysical Services; GEOSS - Geohydrological and Spatial Solutions International (Pty) Ltd
No. 1916

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 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. Groundwater Region 10 stretches from approximately Delmas and Springs, east and southeast of Johannesburg, respectively, to the Botswana border north of Mafeking, an east-west distance of just over 300 km. It has a

roughly triangular shape extending from the Delmas/ Springs area in the east to a maximum width of almost 100 km in the west where it abuts against granitic basement rocks and a short section of the Botswana/ South Africa border. Region 10 has been subdivided into three areas: (1) Northwest area (between the Botswana border and longitude 27°); (2) Tarlton area (between approximate longitudes 27°30' and 28°), and (3) Pretoria/ Bapsfontein area (between approximate longitudes of 28° and 28° 30').

Cost: 550 000
Term: 2009 - 2012

Delineating quinary catchments for South Africa and modelling their associated hydrology
CSIR; University of KwaZulu-Natal (Durban); Rhodes University; Department of Water Affairs; Southern Waters Ecological Research and Consulting; University of the Witwatersrand
No. 2020

Nested hierarchical catchments are employed in a wide range of applications (e.g. water resource management, conservation planning, environmental impact or flow assessments, climate change or hydrological modelling, etc.). However, quaternary catchments are fairly large topographical units within which the physiography is highly heterogeneous. This makes quaternary catchment interpolation to finer resolutions incorrect. Presently, there are efforts for sub-delineation of catchments both locally and internationally but these efforts are piecemeal. Thus the consistent and standardized methods and protocols for sub-delineation are lacking, and conflicting boundary extractions hinder data sharing and comparison of assessment and monitoring information. Therefore, this project was initiated to produce a fifth-level, quinary catchment GIS layer with linked hydrology, for which the pre-cursors were altitudinal and river network quinary catchments. This report discusses the methodology used in creating altitudinal quinaries and the methodology used to assign daily hydrological data. The methodology used to transpose the daily hydrological data to the river network quinaries is given for the following hydrological information: daily rainfall values; daily minimum and maximum temperatures; daily values of solar radiation; daily vapour pressure deficit; reference potential evapotranspiration; hydrological soils attributes and hydrological baseline land cover types.

Cost: R295 000
Term: 2010 - 2012

HYLARSMET: A hydrologically consistent land surface model for soil moisture and evapotranspiration modelling over Southern Africa using remote sensing and meteorological data
Pegram and Associates (Pty) Ltd; Joseph Fourier University of Grenoble; University of Cape Town; University of KwaZulu-Natal (Westville); Vienna University of Technology (TU Wien)
No. 2024

The purpose of this project was to make substantial improvements to the existing methodology and software implementation for modelling soil moisture information/maps over South Africa (generated in the fore-runner WRC Project K5/1683) in order to provide soil moisture and evapotranspiration data at appropriate scales to institutions responsible for flood forecasting, drought monitoring, crop modelling and catchment management. Through this project an automated modelling system that produces country-wide estimates of soil moisture state (and actual evapotranspiration as

a by-product), at a 3-hour time-step on a 12 km spatial grid, has been established as a practical and useful product which has been adopted for operational use by the South African Weather Service (SAWS) in their national Flash Flood Guidance (FFG) system. This product informs numerous other fields (other than FFG), particularly in agriculture, for which soil moisture estimates are beneficial, such as crop modelling and drought monitoring.

Cost: R1 423 000
Term: 2010 - 2013

Programme 2: Surface water / groundwater hydrology

Nutrient and organic carbon fluxes from small-scale agriculture
University of KwaZulu-Natal (Durban); University of Pretoria; Institute of Research for Development (IRD)
No.1904

An improved understanding of the processes of land degradation, either by sheet or linear erosion, and the impact of these on vegetation cover, land management and fluxes of water, nutrient and organic carbon, constitutes one of the most important evaluation prerequisites for successful improvement of ecosystem functioning. The results of this study showed that on gully formation and evolution, adequate mitigation of linear erosion can only be achieved by lessening soil piping and bank collapse. No-tillage not only decreases soil erosion, but exporting of the mulch (as forage for small-scale farming or as a potential source of energy/ biofuel in large-scale farming) can also reduce soil CO_2 emissions and thus mitigate climate change. The study tends to contradict the popularly-held attribution that overgrazing is responsible for land degradation. A simple shift in the way livestock are managed, where pasture rotation could replace free grazing, could help to rehabilitate the land and increase livestock density in the future.

Cost: R1 639 600
Term: 2009 - 2012

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

Characterising fractured rock systems is probably one of most challenging hydrogeological problems, due to their heterogeneity. South African aquifers are predominantly fractured. Fracture connectivity and hydraulic conductivity controls groundwater flow and transport processes. Several approaches can be used to characterise fractures; all are based on certain assumptions which are difficult to meet in reality. Fracture geometry and other features are sometimes measurable in the field and based on these measurements a method of 3-D fracture connectivity, based on statistical and 3-D geometrical principles, was developed.

Cost: R300 000
Term: 2010 - 2012

Programme 3: Water resource planning

National water resource planning for operational needs: an update of applied approaches (Phase 1): Integrated modelling for water resource planning and operational management
University of KwaZulu-Natal (Pietermaritzburg); DHI (SA); University of Colorado; Inkomati Catchment Management Agency
No. 1951

The aim of this project was to develop an integrated modelling framework to support water resource managers by meeting some of the modelling requirements identified for water resource planning and operations. This project has demonstrated that integration of independent domain models using OpenMI is possible, and has explained and demonstrated the advantages of model integration in being able to better represent real-world complexity and thus provide a systems view of water resource systems.

Cost: R2 300 000
Term: 2009 - 2013

Programme 4: Water resource infrastructure

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

The Berg River Dam is equipped with the first multi-level draw-off environmental flood release outlet in South Africa and can release flows of up to 200 m^3/s. The outlet is controlled by a radial gate and is protected by a vertical emergency gate. Commissioning tests of the emergency gate in 2008 found that large volumes of air were expelled from the air supply shaft designed to reduce expected negative pressures in the conduit during emergency gate closure. In 2009 the WRC commissioned Stellenbosch University to investigate the air entrainment phenomenon at dam bottom outlet works during gate closure. The study, comprising of tests on a 1:40 scale physical model and a two-dimensional numerical computational fluid dynamics (CFD) analysis, was inconclusive on the cause of the large air releases. Volume I of this report covers subsequent study using a 1:14.066 scale physical model. The accompanying Volume II covers a study using three-dimensional CFD analyses. Simulations of continuous gate closure on the as-built physical model of the Berg River Dam outlet showed predominant inflow of air into the airshaft during emergency gate closure with short high speed air releases while the emergency gate was between 35% and 25% open. The problem was determined to be one of air blowback in the air shaft rather than continuous air release. The cause of the blowback was found to be the constriction of flow at the radial gate chamber. A number of modified model configurations were tested and recommendations were made for future design. The most crucial of these is that flow in high-headed outlets should not be constricted.

Cost: R1 057 800
Term: 2009 - 2012

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

Golder Associates Africa (Pty) Ltd; Chamber of Mines; Tshwane University of Technology; Department of Water Affairs

No. 1970

The objectives of the project were to (i) develop an understanding of source-resource relationships in respect of South Africa's surface water and groundwater resources and to capture this understanding in a water quality map for South Africa; (ii) develop a tool based on the above data and possibly additional determinants that could be used to identify hotspots for prioritization and implementation, and (iii) contribute towards strategic intervention in the deteriorating water quality in South Africa. 'Priority' maps were produced that used coloured icons to indicate surface water monitoring points that were 'low', 'moderate', 'high' or 'very high' priority. This priority category was based on standardised rating curves for the following parameters: EC, pH, Na, K, Ca, Mg, Cl, F, NO_3, SO_4, NH_4 and PO_4. 'Source fingerprinting' maps were also produced for each WMA based on the ratios of various combinations of anions. Certain pollution sources are known to have characteristic ratios of anions. Icons were coded by colour and shape which allowed possible generic sources of the pollution to be identified.

Cost: R500 000
Term: 2010 - 2013

Programme 2: Water quality modelling

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

North-West University (Potchefstroom); Agricultural Research Council - Grain Crops Institute; University of the Free State (Institute for Groundwater Studies); North-West University (Mafikeng)

No. 1966

The aims of the project included (a) quantifying selected waterborne pathogens, (b) assessing the usefulness of molecular fingerprinting, (c) measuring cytotoxicity, and (d) investigating the risks of consumption of water from sources in the North West Province. Generally speaking, a degree of both chemical and microbiological contamination was evident in some surface and groundwater in North West Province. Some antibiotic resistance was also evident in faecal coliform bacteria and enterococci. There was also some evidence of pathogenic *E. coli*. A social study examined (a) how and for what reasons communities in the province interact with water, and (b) possible differences between two such communities in a high- and low-rainfall area. There were differences between the two community groups in respect of their perceptions of how their water is managed. The uses of water appear to be similar in most communities. The results confirmed that most people have a strong spiritual and cultural connection with water.

Cost: R1 204 800
Term: 2010 - 2012

Investigations into the existence of unique environmental *Escherichia coli* populations
University of Pretoria; City of Tshwane; ERWAT; South Dakota State University; North-West University (Potchefstroom)
No. 1967

Escherichia coli is widely used as an indicator of recent faecal contamination. This is based on the assumption that it does not multiply or survive for long periods outside the intestines of warm-blooded animals. However, several recent studies have reported that some *E. coli* strains are capable of surviving and multiplying in the environment and were present in the absence of any obvious faecal contamination. This raises questions about the suitability of *E. coli* as an indicator. The overall aim of this study was to obtain *E. coli* isolates from local water resources and determine whether or not populations exist that are distinct from that found in humans and warm-blooded animals. In a series of samples from dams in the highveld region, it was evident that there was a high level of diversity within the *E. coli* population isolated from aquatic environments. Although many of the strains isolated could not be distinguished from the sewage isolates, there was some evidence that some plant-associated isolates showed some level of separation from the rest of the *E. coli* population. Future studies could focus on these genetically distinct *E. coli* strains to establish the degree to which they affect interpretation of *E. coli* analyses performed to protect human health.

Cost: R600 000
Term: 2010 - 2013

Programme 3: Impacts on and of water quality

Guidelines for EDC Management in Water Resources: Volume 4: Management Options for EDCs in Catchments
Golder Associates Africa (Pty) Ltd; Zitholele Consulting (Pty) Ltd; Tshwane University of Technology
No.1933

The aim of this project was to provide water resource managers with a catchment perspective on the management of endocrine disrupting compounds (EDCs). Some EDCs cause effects at concentrations orders of magnitude lower than those levels associated with, for example, carcinogenicity. Furthermore, these levels may be below typical limits of analytical detection. While some work has been done on the occurrence and effects of EDCs in South Africa, generally our knowledge of occurrence and effects on people and the environment remains limited. This means that considerable emphasis should be placed on prevention rather than cure. Management strategies include using existing legislation, adaptive management, applying the precautionary principle, the 'duty of care' concept, self-regulatory approaches and incentive-based regulation. Risk management, including structured risk communication which carefully considers perceived risk and acceptable risk, provides a sound overall framework within which to approach EDC management.

Cost: R1 500 000
Term: 2009 - 2012

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Investigation of the fate and transport of selected microorganisms in two simulated aquifer conditions in the laboratory and in the field
CSIR; University of the Free State (Institute for Groundwater Studies); University of the Western Cape; Department of Water Affairs; Insight Modelling Services
No.1905

The objective of this project was to investigate the fate of microorganisms under selected geohydrological conditions. The specific activities undertaken to achieve this included a literature study, evaluation of models that are suitable for South African groundwater conditions, investigation of the fate and transport of the microbes in the simulated aquifer conditions and in the laboratory, and modelling transport of the microorganisms, including simulation of the lab and field results. Detailed formulation of modelling requirements for fate and transport models was also completed and a prototype model was run using curve-fitting algorithms and data. Other findings were that attachment and deposition kinetics of microbes are mainly determined by electrostatic interactions, and that increased temperatures are associated with a substantially higher adsorption rate to particulate matter in an aquifer, while decreasing temperatures play a role in detachment. Studies also showed that transport and deposition behaviours differ between viruses and bacteria as they respond differently to specific chemical and physical factors.

Cost: R1 406 000
Term: 2009 - 2012

Assessment of the prevalence of human viral and bacterial pathogens in rivers and dams in Amathole District Municipality of the Eastern Cape Province of South Africa
University of Fort Hare; University of California; Walter Sisulu University
No. 1968

The aims of this project were to select a series of rivers and dams in the Amathole District Municipality in the Eastern Cape Province, establish the viral, bacterial and physicochemical properties of the waters, assess fitness-for-use, and assess the human health risks associated with the viruses. The Tyume and Buffalo Rivers were chosen. Most of the physicochemical results were within target water quality ranges for domestic use, except for some pH and turbidity values. The bacteriological qualities of the water (based on total coliforms, faecal coliforms and enterococci) in both rivers was poor. Adenovirus, norovirus, rotavirus, hepatitis A virus and enterovirus were found in the Tyume River in 0 to 31% of samples (depending on the virus) and in the Buffalo River in 10 to 43% of samples. Although there are considerable uncertainties associated with the estimated human health risks due to the viruses, indications are that likely risks of infection may be above acceptable levels.

Cost: R680 000
Term: 2010 - 2012

THRUST 5: WATER RESOURCES AND CLIMATE

Programme 1: Predictive tools

Tropical systems from the southwest Indian Ocean into southern Africa: Impacts, dynamics and projected changes
Agricultural Research Council, University of Pretoria
No. 1847

This project aimed to investigate the influence of tropical systems (such as cyclones, storms, and depressions) from the South West Indian Ocean (SWIO), over the Limpopo River Basin. These systems are associated with widespread heavy rainfall and subsequent flooding over the Limpopo River Basin. The resultant rainfall over the Limpopo River Basin is historically confined to the January–March period, with a maximum around early February. Less than 10% of the average annual rainfall can be attributed to these systems, yet widespread heavy rainfall events are mostly the result thereof over the region. Deep negative vorticity values are usually confined to regions to the south of the southern African subcontinent while tropical systems are steered towards and into the subcontinent within a warm subtropical upper air ridge. At climate-change time scales, the influence of tropical systems from the SWIO over the Limpopo River Basin is expected to decrease by the late 21st century under enhanced anthropogenic forcing. This is due to a simulated intensification of the subtropical high pressure systems over the northern and eastern parts of the southern African subcontinent, responsible for steering these systems further north, where an increase is simulated.

Cost: 680 200
Term: 2008 - 2012

Modelled sea-surface temperature scenario considerations and Southern Africa's seasonal rainfall and temperature predictability
South African Weather Service; University of Pretoria; Centre for High Performance Computing (CHPC); International Research Institute for Climate and Society
No.1913

The research team developed and then configured an ocean-atmosphere coupled climate model for operational seasonal forecasts. The two-tiered forecasting system administered by the SAWS was also optimized and brought to the standard currently practised by leading international centres which are still running two-tiered forecasting systems operationally. This optimized forecasting system demonstrates large-scale consistent skill improvements over the old system for a number of variables including, inter alia, surface temperature and rainfall. The results indicate that the coupled models are more skilful than the atmospheric general circulation models in predictions over the equatorial regions and in discriminating between hotter or colder events on a global scale. Coupled models were also found to be relatively more robust in reproducing the observed slow evolving inter-annual modes of variability. The coupled model was found to be superior to the uncoupled model in predicting rainfall both deterministically and probabilistically, while the uncoupled model appeared to outscore the coupled model over South Africa in both the multi-model system and the slow inter-annual component that accounts for the sub-seasonal forcing. The main conclusion from this analysis was that the coupled model is superior to the uncoupled model.

Cost: R488 625
Term: 2009 - 2012

Programme 2: Climate change risk, vulnerability and adaptation

Investigation of effects of climate change on eutrophication and related water quality and secondary impacts on the aquatic ecosystem
Golder Associates Africa (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); DH Environmental Consulting cc; University of Stellenbosch
No. 2028

Eutrophication is a process of nutrient enrichment of a water body, either natural or unnatural, resulting in a reduction in species diversity at all trophic levels. Research indicates that the extent of eutrophication has increased in South African water bodies since its discovery in the 1970s, increasing the problems of high concentrations of algae and reduced water quality. Hence, the aim of this project was to investigate the impacts of climate change on eutrophication and to determine effects of resultant decreased dissolved oxygen on aquatic ecosystems. The methodological approach entailed an extensive literature study, interviews with experts and various stakeholder workshops and meetings. Some of the key activities included use of downscaled General Circulation Models (GCMs) to project changes in rainfall and temperature under A2 climate scenarios across the country at quinary catchment level. This information was used as a basis for the identification of impacts on the selected case study systems. This report summarises the water quality modelling exercises carried out for this project, provides an investigation into the impacts of these changes, and provides recommendations for adaptation and mitigation options.

Cost: R1 500 000
Term: 2010 - 2013

Programme 3: Integrated flood and drought management

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

The purpose of this study was to investigate changes in the characteristics of extreme rainfall by establishing relationships between existing station data and the daily synoptic states. To achieve this aim, the main objectives entailed producing rainfall station data set that had been quality controlled according to international standards so that these data could be confidently used in identifying key synoptic processes that resulted in extreme rainfall, based on the cleaned station data and atmospheric circulation fields and trends in these. The methodology entailed application of station data quality control to station data obtained from the CCWR, ARC and SAWS. Despite errors and conflicts identified among the datasets, a quality-controlled station data set that could be used in the rest of the study was produced. The regionally specific characteristics of extreme rainfall in South Africa were also identified. Findings were that: summer recorded the highest occurrence of extreme rainfall in all regions with the exception of the South Western Cape and South Coast regions. Based on the results, it was recommended that extreme rainfall regimes should be identified as opposed to general rainfall regimes, an event-based classification procedure of extreme rainfall synoptic circulation modes should be used, a climate change study on projected changes in the characteristics of extreme rainfall CODEX framework should be undertaken, and a downscale to station scale the new CMIP 5 GCM data must be done to compare with contemporary station data.

Cost: R420 000
Term: 2010 - 2012

CURRENT PROJECTS

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

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

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

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

The development of an institutional adequacy index using the multi-dimensional poverty approach
University of the Western Cape
No. 1971

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

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

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

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

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

Advancing Strategic Adaptive Management (SAM) as a framework for implementation of IWRM by catchment management agencies
University of the Witwatersrand
No. 2072

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

- Actively partnering with the ICMA to implement the Inkomati CMS in a participatory and adaptive manner that is cognisant of the demands of complex system management

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

Estimated cost: R1 637 975
Expected term: 2011 - 2014

Change-oriented learning and water management practices: knowledge flows and mediation tools
Rhodes University
No. 2074

The aim of this study is to:

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

Estimated cost: R900 000
Expected term: 2011 - 2014

Investigating stakeholder engagement cycles and identities within water resource management, using narrative techniques
The Narrative Lab
No. 2076

This study will be undertaken in collaboration with Monash University and other notable researchers and will focus on investigating the stakeholder engagement cycles and stakeholder identities that impact on effective water resource management within three contexts selected according to current engagement levels. The study will utilise a narrative research paradigm to ascertain the history of stakeholder engagement at the focus sites, to understand and interrogate the cyclical nature of engagement. The study will also aim

to identify the identity discourses that prevail within varying levels of engagement, with a particular focus on the volunteer identity. The second leg of the study will aim to identify the high potential opportunities that occur within stakeholder engagement cycles so that locations with water resource challenges may leverage the opportunities that present themselves in the future for stimulating increased and sustainable stakeholder engagement.

Estimated cost: R746 108
Expected term: 2011 - 2014

Programme 2: Compliance and enforcement

Development of the AWARE model for the Inkomati CMA
University of KwaZulu-Natal
No. 1935

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

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

Considering alternative dispute settlement practices for water resources management In South Africa
University of Stellenbosch
No. 2077

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

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

Programme 3: Pricing and financing WRM

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

This study is aimed at: (1) framing possible government and corporate responses at a basin level which reflect the shared risk paradigm, the political economy of water use and the challenges of future development and climate uncertainty. It also intends to (2) improve the understanding of the political economy of water use in a river basin, based on the use and movement of embedded water in goods and services, at subsistence,

local market, regional economic and international trade levels, and considering linkages into food, energy and water security. The study will (3) develop and improve tools and approaches for quantitatively and qualitatively evaluating basin water use and its political economic implications, under future climate and development uncertainties, and (4) foster dialogue between government, corporate and civil society representatives about the use, protection and development of basin water resources to secure political, economic, social and ecological development imperatives, through the lens of shared risk in a basin with increasingly stressed water resources.

Estimated cost: R700 000
Expected term: 2011 - 2014

An analysis of water pricing instruments governed by the DWA water pricing strategy, and its potential for generating revenue for CMAs
Prime Africa Consultants
No. 2078

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

Estimated cost: R610 000
Expected term: 2011 - 2014

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

Programme 2: Surface water / groundwater hydrology

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

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

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

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

It has been recognised that there is an intrisic and interactive relationship between soil and hydrology; thus

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

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

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

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

Estimated cost: R800 000
Expected term: 2010 - 2012

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

Groundwater-surface water interaction: From theory to practice
University of the Free State
No. 2054

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

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

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

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

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

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

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

Estimated cost: R400 000
Expected term: 2011 - 2013

Validation of the forcing variables (evaporation and soil moisture) in hydrometeorological models
University of KwaZulu-Natal
No. 2066

This project aims to:

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

Estimated cost: R700 000
Expected term: 2011 - 2014

Programme 3: Water resource planning

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

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

Estimated cost: R450 000
Expected term: 2010 - 2011

Optimal utilisation of geothermal water resources
UNISA
No. 1959

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

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

Development of a groundwater resource assessment methodology for South Africa: towards a holistic approach
University of the Free State
No. 2048

Project aims:

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

Estimated cost: R980 000
Expected term: 2011 - 2013

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

Project aims:

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

Estimated cost: R600 000
Expected term: 2011 - 2014

Programme 4: Water resource infrastructure

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

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

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

Programme 5: New water

Optimising fog water harvesting
UNISA
No. 2059

Project aims:

- Understanding the physical and chemical complexities of fog and its formation: a) to determine the physical and chemical characteristics of East and West Coast fogs (drop size, density, moisture content, biological and chemical characteristics; b) to determine the factors affecting the occurrence

and moisture content of fog (including the relationship between fog occurrence and rainfall, wind speed, sea surface temperature, upwelling extent (west coast), synoptic conditions (west coast); c) to determine the possible influence of climate change on the fog phenomenon and associated environmental and social impacts

- Optimising the fog water harvesting processes: a) to delineate optimal sites for fog water collection; b) to evaluate different materials so as to identify the most effective fog water collector; c) to assess the impact of the erection of fog water collection systems on the environment; d) to investigate possible alternative uses for fog water
- The development of novel products: a) to design and build a water flow meter for low-flow conditions; b) to design and develop fog water harvesting systems for unique/specific environmental conditions; c) to develop a low-cost optical fog detector with LWC potential; d) to develop new materials for fog water harvesting

Estimated cost: R2 500 000
Expected term: 2011 - 2015

THRUST 3: WATER QUALITY MANAGEMENT

Programme 1: Water quality monitoring

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

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

Estimated cost: R175 000
Expected term: 2010 - 2014

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

Programme 3: Impacts on and of water quality

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

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

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

THRUST 4: WATER RESOURCE PROTECTION

Programme 1: Source water protection

Vadose zone hydrology: Spatial and temporal influences, assessment techniques and aquifer susceptibility
University of Pretoria
No. 2052

The safe locating of potential sources of contamination and the mitigation and rehabilitation of contamination can be better assessed based on an improved understanding of the spatial (or lateral), vertical (or horizon-based) and temporal (or time-dependent) influences on vadose zone seepage. This project will

investigate the behaviour of water and solute within the unsaturated zone and evaluate field, laboratory and empirical assumptions currently being made to assess the fate and transport of contaminants in the vadose zone.

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

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

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

Estimated cost: R1 100 000
Expected term: 2011 - 2013

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

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

Estimated cost: R740 000
Expected term: 2011 - 2013

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

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

to fixation of Fe (II) in SA aquifers would be through the in situ iron removal treatment.

Estimated cost: R600 000
Expected term: 2011 - 2014

Programme 2: Land-water linkages

Water Sensitive Urban Design (WSUD) or Low Impact Design (LID) for improving water resource protection/conservation and reuse in urban landscapes
University of Cape Town
No. 2071

The aim of this project is to assist planners in water management through guidelines on water resource protection, conservation and reuse using WSUD or LID. The guidelines will include holistic best management practices and assist in establishing urban spaces that will protect the health of watercourses as well as how to implement these BMPs. Innovative solutions will be developed for, among others, reducing run-off; minimising effluent discharge; increasing recycling opportunities and reducing water demand. This will be achieved within a catchment management framework. It is expected that this project will build on an ongoing WRC project entitled 'Alternative technology for stormwater management'.

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

THRUST 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
No. 2018

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

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

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

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

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

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

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

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

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

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

Estimated cost: R950 000
Expected term: 2011 - 2014

South African climate multidisciplinary analysis
University of Cape Town
No. 2060

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

and researchers in data analysis of large and complex datasets, such as the huge dataset generated by high resolution coupled models or satellite remote sensing.

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

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

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

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

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

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

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

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

Programme 2: Climate change risk, vulnerability and adaptation

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

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

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

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

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

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

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

Climate change is already starting to affect some of the poor and most vulnerable communities around the world. The effect that increased droughts, extreme weather events, tropical storms and sea level rises will have on large parts of Africa will be inflicted in our lifetimes. For some rural communities, the consequences could be apocalyptic. These communities have limited access to essential services, and this is also compounded by uneven distribution and overexploitation of water resources. Understanding sensitivities and vulnerabilities of systems and communities is necessary to inform adaptation action. This approach is particularly crucial since communities' resilience varies according to their adaptive capacities to climate change. These

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

Estimated cost: R700 000
Expected term: 2010 - 2012

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 reform

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' (Ref 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 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

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

- Identify, deliberate and evaluate research questions currently being asked by researchers active in the water sector in South Africa in relation to medium- and long-term future considerations
- Identify, deliberate and evaluate research questions currently being asked by researchers active in the water sector in South Africa in relation to medium- and long-term future considerations

Estimated cost: R300 000
Expected term: 2012 - 2014

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

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

Update of water resources of South Africa (WR2005): Phase 1
SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2143

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

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: R400 000
Expected term: 2012 - 2015

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

The aim of this project is to develop an efficient and effective nonparametric multi-site monthly stochastic rainfall generator that incorporates non-stationarity due to climate change/variability.

Estimated cost: R417 600
Expected term: 2012 - 2014

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

Evaluation of the monthly stochastic rainfall generator in existing Department of Water Affairs risk-based water resources yield assessment processes
Hydrosol
No. 2155

This project aims to:

- Undertake an independent evaluation of the monthly stochastic rainfall generator
- Assess the impact of migrating from the application of monthly stochastic stream flow to monthly stochastic rainfall in water resources yield calculations for various climatic zones
- Quantify and explain the differences in yield results obtained from the two alternative methods
- Undertake a cost-benefit analysis of the full scale implementation of the stochastic rainfall methodology in DWA water resources planning studies
- Develop and communicate recommendations on the process and the way forward with DWA and other stakeholders

Estimated cost: R700 000
Expected term: 2012 - 2014

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

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

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: Water sources protection

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

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

The aims of this project are to:

- Acknowledge the Upper and Lower Fountain in Pretoria, City of Tshwane Municipality, as a heritage site forming part of South Africa's diverse cultural history
- Acknowledge the importance of this site in the history of South Africa and subsequently the need to create awareness at all levels (local resident, education and scientific) to preserve not only the history of the fountains, but also to ensure public understanding and awareness in future
- Embark on such a public awareness campaign for the selected site, aiming to capture the history of the site and to elaborate on the scientific workings for public awareness
- Address available data (if available) for brief interpolation of historical trends and to address the importance of protection of water sources (e.g. Groenkloof Nature Reserve as the protection zone; also including surface water resources)
- Evaluate the water resources heritage and history of the City of Tshwane with the emphasis on Pretoria and its groundwater resources
- Supply the products in electronic brochures, booklets and/or posters for educators, municipalities, leisure and heritage sites, and the scientific fraternity

Estimated cost: R100 000
Expected term: 2012 - 2013

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 validation documentation
- Training and implementation of the method

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

The economics of sustainable aquifer ecosystem services: a guideline for the comprehensive valuation of aquifers and groundwater
Prime Africa Consultants
No. 2165

The aims of this project are to:

- Develop a framework and methodology for groundwater valuation for different hydrogeological settings
- Define and demonstrate the role of aquifers as an ecosystem asset, using the Millennium Ecosystem Assessment framework
- Develop an alternative economic approach to the planning and management of groundwater resources, and develop this into a guideline for the comprehensive valuation of aquifers and groundwater
- Develop an updated estimate of the value of the groundwater economy of South Africa

Estimated cost: R827 350
Expected term: 2012 - 2014

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

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

Programme 2: Climate change risk, vulnerability and adaption

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

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