



KSA 1: Water Resource Management

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SCOPE

The global water cycle plays a key role in the chemical, physical, and biological processes that sustain ecosystems and influence Earth's climate and associated global change. Clouds, water vapour, and precipitation influence, among other process, heating and cooling of Earth's surface and atmosphere which, in turn, affects global circulation and precipitation patterns. Hydrologic data from atmospheric, surface, and subsurface stations are critical to the development of more accurate predictions of water distribution and availability, cloud formation, and precipitation in a changing climate. The Water Resources KSA carries out a variety of studies, workshops, and meetings and publishes numerous reports on science-policy issues related to most aspects dealing with the water cycle and its impact on the management, protection, use, control, administration and sharing of water resources and vice versa.

The realisation that water is an embedded sector means that the sector needs to be outwardly focused and furthermore it emphasises that many decisions around water are taken outside the water sector, hence expansion of the stakeholder base is important to affect decisions made around water. The urgent need for coordination is evident as the world is already facing the implications of climate change and all the amplified variability, uncertainty, disasters and apprehension it brings with it. The impacts of a changing climate and climatic variability are already being felt, with more droughts, more floods, more strong storms, and more heat waves – taxing individuals, firms, and governments, and drawing resources away from development. Other factors of pollution, population growth, urbanisation, overuse, etc., are weakening the ecosystems. Producing more and protecting better in a harsher climate

with increased uncertainty will be the future challenge of this century for most developed and developing countries around the world including South Africa.

Integration of sectors, disciplines and institutions is as important as coordination for action. Integration in water resource management requires integrating surface and groundwater resources in assessments, planning, decision making, upstream and downstream parameters, local, regional and international scales, water quantity and water quality, data and information systems at the appropriate temporal and spatial scales. The integration required is both extensive and wide, which is easier to state but most difficult to practice in reality. The increased complexity places the management of water resources in the 'wicked problems' category. 'A wicked problem is one for which each attempt to create a solution changes the understanding of the problem. Wicked problems cannot be solved in a traditional linear fashion, because the problem definition evolves as new possible solutions are considered and/or implemented.' The term was originally coined by Horst Rittel (Rittel and Webber, 1973). Such complexity requires action with less predictability, review and continuous learning-while-doing (i.e. adaptive management approaches). Emerging insights from adaptive and community-based resource management suggest that building resilience into both human and ecological systems is an effective way to cope with environmental change characterised by future surprises or unknowable risks. An exciting development regarding the above is the realisation of businesses as large end-users of their role in governing and managing the resource, recognising it as key factor in their production cycle.

OBJECTIVES

The main objective of research in this KSA is to ensure that the water resources of South Africa are protected, utilised, developed, conserved and managed to achieve environmental, social and economic sustainability. The secondary aims have been streamlined from previous business plans to reflect the needs analysis process and the alignment with the respective relevant impact area of water and society, water and the environment, water and the economy and water and health. Thus, the revised aims to support the main objective are to:

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

In the light of the above, the KSA will continue to follow pertinent developments taking place nationally and internationally with regard to water resources. It will also continue to lead the understanding of 'wicked problems', offering a safe space for experimenting and learning to address the numerous challenges faced in water resource management. In so doing, the KSA will continue to provide guidance for policy implementation and the development of policy instruments. The importance of this KSA is to provide the necessary information systems, guidelines, decision-support systems, prediction tools and technologies/methodologies that support planning, development and protection of water resources.

Since the promulgation of the NWA, South Africa has been showcased as having a progressive water law, which incorporates water as a right for domestic use and for the environmental requirements. It also calls for equitable distribution and decentralisation of the management of this vital resource. Custodianship vested in the state would provide for better assessments, compliance and enforcement of laws and policies. However, the progressive nature of the water law does not mean that it is easy to implement. For more than ten years now, policy makers, civil society and research have worked closely together to learn and improve on the implementation of this law.

With our broad base of stakeholders, the main issues of national concern regarding water resources are periodically defined, refined and prioritised into pertinent research questions. In continuation from the previous business plan and based on the needs analysis, the research focus of this KSA will continue to support policymaking 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.

These objectives are achieved in support of the desired impacts on the lives and health of people, on the economy and on the environment.

In view of the above, the thrusts remained the same as in the previous cycle:

- Thrust 1: Water Resource Assessment and Planning
- Thrust 2: Management of Natural and Human-Induced Impacts on Water Resources
- Thrust 3: Water Resource Protection
- Thrust 4: Water Resource Institutional Arrangements

THRUSTS AND PROGRAMMES

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

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

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

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THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

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

- Developing predictive tools and adaptive measures to global climate change and hydro-climatic variability
- Managing human induced impacts on water quality and quantity
- Integrated flood and drought management.

THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water resource management, with reference to point sources and diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation. Scientific and technological approaches that will assist in characterising and addressing these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies, uncertainty, etc.); (3) Technological innovation and (4) Implementation approaches and technology transfer options.

- Protection and management of surface water and groundwater quality
- Urban and rural water resource management
- Integrated river flow and catchment hydraulics.

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Scope: This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders based on catchment and water management area boundaries. The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of integrated water resource management (IWRM). The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust supports research

on tools and methodologies for IWRM decision support which aims to provide strategic intervention for new policy development and to improve the understanding regarding the effective functioning of institutional structures for implementing IWRM through:

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

RESEARCH PORTFOLIO FOR 2010/11

From the rigorous interaction with the stakeholders, the KSA continued to actively pursue the full articulation of the coming new challenges in water resource management. These challenges are not necessarily new but can be viewed in different combinations each year and with newly defined priorities. Continuing to monitor the KSA's impact through research investments on society, environment, health and economy is a means to maintain focus on the true target for making a difference. Competition over scarce or inequitably allocated resources can lead to tension and insecurities. Strategies for reducing demand, increasing efficiency, and tapping into new water resources from targeted recycling, reuse, artificial recharge, etc., will be important research topics. Water as an economic good and aspects of valuing water in the South African context can be complicated due to the prevalent inequities in distribution of the resource and the large poorer population whose ability to pay for water is limited. In all of the above, the need to safeguard society and the economy through early warning systems has been identified. Research results need to be shared and communicated effectively to be optimally used for the benefit of South Africa and further afield. Finally, water governance, which has received a lot of attention recently, continues to occupy centre stage in the water sector bringing with it tremendous uncertainty and optimism from a continued desire for improvement and self reflection. This KSA will continue to be willing to support these processes for a more locally suitable and resilient institutional landscape in the water sector.

During the past funding cycle the research community has been given an opportunity to respond to the water resource management challenges through both the solicited and the non-solicited proposal streams of funding. This year's plan was informed by the needs expressed by the Minister of Water and Environmental Affairs and the broad stakeholder inputs shared earlier, as well as the continuous interactions with various researchers and community members. New solicited calls were prompted by stakeholder inputs and some strategic partnerships, leaving a sufficient amount for non-solicited inputs which normally

bring about interesting and innovative topics, considered according to importance, relevance and budgetary allocations to each thrust.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to a committed and approved funding budget, inclusive of roll-over, of R29 464 022. Funding for new projects of R10 201 450 in 2010/11 was requested to support new projects within the four thrusts. The proposed new projects will continue to develop tools, technologies and guidelines that are necessary to support sustainable water resource management.

CORE STRATEGY

Strategic context

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

Water resource assessments are expected to benefit from improvements in the accuracy and detail of hydrological measurements and how these are interpreted in water resource simulations and other tools for water resource decision making. The extent to which interpolations and extrapolations can be used in modelling real water regimes can only suffice if real, reliable data are available at reasonable spatial and temporal resolutions for verifications. The KSA has invested vastly in enhancing the estimates for quantifying water use and water availability. This year, the KSA also plans to contribute to the streamlining and integration of existing centralised and decentralised water resource information systems in support of the National Water Resource Strategy and the National Information System. Furthermore, the need for integrating surface water and groundwater models has been highlighted. Concerted effort will be made to bridge this gap and to create a continuum starting from improving evapotranspiration estimates, which take into account the unsaturated zone informed by groundwater dynamics.

At a national level the recent momentum towards establishing economic growth and development as the main government driver has seen different sectors, including the water sector, articulating their roles in economic growth

and development. In the water sector this is reflected in the DWA framework strategy Water for Growth and Development (Version 6), where the main objective for water resource management is set to ensure that water resources are allocated for the promotion of social and economic development. In the KSA, research has already started and will continue to address the research issues that will contribute to this government driver of Water for Growth and Development.

The Department of Water Affairs indicated current water quality and quantity as major strategic issues. The KSA recognises the challenge and the need for further research and the provision of knowledge in this regard, as does the WRC. In addition, the KSA foresees that in future these issues will be complicated further with the advent of climate change. The issue of climate change and the linked phenomena of extreme events require both understanding and adaptability. Another linked area is the area of energy including usage of energy by the water sector and production of energy through hydropower. In the light of the above, the importance of expanding the resource via additional or alternative sources and diversifying the 'water mix' is another key challenge. The KSA will continue to support innovative research on the use of hydropower, groundwater, global circulation models and regional evapotranspiration assessments, water reuse and recycling.

The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas.

Water and society

The NWA places emphasis on stakeholder participation in water resource management which forms a blend between decentralisation and democratisation for decision making. Vast resources have been used in ensuring that adequate consultation takes place without necessarily reflecting much value from those investments. International literature confirms that empowerment is a long path which is progressive in nature and highly non-linear. Since the primary focus is to make an impact on the lives of people, the KSA has commissioned studies to establish the lowest appropriate level for decision making in water management in South Africa and the benefits thereof from such engagements and their impact on the lives of women and the poor. The role of local government as the democratic representative of South Africa in water-related decision making is an area that needs further investigation. A benchmarking exercise is currently under way to document international experience in regulations of the sector. With the numerous restructuring efforts undertaken in the sector, it is not easy to establish how the sector will look in the future. In response, scenarios are currently developed

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to map out the institutional landscape by the year 2025 to ensure that current efforts are indeed in support of growing the South African economy by 6% of GDP per annum.

Water and health

The deteriorating quality of water resources including water in some of the major rivers, dams and aquifers has continued to threaten the efficient and sustainable supply of reliable water to various sectors. Previous research has identified a number of water quality challenges. The KSA will seek to support research that addresses the challenges surrounding the provision of suitable and sustainable solutions for water quality issues at the resource level. Special focus is needed on the impacts on water resources from some government policies such as rainwater harvesting and biofuels. The impacts on the health of society, especially those members with compromised immune systems, from land-use practices such as agriculture, mining and endocrine disruptive compounds found in the ecosystem will need to be further understood. The potential for the creation of new water through water recycling, grey-water use and reuse, artificial aquifer recharging, etc., can assist in meeting growing demands for a healthier society. Similarly, and in close association with the recent energy crisis, water infrastructure failings can be one major area that may affect water quality and hence create health issues, and this requires attention. An investigation aimed at quantifying and classifying all national water resource infrastructure is underway. Non-compliant wastewater and water treatment plants prompted a more focused study on the water infrastructure development financial allocation pathways in municipalities, to understand the reasons behind lack of maintenance and upgrades of consistently failing infrastructure in some municipal locations.

Water and the economy

The evidence of global climate change, largely as a result of human activities, has now been documented. There is a growing consensus among global climate model projections regarding the nature and extent of the change. The main climate change consequences which are related to water resources have been identified as increases in temperature, shifts in precipitation patterns, increased frequency and intensity of floods and drought events, and sea-level rises. The KSA has initiated a comprehensive research programme on climate-change impacts on water resources with a view to gaining insight into the magnitude of the impacts and subsequently the consequential adaptation needs for the economy; the first steps to incorporate research on vulnerability, mitigation and adaptation have already been taken. The success of this research relies on the outcomes of considerable prior investment by the WRC in water-related climate, atmosphere and ocean-atmosphere research, as well as hydrological modelling

research, done over a period of more than 15 years. The KSA will seek to drive further research on climate change to deal with regionalisation of climate change knowledge as well as improving the modelling processes to account for conditions that are consistent with the Southern African region. In this cycle, the KSA has strategically allocated all the solicited funding for the purpose of furthering the studies relating to climate change impacts on society, economy, health and the environment on majority water uses such as urban water supply, agriculture, mining, etc. Thus, in line with WRC aims, this KSA aims at providing the country with applied knowledge and water-related innovation, by translating needs into research ideas and, in turn, by transferring research results and disseminating knowledge and new technology-based products and processes to end-users completely in partnership with beneficiaries and service providers.

Water and the environment

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

- An effective alliance with, and active participation of, water resource research stakeholders
- A systematic, strategic, and balanced agenda of both core- and problem-driven research priorities set to meet short- and long-term needs
- The national water resource research effort should be coordinated to reduce needless duplication and to ensure that gaps do not occur
- Research should be multidisciplinary and interdisciplinary
- Research should be proactive and anticipate the nation's water needs and the environmental impacts of management options

- Research should be accountable to the public to assure that the water resource research investment has been appropriately utilised to meet the nation's needs

The KSA deals with freshwater resources and their management. In the previous business plan covering 2009/10-2011/12, the strategic intent of this KSA was drawn from wide consultation with stakeholders.

In continuation from the previous business plan and based on the needs analysis, the research focus of this KSA will continue to support policy-making by: developing tools and technologies for overall water resource management, supporting decision making by reviewing existing policies and strategies, providing quick responses to immediate and specific research questions in support of national initiatives, providing platforms for debate, building capacity in project teams and steering committees disseminating resultant information as widely as possible and encouraging partnerships through joint projects with key stakeholders. During its formal and informal consultation with the various stakeholders, the KSA has defined the following as research areas needing further attention in this business plan cycle from 2010/11 to 2012/13:

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

Water and business: At a global scale business has begun to seriously consider risk around water availability and quality, with some of the more proactive multinationals having formulated the CEO Water Mandate under the auspices of the UN Global Compact. The CEO Mandate commits signatories to action in the following 6 areas: Direct Operations; Supply Chain and Watershed Management;

Collective Action; Public Policy; Community Engagement; and Transparency. The World Economic Forum (WEF), World Business Council for Sustainable Development (WBCSD) and World Wide Fund for Nature (WWF) are each driving initiatives to understand corporate risk and responsibility around water, including focuses on supply chains and water footprint. Some of the new exciting developments relate to enhanced awareness of the importance of water in development resulting in enhanced participation from large end-users. SABMiller has developed a position statement on water use, analyzing risks surrounding water security and scarcity at its regional operations. The company analyses its water use using an industry metric, the amount of water used to brew a hectolitre of beer, and it recognises that in addition to saving costs, water is a material risk factor for the company, as some of its operations are located in watersheds facing water stress. The company accordingly recognises that it has a part to play in water efficiency in order to protect its resource base. Competition is around security issues which directly relates to allocations and transparency of decision making i.e. governance aspects. The significant role of the end users in ensuring good management of water resources is heightened since the realisation of the immediacy of water scarcity is amplified. Another example of how a common interest of large users to protect water can steer water development is the pilot implementation of BHP Billiton of their eMalahleni Water Reclamation Plant (EWRP). The long-term water management approach for the mine closure at the South Witbank Colliery of BHP Billiton has resulted in the EWRP, a permanent infrastructure put in place to abstract decant mine water from the deepest point in the underground workings for treatment to potable standards and reuse in the local municipality as a new source of drinking water. Further specific inputs were shared during a meeting held between the WRC and the Minister of Water and the Environment, Minister B Sonjica, in 30 September 2010; the issues identified in that meeting are captured above. The following are aspects pertaining to this KSA:

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

Water pollution and regulation: The 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 main-

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tains 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, who will control pollution with a heavy hand. Wetland protection is also of utmost importance as the wetlands play a major role in sustaining the resource and combating pollution.

Africa: The Minister is the new Chairperson of AMCOW and there is keen interest from The Netherlands in supporting AMCOW-Africa. The Minister emphasised the African Water Week and the need for partnership with Africa and supported the NEPAD initiative for building Centres of Excellence for Water Research in Africa.

Other inputs, ideas and concerns from other stakeholders included:

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

Water scarcity with regards to future water supply options; new water such as water re-use, 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 be addressed in a consolidated fashion to satisfy increased demands sustainably. Augmentation options versus new water sources and feasibility studies have been the domain of national planning. Timely implementation of new infrastructure, including the planning cycle, can be enhanced through scenario building and economic valuations. Water accounting has been hailed as an instrument for ensuring the mapping of water footprints. Water footprints are an indicator of water

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

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

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

Uncertainty and climate change go hand in hand. Small uncertainties in the physical processes are amplified into large uncertainties in the climate response. The challenge for policy-makers, planners and environmental decision makers is to understand how the timing and magnitude

of impacts may be affected by changes in climate and sea level rise associated with differing amounts and rates of change in global average temperature. The challenge for climate change research is to develop monitoring and observation systems; refine models to determine the impacts of climate change in a specific area; identify measures to enhance our capacity to adapt (building adaptive capacity) and take advantage of the opportunities presented by climate change; and make information available for those responsible for policy, planning and environmental decision making.

Sectoral and political cooperation: The realisation that water is an embedded sector and needs to be outward-focused emphasises that many decisions around water lie outside the water sector and hence expansion of the stakeholder base is important to affect decisions made around water. Alignment of powers and functions between the 3 spheres of government is defined in the respective laws and legislation. However, the complexity in the management of water and other resources in an integrated manner is proving to be a challenge. This requires a cooperative government functioning seamlessly between national, provincial and local governments. 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 institutional alignment project of the Department of Water Affairs is yet to define the local provision for management of water resources and further define the role, if any, of local government. The reform of water allocations can only be successful if there is complete alignment between the responsible departments, viz, Trade and Industry, Rural Development and Traditional Affairs, Agriculture and Land Affairs, Labour, Treasury, Land Bank, etc. The new Planning Commission calls for futuristic studies which are able to project alternatives in future scenarios. This KSA will invest in research efforts to further define available options in support of national sustainable growth and development.

Public participation: The move towards a common goal for use of the water resource involves identifying conflicting needs for use of the resource, and resolving or negotiating these conflicts. This process would use IWRM tools like water demand management, water quality management, or the conjunctive use of surface water and groundwater resources. This process would also rely on water resource assessment techniques such as water resource yield models or water quality modelling. It is an iterative process of interaction with stakeholders, and of bringing conflicting stakeholders together to resolve potential conflicts. During the above meeting stakeholders indicated that the WRC provides leadership in research and is not a research follower. There is a need to balance current challenges and forecast future research needs. More partnerships with other sectors; local government, private sector and other

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

Overview of technological trends

The National Climate Change Committee (NCCC) mandated DST to lead a Technology Needs Assessment (TNA) in relation to climate change in 2007. The TNA shows that, despite remaining uncertainties regarding the exact nature, magnitude and pattern of future rainfall changes in South Africa, it appears that water resources, already under pressure as a result of growing water demand in relation to a finite and limited supply, will be under even greater pressure in the future as a result of climate change. According to the IPCC Technical Paper on Climate Change and Water of June 2008, major gaps in observations of climate change related to freshwater and hydrological cycles were identified as follows:

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

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

Satellite radar tools and applications: Wider availability and use of satellite radar in water-use and evapo–transpiration monitoring is widely accepted. Our research has continued to improve and investigate new techniques for improving measurements and estimates of evapotranspiration and other variables in the water balance. Most of our users are, however, still stuck in the use of outdated and less reliable sources of information such as open water evaporation data. Our research on evapotranspiration is now looking at how the knowledge gained can be incorporated in some of the commonly-used water management tools. Water legislation and management guidelines are clearly showing that spatial processes such as those in water catchments and in land-use management practices will be driven by remotely-sensed data in the future. In July 2006 the South African cabinet approved the establishment of South Africa's first space agency, an initiative that heralds the wider development of many local and new research activities around satellite development and satellite data applications. Data monitoring using remote sensing is undergoing a revolution in terms of technical monitoring capabilities through the advances in spatial and spectral resolution of new sensors. The continuing improvements to the analysis are also expanding the level of detail that can be extracted from imagery. One of our research projects is now applying hyperspectral imagery to accurately estimate evapotranspiration, plant water content, water stress and plant- or soil-water availability. Unlike low-spectral resolution imagery which covers only selected regions of the electromagnetic spectrum, thus giving more generalised products, high-spectral resolution imagery covers a wide region of the electromagnetic spectrum (approximately 400 to 2 500 nm). This gives more spectral bands with finer bandwidths (generally less than 10 nm). The finer spectral resolution allows for detection of surface materials and their abundances, as well as inferences of biological and chemical processes.

Scenario building as a tool in water management: Scenarios are a way of developing alternative futures based on different combinations of assumptions, facts and trends, and areas where more understanding is needed for any particular scenario project. They are

called 'scenarios' because they are like 'scenes' in the theatre – a series of differing views or presentations of the same general topic. Once several scenarios are produced at the same time, one can better understand the available options or possibilities for informed decision making in the management of water resources.

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

Key stakeholders

The major stakeholders remain to be the following five groups as in last year's Business Plan:

- The Minister of the Department of 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 Minerals and Energy, the Department of Science and Technology, the Department of Cooperative Governance and Traditional Affairs, the National Department of Agriculture, Forestry and Fisheries, the Department of Health, the Department of Rural Development and Land Reform, Working for Water, the Planning Commission in the Presidency and the related Portfolio Committees of Parliament represent the other stakeholder groups
- Major water users including farmers, mines, industries, energy, water service providers and civil society

- South Africa shares many rivers with its neighbouring countries, therefore, the governments and major water-user groups from these countries constitute the fifth group of key stakeholders. South Africa is also a signatory to several international conventions that govern water resource management at all levels.

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

Other stakeholders

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

International player

As in previous years, the WRC maintains its peer review and best practice through continuous interactions with international role-players. A new close association will be witnessed in the following year with UNESCO IHP for which the KSA carries the position of Secretariat for the country committee. Other role-players include: CapNet, an established capacity building organisation hosted in the WRC building and a number of their extended networks such as the Philippines CapNet; SaciWATERS, South Asia Consortium for Interdisciplinary Water Resources Studies; the World Water Council, of which the WRC is a member; and United Nations Agencies such as the UN Environment Programme, which was a partner to the WRC in two completed studies showcased in the Africa Water Week in November 2009. WRC is chairing the review of all the river basins research funded by the Global Environment Facility in partnership with the United Nations University. Waternet contributes experience on an administration of partnerships and GWP and IWMI are leaders in their respective fields. Interactions can be by sharing research projects such as the Water Research Coalition, FRIEND, African Water, and by participating in NEPAD. The KSA is an active partner in a number of EU-funded research coalitions. In other instances, KSA members are invited internationally to make technical contributions in most of the fields, mainly institutional governance, climate change, water quality (mainly in the area of endocrine disruptive compounds), groundwater research and hydrology research, mainly now-casting and innovations in new hydrology models.

STRATEGIC INITIATIVES

National initiatives

Staff members continue to occupy various leadership positions and partake in initiatives (many positions and initiatives are ongoing or set for a term of a number of years). The following are contributions made by the KSA:

- Steering Committee member for drafting National Groundwater Strategy (DWA)
- Member of the Energy and Water SETA task team
- The KSA is assisting DWA in updating the Groundwater Resource Directed Measures manual.
- Presentation to the Water and Environmental Affairs Portfolio Committee on AMD: Groundwater-related research
- Strategic meeting on water with SALGA
- Involved in the Council for Geosciences strategic review

Leadership positions

- Chairperson of the Organising Committee, Groundwater Division - International Association of Hydrogeologists Conference (September 2011)
- Member of Negotiating Team (responsible for water-related climate issues and research), National Climate Change Committee (coordinated by Department of Environmental Affairs)
- Chairperson, National Climate Change Task Team for water hosted by DWA
- Member of the Steering Committee (water issues), Risk & Vulnerability Atlas (coordinated by Department of Science and Technology)
- Steering Committee member, National Outbreak Response team (NORT)
- Steering Committee member, Multisectoral National Outbreak Response team (MNORT)
- Member, Hand washing campaign
- Member, (WASH United Local) (Water and sanitation health)
- Member, National Implementation Plan for Stockholm Convention (NIP)
- Advisor, National Water Quality Forum
- Founding Member, Country Water Partnership
- Board member, Ecolink (an environmental NGO)
- Advisory Board member, Water Research Node, Monash South Africa
- Executive Committee member, African Development Bank and African Water Facility funded project on rainwater harvesting
- Advisory member, National Institutional Realignment Working group
- User Forum Member, National Water Resources Planning Systems
- Member of the Steering Committee of the Working for

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- Water Research Advisory Panel
- Member of the Groundwater Division of the Geological Society of South Africa
- Member, South Africa Committee for the International Association of Hydrological Sciences (SANCIAHS)
- Member, South African National Commission on Large Dams (SANCOLD)
- Member, Vaal River System Strategy Steering Committee
- Member, Crocodile West Maintenance Reconciliation Strategy: Strategic Steering Committee

Strategic positioning

- Discussions with Advisor to Minister on strategic repositioning of the Department of Water Affairs to appropriately respond to challenges associated with climate change.
- Strategic discussions with the Forestry Climate Change Unit at the Department of Agriculture Forestry and Fisheries, addressing the problem of quantification of carbon stocks in forests, which will enhance the understanding of the link between forest degradation and climate change.
- Two MOUs were signed with DWA for consultancies to commence during 2010/2011 with the following titles:
 - Policy implementation lag time
 - The concept of public trusteeship as embedded in the National Water Act of South Africa of 1998
- An MOU was signed with Working for Water aimed at supporting the Two Streams Catchment research in KwaZulu-Natal.
- The KSA was an advisor to the study entitled: 'The State of Water in South Africa' conducted by the South African Academy of Science.
- The KSA is a member of the Energy and Water Sector Education and Training Authority's Task Team developing the Policy, Guidelines, Procedures & Criteria for the recognition of Institutes of Sectoral or Occupational Excellence (ISOE).
- Initial discussions were held on the State of Water Resources in South Africa with Aalia Ismael of the Presidency's Planning Commission, in support of the newly-appointed advisory panel meetings.
- Discussions were held with Dr Jeremiah Mutamba; Manager: Water-Centred Knowledge at TCTA, regarding potential partnerships on knowledge dissemination activities for water resources management
- A meeting was held on 15 July 2010 between the WRC and Dr Dirk Roux of Monash University South Africa and Dr Mark Pascoe of the Internal Water Centre in Australia to discuss capacity building potential.
- In his capacity as a member of the DEA-led National Committee on Climate Change, a research manager attended a planning meeting on 14 July 2010 in preparation for the UNFCCC meeting held in Mexico in December 2010.
- The WRC organised a strategic meeting between WISA and the Global Water Partnership (GWP) to discuss the hosting of the Country Water Partnership (CWP) for South Africa.
- A WRC and SALGA task team roundtable discussion consolidated the partnership between the two parties and a number of research topics were highlighted as priority to be conducted during 2011/12 cycle.
- WRC co-hosted a conference 'Water and Poverty: a dialogue for action' with DWA, Ethekeweni Municipality and the Danish International Aid Department (DANIDA).
- A research manager made a presentation to the Portfolio Committee on Water Affairs on groundwater-related research during the Acid Mine Drainage briefing at Parliament.
- The KSA chaired a session on 'Freshwater ecosystems' in Cape Town during the Summit on Biodiversity upon invitation by SAEON.
- The KSA was invited to make inputs into the strategic plan of the National Department of Agriculture on flood management.
- The KSA was invited by the CEO of Rand Water to attend and participate in the strategic planning meeting of the Board on 5 November 2010 at Muldersdrift.
- KSA 1, jointly with KSA2, held a second strategic meeting with SANParks in which elaborations on joint activities were shared. The proposed use of the national parks as water resource laboratories was welcomed, as well as joint workshops on specific aquatic and terrestrial research.
- Strategic discussions with DWA, North West regional office, were held, as to how WRC can manage and steer the review and scientific evaluation of the *Harties Metsi a me* project as per request from Parliament. The review will be jointly funded by the two parties.
- The KSA participated in the Vaal River Strategy Steering Committee as a member and representative of the WRC.
- The KSA was invited to a meeting hosted by the Provincial Drought Management Centre in Cape Town, to explore potential collaboration in hosting a workshop on debriefing and a 10-year strategic plan for extreme events (such as droughts and floods).

African leadership

In Africa, the WRC plays an active role in activities aimed at building water-centred knowledge. Key initiatives include:

- The hosting of the Southern African Regional Capacity Building Centre: The WRC supports the TIGER Initiative (an initiative by the European Space Agency), a UNESCO-IHP supported programme that is aimed at assisting African countries to overcome problems faced in the collection, analysis and dissemination of water-related geo-information, by exploiting the advantages of earth observation technology. The WRC is, with effect from

December 2009, hosting the Southern Africa regional centre of the TIGER Initiative. An agreement between the TRC and the International Institute for Geo-Information Science and Earth Observation (ITC) of the Netherlands has been entered into in this regard.

A WRC research manager, who coordinates TIGER activities including capacity building for aquatic scientists involved in TIGER projects, also manages the centre.

- A meeting was held with SADC Water Division in Gaborone to discuss the collaborative potential between SDC and TIGER and WRC.
- The WRC, on behalf of UNEP-Sudan hosted a delegation of technical water professionals from the Darfur regions, West of Sudan. A follow-up delegation of 20 representatives, including Ministers of water, agriculture and land, mainly from Darfur, visited South Africa in November to learn from South African scientists about conducting regional water resource assessments and the establishment of decentralised water management institutions.
- The WRC is supporting the proposal for the establishment of the first Category II UNESCO Centre in Africa, called the 'The African Centre for Global Change and Water Resources Research', to be hosted by the University of KwaZulu-Natal.
- The WRC was invited by the Academy of Science of South Africa (ASSAf) to make a presentation on the South African water situation at the NASAC Water Programme Workshop in Nairobi. At the workshop the WRC was appointed as co-chair of the NASAC Water Programme.

Global player

The KSA took part in the following global initiatives, among others:

- The WRC continues to support SAFewater (the French-South African cooperation for research on water), and continues to act as the Secretariat for the UNESCO International Hydrological Programme (IHP) National Committee.
- The WRC continues to be an active member of the Global Water Research Coalition (GWRC), and is currently collaborating with members of the GWRC in research programmes addressing the removal of pharmaceuticals, the influence of EDCs on the thyroid and other ED functions, known, new and emerging microbial pathogens, and the occurrence of pathogens in source water with a special focus on the occurrence of enteric viruses.
- The KSA acted as a reviewer for the *Water Alternatives* journal which is a multi-disciplinary international journal on water, politics and development.
- A workshop was co-convened by the WRC and the World Water Council on 'Water for Growth and Development in Africa – Understanding and Addressing Policy Complexities'. The WRC is a member of the World Water

Council and this workshop is considered as a strategic joint venture which can bring about other collaborations with the Council.

- The WRC hosted the second review meeting of the Global Environmental Facility (GEF) International Waters (IW) Science Assessment, attended by both the River Basins and the Lakes Working Groups.
- A request from the Swiss Embassy was received to host a fact-finding mission from EAWAG and the Swiss Federal Department of Foreign Affairs (FDFA) to South Africa.
- The KSA facilitated and managed the World Bank's global groundwater governance assessment.
- A research manager attended the United Nations Framework Convention on Climate Change (UNFCCC) in Cancun, Mexico, and was involved in supporting the Minister of Water and Environmental Affairs to develop a position paper that ensures that water becomes a standard item on the Convention of Parties (COP) agenda.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

The number of postgraduate students benefitting through WRC-funded research is reflected in the table below. This was in line with the set targets.

TABLE 1
Capacity building through student involvement in KSA 1 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Agricultural Research Council (ARC)	1	3
Centre for Environmental Economics and Policy in Africa	3	3
CSIR	5	10
Golder Associates Africa (Pty.) Ltd.	4	4
Groundwater Africa	0	1
Hydrosoft Institute	1	1
Jeffares & Green (Pty.) Ltd.	1	2
Ninham Shand Consulting Engineers (Aurecon)	2	7
North-West University, Potchefstroom Campus	5	12
Pegasys Strategy and Development (Pty.) Ltd.	0	1
Pegram and Associates (Pty.) Ltd.	6	8
Rhodes University	6	6
South African Weather Service	2	3
SSI Engineers and Environmental Consultants (Pty.) Ltd.	4	5
Umvoto Africa	3	4
University of Cape Town	6	9
University of Kwazulu-Natal	10	26
University of Pretoria	1	4
University of Fort Hare	6	6
University of South Africa	2	5
University of Stellenbosch	8	16
University of the Free State	17	25
University of the Western Cape	8	9
University of Venda	10	10
TOTALS	111	180

In total 16 project leaders were women (compared to 18 in 2009/10) and 17 project leaders were Black males (compared to 13 in 2009/10). Of the 180 students capacitated within WRC projects, 111 were historically disadvantaged. As part of its capacity building initiatives, the KSA was involved in hosting the following workshops, among others:

- In collaboration with the South African Weather Service (SAWS), a workshop aimed at resuscitating implementation of weather modification as a water availability augmentation option and adaptation action to climate change.
- Workshops on 'Groundwater governance' in partnership with the World Bank.
- The WRC hosted a number of workshops at *WISA 2010*,

Durban:

- A workshop on 'Groundwater-surface water interactions'
- Two workshops on water quality, i.e. on emerging contaminants that could have an influence on drinking water quality and another workshop on best practices to manage water quality at a catchment scale
- A workshop was co-convened by the WRC and the World Water Council on 'Water for growth and development in Africa – understanding and addressing policy complexities'
- A workshop was held at the launch of a project between the WRC, the World Bank, the University of Pretoria and the University of Riverside, California, on 'Water governance decentralisation in Africa: a framework for reform process and performance analysis'.
- A workshop was jointly organised by WRC and DWA on 'Exploring fundamentals of water quality modelling'.
- A discussion workshop with DWA (Western Cape regional office) and National Disaster Management to chart the way forward for the potential 'Documentation of lessons from the Southern Cape drought experiences'.
- A joint WRC/ASSAf workshop on 'State of water in South Africa'.
- The WRC hosted a workshop on investigating innovative ways of incorporating climate change modelling scenarios into water resource planning processes.
- A joint workshop with the National Business Initiative (NBI) on water footprinting.

Knowledge dissemination

The KSA participated in a number of initiatives contributing to the water-centred knowledge base in South Africa. These initiatives included participation at open days and arrangement of technology transfer workshops (including participation). The following strategic capacity building interventions were undertaken to enhance representation from HDI universities:

- The KSA was invited to make a presentation within and facilitate a session at a Water Research Workshop organised by the Faculty of Science, Engineering and Technology (SET) at Walter Sisulu University. This was a follow-on workshop which came about as a result of the KSA1 initiative in September 2009 to build research capacity in former Black universities, and to encourage them to participate in WRC-funded water research. The workshop was attended by Heads of Schools and Departmental research coordinators; key research themes were identified and the group is planning to prepare research proposals in due course.
- The KSA met with the University of Zululand's Faculty of Science to explore future potential research collaboration and to encourage the University to participate in WRC-funded water research. The meeting was attended by the Rector of the University together with Deans,

Heads of Department and representatives from the Faculties of Arts, Commerce and Science.

- The KSA undertook a visit to the Tshwane University of Technology to have discussions regarding research collaboration with the climate change group.
- A DVD on the water cycle was produced as an introduction to the fundamentals of water resource management. The aim is for the video to act as a general base for further elaborations of other aspects such as water use, water protection, water assessments, etc.
- DVDs were produced on Water Resources and Local Government, in partnership with SALGA and WIN-SA.
- Another DVD, *Water from Stone*, was produced on groundwater in the hydrological cycle.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- A paper was presented on the 'Value of monitoring in WRM' at the Eden Drought Summit.
- A presentation on 'water resources and the green economy' at the Green Economy Summit .
- A presentation entitled 'Urban hydrogeology in South Africa: Current status and future challenges' was made at *International Water Association World Water Congress and Exhibition*, Montreal, Canada.
- The KSA delivered the welcoming address at the *11th International Symposium on Sedimentation and Sustainable Use of River Systems*.
- Reviewer for *Hydrogeology Journal*.
- External examiner: University of the Free State and Cape Peninsula University of Technology.
- Co-authored a chapter in the book *Transforming Water Management in South Africa - Designing and Implementing a New Policy Framework, Global Issues in Water Policy 2 Series*.

IMPLEMENTATION PLAN

Research portfolio for 2010/11

The primary objective of the research in this KSA continues 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 2010/11 addresses this primary objective as reflected by the following secondary aims to:

- Improve water resource information systems and access to data.
- Achieve integration between surface water and groundwater research. A programmatic approach will be designed addressing the need for joint studies.

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- Build up appropriate quantitative understanding, tools and adaptive strategies for managing the impacts of extreme climatic events (floods and droughts) due to global warming and human-induced impacts on water resources (include understanding of health impacts on humans).
- Broaden the scope for policy and institutional studies to deal holistically with the legal, economic, compliance and implementation aspects.

The research portfolio for 2010/11 is presented in Table 2, which provides an overview and description of research thrusts and programmes.

TABLE 2
Overview and description of thrusts and programmes

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

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

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

<p>Programme 3: Water resource planning</p>	<p>Scope: This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps such as the absence of reliable information in un-gauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water systems 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 allowing 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 account for other factors which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals.</p> <p>Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water uses will be investigated and included as part of future water resource plans.</p>
<p>Programme 4: New water</p>	<p>Scope: This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges and economic growth target of 6% of GDP per year will require thorough understanding and assessments of alternative sources of water. Such sources could be built into future projections for new water, virtual water and water transfers, be they national or international, from desalination, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development. Solutions for supporting and complementing the processes and strategies pursued by the Water Infrastructure Agency will be developed.</p> <p>The initial development of research under the new theme of Water and Energy will be initiated through this programme. In this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.</p>

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Scope: Research in this thrust focuses on the generation of information and knowledge to improve water resource management, with reference to pollution/contamination from point sources and diffuse sources, and addressing chemical, microbial, physical and biological pollution/contamination impacts on surface water and groundwater. This thrust also addresses water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation within water bodies. Scientific and technological approaches that will help characterise and address these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies; uncertainty, etc.); (3) Technological innovation and forecasting and (4) Implementation approaches and technology transfer options.

<p>Programme 1: Developing predictive tools and adaptive measures to global climate change and hydro-climatic variability</p>	<p>Scope: The need to prepare the country to cope with global climate change is of paramount and strategic importance. Taking the view that water is South Africa's key resource implies the need to adapt water resource management progressively as global climate change progresses, in order to maintain optimal levels of both resource protection and beneficial use of water for society. The development of coping strategies will require the development of informed, quantitative scenarios of potential impacts at regional and catchment level on rainfall regimes and rainfall variability, hydrological and geohydrological regimes, water availability and reliability, water quality, ecosystem structure and function and ecological processes. The following key issues thus need to be considered and addressed in this programme: determination of the confidence level that can be placed on current GCM-generated scenarios of global climate change; degree to which current techniques for downscaling of scenarios from global to regional and catchment scales can be reliable and robust; detection and attribution of anthropogenic impacts on climate change in the Southern African context to distinguish those from natural climate variability and change. Choice of relevant and appropriate 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), and 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. This programme is also aimed at improving understanding 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 on 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, provincial as well as other more localised scales.</p>
<p>Programme 2: Managing human-induced impacts on water quality and quantity</p>	<p>Scope: The quality of water is an important factor in determining the quantity of water that is potentially available for productive use. Determining the amount of water available for different uses is further complicated by the considerable variation that exists in quality requirements between and within different user groups. This programme is aimed at developing and refining fitness-for-use criteria, developing the means to monitor and assess water quality at regional and national levels, improving the manner in which water quality information is conveyed and the identification of emerging water quality issues. This programme also promotes water demand management and the use of poor quality water and further seeks to investigate and apply water quality control and mitigation measures. Various kinds of human activities can influence the quantity, quality, reliability and ecological health of water resources, including activities which take place in other environmental compartments within the hydrological cycle. Hence, the research focus is further aimed at improving our ability to assess, evaluate and predict the effects on surface and groundwater resources of human activities and human-induced impacts, with a view to developing strategies for management and mitigation of water quality and quantity impacts.</p>

<p>Programme 3: Integrated flood and drought management</p>	<p>Scope: Flooding and drought are major natural hazards to human society and have important influences on social and economic development. This programme focuses on research that will result in the development and implementation of integrated institutional frameworks and technological tools to reduce and combat floods and their negative effects while enhancing positive flooding patterns that are important to the natural ecosystem. Research related to drought management will focus on integrated tools and strategies for early identification and mitigation of the social and economic impacts of drought, with the aim of supporting collaborative, multi-institutional processes and programmes.</p>
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THRUST 3: WATER RESOURCE PROTECTION

Scope: Research in this thrust focuses on the generation of information and understanding in order to improve water resource management, with reference to point sources and diffuse sources, and addressing chemical, microbial, and biological pollution impacts on surface water and groundwater. This thrust will also address water resource protection from flow-reduction processes as well as other physical processes such as sediment accumulation. Scientific and technological approaches that will help characterise and address these problems include: (1) Assessment, prediction and decision support; (2) Basic science (e.g. data and methods for evaluation of multi-scale interdependencies, uncertainty, etc.); (3) Technological innovation; and (4) Implementation approaches and technology transfer options.

<p>Programme 1: Protection and management of surface water and groundwater quality</p>	<p>Scope: Urban and industrial activities expose groundwater and surface water resources to a range of chemical and microbiological pollutants. This programme investigates the natural and anthropogenic occurrences of hazardous constituents with the aim of developing strategies to minimise the negative impacts on groundwater and surface water resources. The development of improved pollution prevention, control, detection and remediation strategies is essential for the effective management of the water resources. The programme addresses both point and non-point sources of pollution, resulting from activities in the subsurface and/or on the surface.</p>
<p>Programme 2: Urban and rural water resource management</p>	<p>Scope: An integrated approach to water resource planning and management is essential to the sustainability of urban and rural water resources. In many urban and rural areas, water shortages stem from improper use and degradation of the available water by pollution. The outcomes of this programme will enhance the capabilities of various authorities to protect water resources (groundwater, dams and rivers) in a sustainable manner through the development of, among others, groundwater protection zones, pollution control and monitoring as well as improved land-use planning.</p>
<p>Programme 3: Integrated river flow and catchment hydraulics</p>	<p>Scope: Research in this programme is focused on establishing and maintaining high-quality river flows, reduction and mitigation of river degradation which is caused by river hydraulic processes such as damaging flow regimes, sediment transportation and deposition. The programme will also integrate improved catchment management as part of a holistic strategy for the protection of groundwater and surface water resources, and will seek to establish processes and practices that will ensure minimum disruptions to natural water flow regimes, especially low flows which usually result in periods of critical water constraints in river systems. The groundwater and surface water processes which are associated with the critical flow regimes are also investigated in this programme.</p>

KSA 1: Water Resource Management

THRUST 4: 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.

<p>Programme 1: Institutional governance and reforms</p>	<p>Scope: The principle of subsidiarity, or as is sometimes referred to as democratisation of water resource management, has brought about challenges, both conceptually and in terms of application. Although current reforms in South Africa are based on sound IWRM principles, to date the implementation thereof continues to break new ground, proving that institutional engineering cannot provide a one-size-fits-all solution to the new management paradigm. Further understanding and research are hence needed to learn and decide on best practice as defined in the South African or similar socio-economic settings.</p>
<p>Programme 2: Compliance and enforcement</p>	<p>Scope: For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Benchmarking and best practice are crucial here to learn from lessons.</p>
<p>Programme 3: Pricing and financing WRM</p>	<p>Scope: The issues of financial sustainability, affordability of charges by users, transparency and corporate governance aspects are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good groundbreaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource charge exclude the poor and will it further cripple local government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.</p>
<p>Programme 4: Transboundary water resources</p>	<p>Scope: This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.</p>
<p>Programme 5: Future scenarios</p>	<p>Scope: This activity has been warranted 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 have a phased programmatic approach to adding more and more layers to the scenarios and for them to be customised for localised aspects that need not be of national interest.</p>

RESEARCH PROJECTS FOR 2010/11 COMPLETED PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

Land-water linkages: Agent-based modelling of land-use change and its impact on water resources in the Modder River basin

Central University of Technology

No. 1753

The premise of the study is that hydrological balance of any river basin is directly and indirectly influenced by the spatial and temporal distribution of land-use and land-cover changes. Changes in land cover can modify crucial hydrological processes, such as evapotranspiration and groundwater recharge. Upstream land-use change could bring about a significant on-site effect on catchment water resources and off-site effect on downstream users. For instance, the introduction of IRWH in the upper Modder River basin catchment may result in a significant impact on the downstream water users and the ecological balance of the system if allowed to expand unchecked. Therefore, the aim of this study was to contribute to the understanding of the dynamics of human-environment interactions and decision-making processes for the sustainable use of land and water in the Modder River basin.

Cost: R357 000

Term: 2007 - 2010

Programme 2: Surface water / groundwater hydrology

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

Umfula Wempilo Consulting

No. 1212

This project aimed to satisfy the need for a simple-to-apply evaluation tool, which can rapidly assess the impact of waste load discharge permit applications and the permit conditions that would be required to meet water quality objectives. Models that were available for this purpose are generally complex and data-intensive, requiring experts to set them up and run them. The model that was developed makes good use of new water quality data; it simulates the effects of both conservative and non-conservative pollutants and takes account of both point and diffuse inputs. While the model requires experts to first set up the model, thereafter it can be used by CMA and Regional Office personnel to rapidly test a range of waste discharge options

with minimal input from experts. This should reduce the cost of processing waste discharge applications and testing of alternative discharge permit conditions.

Cost: R494 890

Term: 2001 - 2010

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

University of Pretoria

No. 1693

Almost the whole continent of Africa is underlain by crystalline basement rocks, albeit in places under a thick cover of more recent material. Consequently, crystalline basement rocks form the largest of the four major aquifer domains or 'hydrogeological provinces' found in sub-Saharan Africa, covering about 40% of the region's 23.6 million square kilometres. Crystalline basement aquifers differ in important ways from other aquifer types, and demand specific knowledge and techniques if groundwater is to be extracted and managed efficiently. The study covered two distinct geological and morpho-structural domains within the Limpopo Province, the Limpopo Plateau in the west and the Letaba Lowveld in the east, together covering about 23 500 km². The basement rocks of the Limpopo Province are structurally complex, shaped by multiple tectono-metamorphic events spanning at least 600 million years. The borehole dataset compiled for the study consisted of over 8 000 boreholes contained in the Groundwater Resources Information Project (GRIP) Limpopo database of the South African Department of Water Affairs. Approximately 3 000 of these boreholes have been hydraulically tested and the lithology has been recorded for 1 200. The basement lithologies of the study area are characterised by a generally thin regolith overlying a primarily structurally-controlled fractured aquifer. Compared to the Letaba Lowveld, the Limpopo Plateau is generally characterised by deeper boreholes due to deeper water strikes, water levels, weathering and fracturing depths. Geology has a clear influence, with boreholes exploiting intergranular aquifers composed of highly permeable material showing generally higher yields. Other identified favourable groundwater targets are the metamorphic aureoles of younger granite intrusions and complexes. Despite the local importance of the regolith as a recharge and storage mechanism for the underlying fractured bedrock, no correlation between borehole yields and depth of weathering was found. A differentiated pattern of lineament, shear zone and dyke orientations in the different domains led to a more complex conceptual model of groundwater occurrence and borehole productivity. This conceptual model is inconsistent with the predicted regime based on regional stress field data and suggests that local variations have a strong influence on groundwater occurrence.

Cost: R3 500 000
Term: 2006 - 2010

Hydro-pedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models

University of the Free State

No. 1748

The main hypothesis of the research was that soil properties, presented in the form of hydro-pedological soil maps together with the relevant soil hydrology data, can serve as indicators of the hydrological behaviour of soils in a hillslope, and therefore facilitate prediction of the hydrological behaviour of hillslopes, particularly those in ungauged catchments. Five catchments were surveyed, the Weatherly, Cathedral Peak VI, Two Streams, Craigie Burn and Bedford catchments. Soil data were used as input to ACRU, Pitman, SWAT and Waves. The soil data improved the efficiency of the models, with the greatest improvement in the models capable of simulating enhanced process complexity.

Cost: R1 873 500
Term: 2007 - 2010

Programme 4: New water

An investigation of the potential use of ocean colour remote sensing to assess the influence of variations in freshwater inputs to coastal ecosystems: Phytoplankton and sediment dynamics of the Natal Bight

CSIR; University of Cape Town

No. 1852

The preliminary findings of the study show that ocean colour remote sensing provides a unique means of assessing the effects that variation in freshwater influxes have on the coastal marine environment, as it provides a cost-effective ability to routinely provide quantifiable synoptic data of phytoplankton biomass and production, as well as fluctuations of sediment and dissolved organic material from riverine input. Specifically, the MERIS C2R algorithm provides optimal products in Case 2 waters, but the default atmospheric correction and 'Algal 1' in-water products will serve users better in offshore Case 1 waters. Validation data have been gathered in 2009 and 2010, and these will form the basis for routinely providing error products along with geophysical products in the region – an important step in the effective utilisation of the ocean colour data in climate-related time series analyses.

Cost: R315 000
Term: 2008 - 2010

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

Programme 1: Developing predictive tools and adaptive measures to global climate change and hydro-climatic variability

Secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change

University of Cape Town

No. 1562

The purpose of this project was to investigate effects of climate change on second-order impacts, viz. ecological flow indicators and water temperature parameters, with particular focus on scientific techniques and methods. This was achieved by downscaling climate output from the ECHAM5/MPI-OM general circulation model (GCM) and then using the results as input data into the daily time-step ACRU hydrological model in order to simulate the impacts of climate change, as projected by this particular GCM, on the selected eco-hydrological indicators at a fine spatial scale. The first section of the report describes how the downscaled climate scenarios were developed, the state of current knowledge with respect to the climate system and how it may evolve, as well as the context within which these climate scenarios should be assessed. The second section deals with the hydrological modelling and derivation of ecological parameters. The results are also presented by means of maps at the scale of quinary catchments. The results of the water temperature analysis for the Thukela catchment are also presented by means of maps, while time-series graphs are used to describe water temperature parameters for 15 selected quinary catchments. In the final chapter the project aims are revisited and a summary of findings and recommendations for future research are provided.

Cost: R2 500 000
Term: 2005 - 2010

Programme 2: Managing human-induced impacts on water quality and quantity

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

University of Pretoria

No. 1686

The aim of the study was to investigate the possible impact of growth stimulants used at cattle feedlots on EDCs in water. Objectives were to screen water sources close to selected feedlots in South Africa for estrogenic and androgenic activity using bio-assays, to determine

the endocrine-disrupting (estrogenic and androgenic) activity of growth stimulants, by using a battery of screening bio-assays, to do a reproductive toxicology study, using the rat model, on the identified mixture of compounds at environmentally relevant concentrations, and to perform a toxicological study on sharp-toothed catfish, as well as to investigate the impacts of selected cattle feedlots on aquatic ecosystems at different sites. As most of the identified growth stimulants used in South Africa were found to be below the detection limit in the collected samples, there is a clear need for refinement of methodology and analytical techniques. The bioassays were successfully applied to measure the estrogenic and androgenic activity and potency of the selected growth stimulants used in South Africa. In addition to the rat toxicology, effects were seen in life stages of the exposed fish species. Macro-invertebrate community structures (diversity and abundance) were found to differ between upstream and downstream sites associated with feedlot activities. Seasonal differences were also observed. Evidence and observations from this study suggest the need for a proper investigation of cattle feedlots regarding the use of EDCs and other veterinary compounds as there is reason to suspect an impact on surface water and groundwater. No environmental impact studies are currently done for registration of EDCs. It is suggested that monitoring should become part of the licensing process for these potentially harmful compounds.

Cost: R1 900 000
Term: 2006 - 2010

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

University of the Western Cape
No. 1692

This research addresses issues regarding water quality arising from land cover type change and urban sprawl in a predominantly agricultural catchment in Cape Town. The Kuils and Eerste Rivers are two important rivers that run through the eastern part of the Cape Metropolitan Area (CMA). An assessment of nonpoint source (NPS) pollution in the Kuils-Eerste River catchment in the Cape Metropolitan Authority Area (CMA) through hydrologic experiments and modelling using a geographic information system was achieved. One of the critical components of this study was to conduct hydrologic experiments at selected locations for measuring surface runoff within the catchment in order to generate data for the GIS models. Collation of existing data on stream flow measurements and water chemistry of stream and surface runoff water was conducted. The values obtained show the influence of precipitation and the seasonal variability of the rainfall as it affects the amount of discharge in the river. Such variations are likely to influence the distribution of surface pollutants in the river network, as a high percentage of the discharge in the

river originates from storm runoff. The RINSPE and N-SPECT models were successfully applied to the Kuils-Eerste River catchment and to estimate NPS pollutant loads of chosen variables such as nitrate, chloride, total nitrogen, total phosphorous and total suspended solids. The success with which surface water variables such as concentrations and loads of nitrate, chloride, nitrogen, phosphorous and suspended solids may be simulated in surface water using the above two models depends largely on the quality of input data available, such as rainfall, runoff distribution and a digital elevation model.

Cost: R765 000
Term: 2006 - 2010

Programme 3: Integrated flood and drought management

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

Pegram & Associates
No. 1683

One of the most difficult hydrological variables to collect and interpret is soil moisture. It is more spatially variable than rainfall because of the spatial variability of soil type and depth, local slope of ground and vegetation. Local estimates of soil moisture are valuable in the vicinity of the measurement. However, to interpolate this information spatially is difficult. This project aimed to address this challenge. For the purpose of corroboration two independent approaches were used to estimate soil moisture at the scale of a region-sized catchment (Liebenbergsvlei, 4 625 km², South Africa). The Soil Saturation Index (SSI) was derived from the physically-based hydrological modelling of the catchment using the TOPKAPI model, and the Soil Wetness Index (SWI) was derived from the remotely-sensed observations of the scatterometer on board the ERS satellite; these indices were compared and found to have good agreement. A website was designed to make these valuable data readily available to practitioners in agriculture, catchment management, drought monitoring and flood forecasting.

Cost: R2 483 200
Term: 2006 - 2010

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and ground-water quality

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

University of Zululand (Department of Hydrology)
No. 1168

The study describes the many different methods and techniques that were evaluated in an attempt to understand and quantify the interaction between surface water and groundwater of Maputaland. The study focussed primarily on surface water resources, such as lakes and rivers that have been identified as important management areas, principally for water allocations. However, the concepts and methods described in this report can be applied to all exposed water bodies to determine their level of interaction, which is required as a precursor to the determination of the importance of the groundwater in sustaining the functions (ecological or otherwise) of the systems. The conceptual model of groundwater and its relationship to surface water bodies has been presented in a generic sense but has been illustrated in the five case studies. The case studies describe specific features of the surface water - groundwater interaction, highlighting the role and importance of groundwater to surface water features and methods of analysis.

Cost: R770 000
Term: 2000 - 2010

Groundwater management functions

Umvoto Africa (Pty.) Ltd.

No.1917

Strengthening the capacity of the catchment-based authorities to manage groundwater effectively is an important challenge. This can be achieved by identifying local needs and trends, facilitating communication and cooperation, and promoting best management practices. The success of any groundwater management plan depends on the effectiveness of the responsible authorities and is also a prerequisite for integrated water resource management. The main aims of this project were: (1) Define the functions of planning, organising, directing and control, in terms of groundwater management; (2) Develop and incorporate the appropriate management functions into a groundwater management framework for improved resource management, targeting local municipalities, and (3) To establish the value of groundwater for different users and to determine a tariff strategy for groundwater which will consider both the actual supply costs (fixed and variable) and the value of water.

Cost: R398 600
Term: 2009 - 2010

Programme 3: Integrated river flow and catchment hydraulics

Sedimentation and sediment yield maps for South Africa

University of Stellenbosch

No. 1765

This is a report of work on the revision of the sediment yield map of Southern Africa. The current sediment yield determination methodology for Southern Africa was developed in 1992 (Rooseboom et al., 1992). Continual revision of sediment yield prediction methods is necessary in the wake of changing environments, additional data, advanced analysis tools, increased experience and current technological advancements in the sedimentation field. This report presents the revised methods for the prediction of sediment yields from ungauged catchments for South Africa and Lesotho.

Cost: R1 400 000
Term: 2007 - 2010

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

The criteria necessary for the success of women in the water sector

Palmer Development Group

No. 1762

This study set out to gain an understanding of how women in the water sector have achieved positions of seniority and leadership, and to explore the lessons that can be drawn from their experiences to inspire other women aspiring for leadership in the sector. From the experiences and lessons shared the study distilled a set of criteria for women to achieve career success in the water sector. The study's departure point was to focus on those women who have achieved levels of leadership and senior management in the water sector; to establish how they made it; and to explore the ways in which they cope with the responsibilities of their high-ranking positions. The study represents a focused analysis of women working in the water sector, specifically women occupying senior positions (Director level and above) within public sector water institutions. A study population of 40 people, women and men, was identified and face-to-face interviews were conducted. It was decided to include men in the study population and sample, in order to gain a perspective of their role in supporting women in the sector. Due to challenges of access 34 of 40 people identified were interviewed, that is, 26 senior women and 8 senior men. The research methodology was qualitative and the interviews were carried out according to five broad categories that included background, challenges encountered, support mechanisms, policy environment and women's leadership in the sector.

Cost: R691 385
Term: 2007 - 2010

Exploring the lowest appropriate level of water governance in South Africa

University of the Western Cape; University of Botswana
No. 1837

Arriving at appropriate structures and forms of water governance is particularly important in South Africa. South Africa remains a highly divided society. The early focus on water delivery, facilitated through the Water Services Act (Republic of South Africa, 1997), and on equitable, efficient and sustainable water resource management through the National Water Act (Republic of South Africa, 1998), highlighted the central importance of water in socio-economic development. The catchphrase 'some, for all, forever, together' developed by the Department of Water Affairs (DWA) is simple yet powerful. It stands in contrast to the facts of water resource access, use and development across South African society, which may be accurately captured in the phrase 'almost all for some'. Moving beyond 'almost all for some' has proved exceedingly difficult, for many reasons, many of which are highlighted in this final report.

Cost: R1 000 000
 Term: 2008 - 2010

The impact of IWRM on the lives of women and the poor in South Africa

Ninham Shand (Aurecon); University of the Western Cape; Groundwater Africa; North-West University; Rand Water; The Rural Action Committee; Mbumba Development Services; Umhlaba Consulting Group; FAO; Gavin Quibell (independent consultant); Roger Short (independent consultant); DANIDA/DWA; PLAAS (Institute for Poverty, Land and Agrarian Studies, UWC)

No. 1839

Integrated Water Resource Management (IWRM) is a conceptual guideline for the use, development and management of water resources, as such it seeks to guide activities such as land use and resource use and minimises impacts on the environment, thus maximising resultant economic and social welfare, in an equitable manner without compromising the sustainability of vital ecosystems. The focus of this was to evaluate the impact of IWRM on the lives of women and the poor in South Africa. The evaluation focused on the potential impacts of IWRM, such as sustainable water resources that are accessible for domestic and environmental needs, for international obligations/requirements, and for productive use, rather than on an assessment of the success of implementation of IWRM to date. The aims of this project were to:

- Conduct a comprehensive literature review of how IWRM has been conceived and applied both in international literature and in selected national legislation and policy
- Develop indicators for assessing how IWRM will impact

the lives of women and the poor and apply these indicators to South African case studies

- Build research capacity locally and internationally on approaches to implement and monitor IWRM

Cost: R1 000 000
 Term: 2008 - 2010

Programme 3: Pricing and financing WRM

An investigation into the water infrastructure development financial allocation pathways in municipalities

African Centre for Water Research; Pegasys Strategy and Development; Oscar Somers (independent consultant)

No. 1844

The water services sector has a number of attributes that determines its financing. Firstly, there are many decision-makers within the water services sector. Secondly, there are many sources of finance, including the national equitable share, conditional grants, loans and tariff income. Thirdly, financial and human capacity within the sector varies considerably. Because of the many institutions involved in all of the processes, a complete picture of financing in the sector has not emerged. In order to analyse finances in the water services sector, this research project, following a well-known concept from business management, has postulated a 'value chain'. This envisages the adding of value through a number of sequential functions (or phases), as the technical and institutional arrangements change to match the challenges of each function. This also allows the examination of each function to determine the contribution of the institutions that lead it to overall efficiency and effectiveness. What is important in the context of regulated markets and prices is that 'value', 'cost' and 'price' are not equivalent. (Theoretically they only come together in a perfectly open market.) The purpose of this analysis is, on one level, to guide policy formulation in the water services and municipal sectors and, on another level, to assist all decision-makers to be better informed in making financial decisions concerning matters such as financial grant allocations, tariffs, capital expenditure, operations and maintenance expenditure.

Cost: R2 500 000
 Term: 2008 - 2010

Programme 4: Transboundary water resources

Review of the involvements of national water institutions and civil society in international agreements in South Africa

Pegasys Strategic Management

No. 1758

The SADC Protocol on shared watercourse systems is a

key milestone toward establishing international cooperation to manage water resources in the region. The revised SADC Protocol outlines a number of institutions that are necessary to achieve integrated management of transboundary river basins in the region. The management of transboundary river basins directly impacts on stakeholders at national and local levels in riparian states. The SADC Protocol, however, does not address stakeholder involvement in these water management institutions. The overall objectives of the project were as follows:

- To investigate the extent to which the SADC protocol is applied in South Africa, with special focus on the roles and inter-relationships of national institutions vis-à-vis international commissions and authorities.
- To conceptualise how national development agendas and activities are factored into international agreements.
- To review international literature on similar aspects
- To map out a desired future state for interactions between national and international institutions responsible for management and development of water resources

The involvement of stakeholders in the establishment and management of the river basin organisations formed an integral part of the investigation at both national and international level.

Cost: R3 000 000
Term: 2007 - 2010

CURRENT PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

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

No. 1846

The primary objective of this research will be to develop a framework for optimised monitoring of the most important variables required to manage groundwater resources and understand the fluxes between atmosphere – soil – groundwater – surface water systems at a local level. The secondary objectives of the project are to understanding the institutional and legal interactions of different agencies responsible for various monitoring programmes, develop guidelines for monitoring best practices applicable to South(ern) African conditions and further develop a framework for the monitoring of the different fluxes so that they

are closely measured in time and space, where applicable.

Estimated cost: R1 300 000
Expected term: 2008 - 2011

Development and application of global navigational satellite systems (GNSS) methodology for groundwater resource assessment

Umvoto Africa (Pty.) Ltd.; Purdue University; Department of Land Affairs; Overstrand Municipality

No. 1851

The aim of this project is to demonstrate the use of high-precision global navigation satellite systems (GNSS) technology as a tool for groundwater resource monitoring and assessment; develop a 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 of an underlying confined fractured-rock aquifer; and build South African capacity to establish the technical infrastructure and implement the data-processing methods required for pilot GNSS - for a groundwater scheme at the Gateway well field, Hermanus.

Estimated cost: R1 000 000
Expected term: 2008 - 2011

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

ARC

No. 1908

The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of the earth. This data set is currently in use in most hydrological studies. The data come with several errors that require processing. The worst of these errors are sinks, which are cells whose flow direction cannot be assigned. This study will develop methods for producing hydrologically correct SRTM datasets with gaps and sinks filled. The research will also re-interpolate hydrologically corrected SA DEM to 30 m and do a comparative analysis for a small study over the USA area where both 30 m and 90 m SRTM datasets are available.

Estimated cost: R350 000
Expected term: 2009 - 2011

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

CSIR

No.1909

This project proposes to develop improved process-based estimates of groundwater recharge. Attention will be focused on the determination of two important components of the water balance, in particular, evapotranspiration and water movement through preferential flow. Improved recharge determination will allow more accurate estimates of associated processes, such as, for example, transport and transformation of possible contaminants, leaching, etc., as well as predictions of possible climate change impacts on the groundwater resource. The main outcome will be to develop improved methodologies for the estimation of recharge, by reducing uncertainties in evapotranspiration estimates and preferential flow.

Estimated cost: R2 000 000
 Expected term: 2009 - 2011

The hydrogeology of ground-water Region 10: Karst Belt

R Meyer (private consultant)
No.1916

The following reports in this series have thus far been published by the WRC: Region 1 (Makoppa Dome) and Region 3 (Limpopo Granulite-Gneiss belt) in 2000, Region 7 (Polokwane/Pietersburg Plateau) and Region 19 (Lowveld) in 2003, and Region 26 (Bushmanland) in 2007. The Karst Belt, also referred to as Region 10, has been identified as the next region for which the current state of hydrogeological knowledge should be documented. This region was selected for the following reasons: (a) the importance of the dolomitic/karst aquifers as potential sources of good quality groundwater in large quantities, (b) the vulnerability of these groundwater resources to contamination from a wide range of human and land use activities, and (c) the need to collate in a single reference a synthesis of the current knowledge and understanding of these hydro-geological systems.

Estimated cost: R550 000
 Expected term: 2009 - 2011

Programme 2: Surface water / groundwater hydrology

Protocols assessing the sustainability of springs

Maluti Water
No. 1488

This project intends to develop a protocol for defining a spring-flow sustainability index. The development of a sustainability index would assist with water resource planning and result in security of water supplies to communities. The successful outcome of this project can result in innovative approaches to protect and manage springs (both from a water supply and protection perspective).

The objectives are:

- The development of a protocol for defining a spring-flow sustainability index (i.e. a tool for assessing the sustainability of springs)
- Review all the factors that affect spring-flow
- Assess the value of isotopes in characterising the sustainability of springs, including testing the correlation of perennial and seasonal springs with the isotopic signature
- Develop a weighting system to assess the sustainability of spring-flow

Estimated cost: R734 100
 Expected term: 2004 - 2009

Influence of catchment development on peak urban runoff

University of Pretoria
No. 1752

Developments in urban and informal areas are regulated with regard to potential flooding by the National Water Act (No. 36 of 1998). The 1:100 year flood line is used to define the extent of the development. Furthermore it is required by the municipal authorities that all developers should create temporary storage if the development contributes to an increase in flood peaks. This study will provide a quantification of the influence of a catchment development on the flow rate and volume of runoff. The study will contribute to an effective stormwater drainage design and optimisation of costs for the upgrade of hydraulic infrastructures in targeted urban areas.

Estimated cost: R665 000
 Expected term: 2007 - 2010

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

University of the Free State
No. 1760

In South Africa, more than 90% of the aquifers are of a fractured nature. The physical properties of geological materials exert a significant influence on the storage and ability of fluids to move through them. The existing theory of flow cannot fully account for flow through fractured rocks. Field-scale studies and direct observations/measurements are the most robust means of developing and calibrating models of flow and transport in fractured-rock aquifers. As a result these fractured-aquifer systems can be better exploited and managed through:

- Developing appropriate innovative methodologies/approaches to measure bulk flow and transport characteristics of fractured-rock aquifers and of up-scaling those to appropriate scales and resolution; and

KSA 1: Water Resource Management

- Developing guidelines for future well-field developments in fractured aquifers

Estimated cost: R3 353 940

Expected term: 2007 - 2011

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

Groundwater Africa

No. 1763

There have been a number of recent initiatives to quantify and delineate high-groundwater-potential areas, but they have either been based on inadequate data, or have fallen short in providing the necessary information that can be readily used by planners. This project will address 2 main issues:

- Identify and quantify useable high-groundwater-potential areas in the Main Karoo Basin (through specific case studies)
- Develop the framework for incorporating the high-potential areas into the municipal, catchment and national planning models. This will allow for water resource planning at all levels to properly take into account groundwater as a bulk water source. The project will focus on the Main Karoo Basin, but the methodologies developed will be applicable to all Karoo aquifers.

Estimated cost: R3 499 200

Expected term: 2008 - 2011

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

University of the Free State

No. 1766

The programme outputs will establish an improved understanding of the origin of pollutants, the pathways of these pollutants into the environment and the ultimate fate of these pollutants (LNAPLs). This project will produce tested techniques and guidelines for application in the industry. Available approaches are usually based on international case studies dealing mostly with porous aquifers. South African-specific case studies will enable a better understanding of the behaviour of LNAPLs in the subsurface with a specific emphasis on the fractured-rock environments.

Estimated cost: R3 500 357

Expected term: 2007 - 2011

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, un-completed 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

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

South African Weather Service

No.1913

The objective of this project is to investigate an optimal model configuration that includes the best available description of the surface boundary conditions, as reflected in the projected global sea surface temperature, in order to force global circulation models (GCMs) to produce seasonal rainfall and temperature over South Africa at lead times of several months. A comprehensive analysis between one-tiered and two-tiered forecasting systems will be conducted to inform decisions on development of a fully coupled forecasting system for the region. The model will then be implemented and run to generate required data. Seasonal predictability will also enhance adaptive water management capacity.

Estimated cost: R 488 625

Expected term: 2009 - 2012

Programme 3: Water resource planning

Integrating water resource and water service management tools

WRP Consulting Engineers; DMM Software Services

No. 1840

Integrated water resource management (IWRM) is a concept that has been used to refer to a system where all aspects of human interaction with water resources are considered as potentially inter-related and are therefore addressed together rather than separately. While this definition of IWRM readily accommodates water services provision, narrower definitions that exclude water services are usually preferred and pursued. Among other objectives, this research will develop a framework for the integration of water resource and service management

tools. The framework to be developed will present the best solution which takes account of the present state of needs, available resources, existing commitments and institutional frameworks. As part of demonstrating how easily the research findings are packaged for application, this project will develop and present a case study solution that integrates water service and resource tools for a specific complex water use area such as a large municipal area.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

Programme 4: New water

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

University of Stellenbosch

No. 1759

A DWA survey has estimated that as many as 37% of dams in South Africa have inadequately-sized spillways with a high likelihood of spillway failure. The lack of sufficient freeboard at dams also contributes to dam failures. The existing interim freeboard design guidelines Freeboard for Dams was published as a draft guideline in 1988 by SANCOLD. This document is still being used in the design of new dams, but a number of aspects of the document have become outdated. This project will review and update the existing guidelines for the design of dam freeboards. The project will improve the design provisions for wind, wave and surge effects on dam freeboards.

Estimated cost: R320 000
Expected term: 2008 - 2009

The development and calibration of South Africa's National Standards for water-retaining structures

University of Stellenbosch

No. 1764

The design of water-retaining structures in South Africa is often based on the British Standards for the reason that a local national code of standards does not exist. The British Standards which are currently in use in South Africa will soon be superseded by the Euro-codes, thus leaving the local practitioners with the dilemma of having to adopt yet another new foreign standard with no reference to South Africa or to develop new regionalised standards for the country. This research project will firstly exploit the extensive international and national research aimed at deriving rational design rules for civil engineering infrastructure and buildings. The research will ultimately lead to the development of the South African National Standards for water-retaining structures including the rainwater-harvesting storage facilities.

Estimated cost: R1 100 000
Expected term: 2007 - 2010

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

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

No.1838

All estimation methods in natural resources are subject to uncertainty. Our failure to adequately account for uncertainty could lead to false 'security' in decision making. This research will investigate the links between risk and uncertainty in water resource management and develop an informed understanding of uncertainty and the associated risks in water resource management. Of importance is that the research will develop guidelines for incorporating uncertainty and the associated risk into water resource decision-making processes. Guidance on reducing uncertainty as well as mitigating the impact of uncertainty in water resource management is expected to be another key output of the research.

Estimated cost: R800 000
Expected term: 2008 - 2011

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

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

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

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

No. 1843

Much effort has been expended to improve predictions of how global change will impact on primary biophysical changes such as rainfall and temperature, and the secondary effects on crop production, water resources and ecosystems. However, to date practically no effort has been made to integrate the causal relationships of global change to determine or assess its higher level socio-economic impacts. These impacts can be disastrous on a regional scale and its knock-on effect may have serious implications for the national economy. Vulnerable communities may be most seriously affected. On the other hand, socio-economic activities mostly display remarkable adaptive ability and thus resilience to change. This project will be undertaken

to assess how sensitive socio-economic activities are to expected climate change in four divergent areas of South Africa.

Estimated cost: R2 500 000
Expected term: 2008 - 2011

Tropical systems from the southwest Indian Ocean into Southern Africa: Impacts, dynamics and projected changes

ARC; University of Pretoria

No. 1847

This project aims to determine from historical synoptic-scale weather data instances when tropical systems from the Indian Ocean have influenced rainfall over the Limpopo Province and Mozambique. The period that will be investigated is from 1948 to the present. During this time a sufficient network of rainfall stations allows for the investigation of the impact of these systems on rainfall over the province. The inclusion of rainfall data can enhance the analysis of these types of systems. Tropical depression track data from the Tropical Cyclone Centre, La Reunion, will also be used for this purpose.

Estimated cost: R680 200
Expected term: 2008 - 2011

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

University of Venda

No.1910

In most rural areas, river water is consumed without any treatment. Previous studies in the Limpopo Province have indicated high levels of bacterial indicators in river waters; however, the occurrence of parasitic organisms has not been investigated, as well as the interactions between human activity, groundwater, river water and wastewater. Such information is important and will advise on the involvement of the community in water governance crucial to the protection of water sources. This study will investigate the possible interactions between rivers, borehole water and wastewater, through the analysis of the chemical and molecular profiles of parasitic organisms isolated from the different sources.

Estimated cost: R600 000
Expected term: 2009 - 2011

Investigation of unsteady flow conditions at dam-bottom outlet works due to air entrainment during gate closure

University of Stellenbosch

No.1914

The behaviour of dam outlets that are located in the conduit passing underneath the dams, for large volumes of water releases, is not adequately understood in practice and dam design. Potentially dangerous unsteady flow patterns were experienced during the commissioning tests of the Berg River Dam in June 2008. Air that was sucked into the outlet conduit and released at high flow rates with water resulted in unsteady outflow conditions which could have led to damage and failure of the outlet works, with devastating consequences. This study will investigate in more detail the behaviour and role of air-vent pipes at gates at bottom outlets of dams, to ensure the safe design and operation of outlet works in future.

Estimated cost: R872 800
Expected term: 2009 - 2011

Programme 2: Managing human-induced impacts on water quality and quantity

A guideline for the selection of toxicity tests in support of the information requirements of the National Water Act

CSIR (Natural Resources and the Environment)

No. 1211

An important implication of the National Water Act (NWA) is that the introduction of both source-directed controls and resource-directed measures aimed at improving water quality will be based on the effect of these measures on the resource. Biological toxicity tests are ideally suited to assess these effects for stressors. Toxicity assessments can be used to set the standards used in source-directed controls, or to elicit a site or situation-specific response to a stressor. A large number and variety of biological tests are available internationally for aquatic toxicity assessment. A range of toxicity tests has also been established for South African use. Most of the local tests are presently applied in hazard assessments to establish toxicity at the source level. However, in order to implement the requirements of the NWA, methodologies appropriate for resource-directed measures and source-directed controls are required, as well as knowledge on how methodologies for one application relate to the other. The purpose of this project is, therefore, to establish a guideline for the selection of toxicity tests that would support the information requirements of the NWA. This will be compiled in a user-friendly document that will facilitate the application of toxicity assessment in water resource management.

Estimated cost: R450 000
Expected term: 2001 - 2009

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

Tshwane University of Technology

No. 1341

The Soutpan Stream runs past a very poorly-managed landfill site which serves the local Soshanguve community. The landfill is used for dumping of domestic and industrial wastes. Visible leachate is observed on a regular basis running into the Soutpan Stream. The Soutpan Stream serves a huge informal settlement as sole water source and thus presents a health hazard. The community uses the water for household practices, gardening and for animals to drink. This project aims to improve the situation and make the water and the landfill practices acceptable according to set guidelines. This will serve as an upliftment project for the community as we will make use of their experience and knowledge. The research aims to:

- Conduct an environmental inventory and audit of the study area
- Obtain information on how the landfill site is managed, the hydrogeological conditions, attenuating factors, weather patterns, volume and type of waste dumped, the volume and characteristics of leachate produced
- Investigate the direct and indirect physical, chemical and microbiological impacts and consequences, over a defined range of temporal and spatial scales, of the leachate generated at the poorly-managed landfill site on the Soutpan Stream and its immediate surroundings
- Suggest measures which will help to minimise any adverse impacts on the environment and human health

Estimated cost: R386 000

Expected term: 2002 - 2009

Persistent organic pollutants (POPs) in the environment

North-West University

No. 1561

South Africa is a signatory to the Stockholm Convention, which is intended to minimise and prevent the release of harmful persistent toxic substances in the environment. Although the WRC has recently funded work on persistent organic pollutants (POPs) in the water environment, this research now needs to be taken further in order to:

- Assess with higher confidence the scale and significance of the occurrence of POPs in the water environment in South Africa, the potential short-term and long-term impacts on water resources and water-linked ecosystems and the associated threats to sustainability of water resources and water use
- Better identify and quantify the fate and effect of selected POPs in the water environment
- Guide and inform the development of appropriate policy and regulatory measures that will:
 - Support implementation of the requirements of the

Stockholm Convention

- Substantially contribute to the protection of water resources and water-linked ecosystems with regard to POPs.

Estimated cost: R1 500 000

Expected term: 2005 - 2009

Development of a model to assess the cost associated with eutrophication

The Institute of Natural Resources

No. 1568

Eutrophication and its accompanying effects is one of the intractable symptoms of water pollution associated with modern society. It diminishes the quality of our water resources for many uses and costly treatment is often required to overcome its negative effects. In the prevention vs. cure debate, it is important to not only know the cost of prevention, but also the cost associated with eutrophication when it occurs at various levels, in order to justify often expensive preventative measures. Knowledge of the cost associated with eutrophication will also help in determining and justifying the introduction of waste discharge charges. Similarly to a study that assessed the cost to users that can be associated with water salinity, a multidisciplinary team will conduct this project to determine the costs associated with eutrophication that are experienced by different water users, such as those associated with water purification, recreation, irrigation and the aquatic environment.

Estimated cost: R2 000 000

Expected term: 2005 - 2009

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

University of KwaZulu-Natal

No. 1697

South Africa possesses abundant sources of coal, found chiefly in Mpumalanga Province. This region therefore houses power-generation facilities which supply the majority of the country's electricity needs. The process of combustion of coal leads to the production of wastes which are discharged to the atmosphere, whence they are transported across the region by atmospheric circulation before being re-deposited on the land surface. Amongst the pollutants emitted by the burning of fossil fuels are oxides of nitrogen and sulphur (NO_x and SO_x). These compounds have for decades been associated with large-scale environmental degradation (chiefly acidification of soils and water) in the First World. More recently their deleterious effects have been recognised as potential threats to ecosystems in other parts of the world, including the

eastern regions of South Africa. The project therefore aims to:

- Investigate the deterioration of surface water quality in selected catchments of the eastern regions of South Africa over the past few decades, due to the effects of atmospheric pollution
- Investigate deterioration of soil quality in selected catchments of the eastern regions of South Africa over the past decade and a half, due to the effects of atmospheric pollution
- Project, by means of modelling, future deterioration of soil and water quality in selected catchments of the eastern regions of South Africa under various management scenarios
- Illustrate the cost-benefit dynamics of managing pollution from atmospheric sources
- Ascertain the reliability of available estimates of atmospheric deposition

Estimated cost: R1 435 300
Expected term: 2006 - 2009

A national survey of mercury levels in South African resources

CSIR

No. 1754

Recent estimates indicate that Hg emissions from sources in South Africa, mostly coal combustion and gold mining, contribute more than 10% to the global Hg emissions, thereby ranking the country second after China on the list of major Hg polluters globally. Mercury (Hg) pollution is a world-wide problem that should be addressed at global, regional and national levels. Mercury is released into the atmosphere from anthropogenic sources both as elemental Hg (Hg₀) and in the ionic oxidized form (HgII). The major concern with Hg₀ is that once released into the atmosphere it is oxidized, contributing to the oxidized Hg pool. This HgII is very water-soluble, and is removed from the atmosphere by both wet and dry deposition and enters freshwater and marine resources, where it is rapidly converted into the more toxic methyl-mercury (CH₃Hg) form. This more toxic form bio-accumulates in the aquatic food chain and poses a serious health risk to humans who consume fish or other aquatic organisms that are contaminated with CH₃Hg. Anthropogenic activities, such as artisan gold-mining activities, industrial and small-scale coal combustion, as sources of Hg in the atmosphere, the deposit thereof into water resources, and its effects on water quality, are not well characterized in South Africa. Accordingly, as one important step towards such characterization, this project aims to carry out a national survey of Hg levels in South African water resources. This should provide a sound basis for establishing the extent to which Hg is currently a problem in South Africa. The aims of the

study are to survey the levels and speciation of mercury in water, sediments and biota in priority South African water resources; to assess the degree of compliance of the measured mercury levels with national and international guidelines; to assess the degree to which mercury may be a problematic pollutant in South Africa; and to create local capacity relating to mercury sampling and analysis.

Estimated cost: R918 850
Expected term: 2007 - 2009

Water quality monitoring data and target users: Maximising value

CSIR

No. 1755

DWA operates a vast water quality monitoring network. The information transfer which should form an integral part of the design of such networks is not functioning optimally at present. Much of the value of water quality information is lost if it is not effectively conveyed to users. This project will aim to maximise the value of water quality monitoring programmes by optimising the way in which information is transferred to users. This could have a knock-on effect regarding the appreciation of water quality management by politicians and the man in the street.

Estimated cost: R488 960
Expected term: 2007 - 2009

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

University of the Western Cape

No. 1756

This will be a comprehensive study of the effects of water quality on the immune system of humans. The quality of potable and raw water could vary considerably from place to place and this depends on the microbiological and chemical constituents of the water. Several of the physiological systems (e.g. immune, thyroid-hypothalamus, reproductive and the neuro-physiological system) can be impacted on by the quality of the water. The complexity of mixtures is that different constituents (depending on the concentration of each) could have synergistic or antagonistic or no effects in the particular mixture on the human body. Some man-made chemicals affect the function of one or more immune pathways and this can have adverse effects on the health of man and animals. The objective of the study will be to develop and validate analytical tools to evaluate the impact of aquatic pollutants on the immune system. Water extracts obtained from various areas will be evaluated for its immunotoxicity and analytical procedures will be verified to measure the different effects on the human immune system.

Estimated cost: R1 500 000
Expected term: 2007 - 2010

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

CSIR; University of Cape Town

No. 1845

It is widely assumed that prevention is better than cure. This project will determine whether or not this assumption holds when applied to cleaner production technology costs (prevention) compared to the cost of treatment of pollution and the external costs borne by downstream users (cure). Four of the most important water quality contaminants will be covered: namely, salinity, eutrophication, microbial pollution and sediments. Because of the differences in the sources of the contaminants to be investigated and in the levels of information available for each, a differential approach will be followed in conducting this project. Specific catchments where the specified pollutants are of concern will be identified and the study will be undertaken in the identified catchment, e.g. salinisation in the Vaal catchment and eutrophication in the Crocodile catchment.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

Programme 3: Integrated flood and drought management

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

University of Pretoria

No.1906

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

Estimated cost: R965 900
Expected term: 2009 - 2011

Development of a system dynamics model for the implementation of IWRM in South Africa: Phase 1 - deriving performance indicators for IWRM implementation on a catchment scale

Jeffares & Green (Pty.) Ltd.

No.1911

The aims of this project are: to optimise the approach to integrated water resource management; fostering of successful cooperative governance in the water sector; integration of existing information management systems within the water sector; synergising existing research and other related activities within the water sector; development of a comprehensive water sector database; development of a performance management system for catchment scale IWRM; capacity creation and development in IWRM within the SA water sector; and information dissemination and knowledge creation in the water sector.

Estimated cost: R488 255
Expected term: 2009 - 2010

Programme 4: Water resource quality management

Nutrient and organic carbon fluxes from small-scale agriculture

University of KwaZulu-Natal

No.1904

The understanding of the sources and pathways of water in a catchment is essential for successful prediction of water quality impacts on receiving streams as well as for the evaluation of remedial measures proposed to abate unacceptable water quality loads. This is especially true for sediment and nutrient fluxes in agricultural catchments. The research will quantify impacts on larger scale catchment sediment, nutrient and organic carbon loading from extended small-scale agricultural land use changes. Nutrient management advice for small-scale farmers, as well as to downstream water resource managers, will be available through this project. Carbon flux evaluation will contribute to quantification of the global carbon budget and implications for climate change.

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

The 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

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

Golder Associates Africa (Pty.) Ltd.
No.1933

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

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

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

Novel silicone rubber integrative passive field sampler University of Venda (School of Environmental Sciences/ Department of Ecology and Resource Management) **No. 1504**

Time-weighted average (TWA) passive field samplers provide vital information in ecological risk assessment of chemical pollutants. The passive field samplers quantify the

freely-dissolved pollutant in water that approximates the bio-available fraction in longer exposure times. They therefore also give vital information on changes in pollutant level over time. However, not many passive field samplers are available and those that are available are mostly not very selective. They furthermore require additional clean-up steps before analysing the extracted samples. This project aims to develop, construct and test a simple and cheap TWA passive field sampler that will require no mechanical device and can be used in remote sites. The sampler will utilise silicone rubber in the form of a hollow fibre as absorbing medium. The inside of the hollow fibre will serve as the receiving phase and the outside as the donor phase. The pH of the solution in the receiving phase will be set such that target analytes are ionised and trapped. It is anticipated that this will result in very high enrichment factors over longer exposure periods. The developed sampler will be evaluated under laboratory conditions for its trapping efficiency for a range of pollutant groups as well as potential synergism and antagonism associated with trapping combinations of pollutant groups. The objectives are to:

- Develop a time-integrated sampling device based on silicone rubber for measurements of pesticide concentrations at environmental levels under field conditions
- Evaluate the efficiency of the sampling device for trapping representative examples of pesticides and other pollutant groups
- Determine the synergism and antagonism associated with trapping combinations of pollutant groups
- Evaluate the release of high concentrations during subsequent exposure to lower environmental concentrations.

Estimated cost: R250 000
Expected term: 2004 - 2009

Sampling and monitoring protocol for radioactive elements

University of the Western Cape
No. 1694

The presence of radioactive constituents (uranium, thorium and associated daughter elements) in groundwater poses a health risk. Weathering and leaching of trace element-rich geological formations and also mining wastes result in high concentrations of these constituents in groundwater. The National Radioactive Monitoring Programme (NRMP) of DWA aims to monitor radioactive elements on a national scale. The focus of this study is to support the NRMP by implementing investigations around impacted sites for local monitoring programmes. Specific objectives are:

- Re-evaluate the results of earlier research findings on uranium speciation and the associated anomalies (i.e. anomalies in the aqueous environment) at the selected study area
- Applying recent advances to characterize flow regimes

in fractured-rock aquifer systems, with reference to 'tracing' the distribution of radioactive elements in fractured media

- Development of local-scale sampling and monitoring protocol for radioactive elements in fractured rock formations
- Delineating a groundwater protection zone around a selected study area with respect to an unstressed system taking into account the hydraulics, behaviour of selected radioactive elements, relevant policy documents, etc.

Estimated cost: R1 500 000

Expected term: 2006 - 2009

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

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

No. 1849

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

Estimated cost: R2 964 000

Expected term: 2008 - 2012

Assessment of the toxicity of cyanobacteria in the Kruger National Park

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

No. 1850

Cyanobacteria (blue-green algae) are found throughout the world in freshwater and marine habitats. Cyanobacteria produce a variety of toxins known as cyanotoxins which have an adverse effect on livestock, domestic animals and wildlife. There have been reports of deaths of wildlife suspected to have been caused by cyanobacteria in the Kruger National Park after exposure to water containing cyanobacteria. It is suspected that a large percentage of wildlife succumb to cyanobacterial poisoning every year as no normal data on mortality are recorded. The only time there is assessment of the surface water is when there are

deaths of wildlife, and sometimes the cyanobacterial toxin content of the nearby rivers/dams, which the animals were exposed to, would have changed completely by the time of assessment of the water, thus not reflecting the toxin levels that caused mortality. The study aims to generate information (database) on the extent to which cyanobacteria and their toxins affect wildlife.

Estimated cost: R395 000

Expected term: 2008 - 2010

Quality control and assurance guideline for South African toxicity testing laboratories

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

No. 1853

The South African National Water Act (Act 36 of 1998 (NWA) mandates the establishment of policies and approaches to reduce and prevent degradation; and to assess the quality of water resources. To comply with the above requirements the National Toxicity Monitoring Programme for Surface Waters (NTMP) (DWA, 2005) and the Direct Estimation of Ecological Effect Potential (DEEEP) approach for waste discharge (DWA, 2003) were introduced. Standard methods were documented for both of these approaches. The toxicity methods are presented in terms of the test environment; materials; equipment and reagents; test organism (breeding and maintenance); test procedure; data analysis and expression of results; test precision of results; test report format; as well as related issues such as sample collection; transport; and storage and waste disposal. Quality requirements pertaining to the above-mentioned sub-sections and training of new staff to comply with minimum requirements for accreditation purposes, will also be addressed.

Estimated cost: R600 000

Expected term: 2008 - 2010

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

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

No. 1854

Pesticides are among the most crucial non-point-source pollutants, because of their extremely high toxicity to many non-target aquatic organisms (fish and macroinvertebrates). The Department of Water Affairs (DWA) has recently designed and implemented the National Toxicity Monitoring Programme (NTMP), which monitors toxicity and a number of priority toxic chemicals, the majority of which are pesticides. The National Water Act (Act 36

of 1998) requires rivers to be classified according to a specific class and the establishment of resource quality objectives (RQOs) to protect the desired class of a specific river. Risk indicators can be regarded as lower-tier risk assessment tools that provide a relative assessment of the environmental impact of pesticides through integration of ecotoxicological, environmental fate and pesticide use data. This study proposes to examine the application of pesticide risk indicators as a meaningful tool to predict the relative impacts of pesticides on the aquatic environment.

Estimated cost: R900 000
Expected term: 2008 - 2011

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

CSIR

No.1905

The detailed behaviour of microorganisms in groundwater is not well understood. There are many kinds of microorganisms and many processes that affect their fate and transport, and these vary from one aquifer type to another. The National Microbial Monitoring Programme for groundwater has been developed for DWA. Besides the movement of groundwater, there are processes such as natural die-off, formation of biofilms, adsorption, etc., which are taking place, and there is inadequate local understanding of the nature and extent of the chemical, physical, biological and microbiological processes that control the fate and transport of micro-organisms in South African aquifers. This project aims to develop a sound database and monitoring protocol upon which future comprehensive fate-and-transport modelling of micro-organisms in dolomitic aquifers can be based, and which would enable more detailed modelling (inevitably scenario-based) and could contribute significantly to the development of appropriate strategies that mitigate associated human health risks.

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

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

Golder Associates Africa (Pty.) Ltd.

No.1912

This project follows on from WRC Project No. 1769, entitled 'Implementation of a conceptual framework model for the regulation of water quality in an integrated, preventative management approach'. The earlier project indicated that the management framework under current legislation is inadequate when evaluated against the integrated

catchment-to-consumer cycle. The regulatory process is indistinct in the sense that water resources and water services are managed under different Acts and different institutional structures. The current management framework is, furthermore, reactive rather than proactive since it is primarily focused on the monitoring of raw and drinking water quality. The project produced a structured conceptual model for integrating water quality management, taking into account the current legislative gaps, as well as indicating required changes to the legislative framework that will strengthen the regulatory framework for integrated management. This project will implement the conceptual framework model for the regulation of water quality in an integrated, preventative management approach, and test it at the various management boundaries that have been identified (e.g. catchment, WSA, industrial zone).

Estimated cost: R857 120
Expected term: 2009 - 2011

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

University of Pretoria

No.1934

Developing countries experiencing a growing demand for housing and sanitation provision are placing a burden on local authorities to provide for the need. The growing informal settlements around towns and cities are often also near water resources in South Africa. Due to the lack of sanitation the water sources are receiving great loads of microbial pollution making the source water unfit for direct consumption and recreation activities, as well as for irrigation. These sources are often also used for laundry purposes and children play in this water. The sewage treatment plants can often not handle the extra burden of sanitation projects, resulting in these plants not performing to standards and overflows occurring during heavy rainstorms. The study will investigate available management options and models to determine and manage the microbial pollution on a catchment scale. This will include the possible effect of the chemical quality of the receiving waters in the catchments. The project will make recommendations on research needs and follow-up projects.

Estimated cost: R250 000
Expected term: 2009 - 2010

Programme 2: Urban and rural water resource management

Nitrate removal for groundwater supply to rural communities

CSIR; University of Stellenbosch; Biostream

No. 1848

This is a follow-up project whose main contribution will be the design criteria for a range of in situ and ex situ treatment of nitrates in groundwater. This provides alternatives for the specific needs of rural communities. The project investigates applicable identification systems in specific circumstances (i.e. rural communities, town water supply and stock watering, etc.).

Estimated cost: R600 000
Expected term: 2008 - 2010

Programme 3: Integrated river flow and catchment hydraulics

The impact of deep-rooted trees on the hydrological balance of a small catchment in the KwaZulu-Natal midlands

CSIR

No. 1682

Recent WRC studies and modelling of forestry water use have shown that our best estimates of tree water use, and in particular dry season water use, are not within acceptable error margins. One of the main reasons for this is the inability of hydrological models to accurately simulate the deeper soil water processes. This project, which will rely on field-based experimental work and computer modelling, is expected to:

- Quantify the long-term effects of commercial forestry species on deep soil water profiles, streamflow and evaporation
- To investigate and describe environmental and soil water processes which allow for total evaporation to exceed the annual rainfall
- To provide a modelling framework for the catchment water balance to improve streamflow predictions and specifically low flows
- To extend and test the database of catchment hydrological variables, including data on tree root behaviour and its effect on soil water in deeper soil layers, in modelling studies

Estimated cost: R639 200
Expected term: 2006 - 2009

THRUST 4: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

Programme 1: Institutional governance and reforms

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

Source Strategic Focus (Pty.) Ltd.

No. 1563

Rainwater harvesting (RwH), an old technology that dates

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

Estimated cost: R2 800 000
Expected term: 2005 - 2008

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

University of Cape Town

No. 1698

This project seeks to analyse, monitor and evaluate the new water management institutional arrangements by focusing on the role of socio-cultural issues, particularly the role of traditional leadership, customary water tenure and cultural and religious practices in determining water management outcomes. Some of the long-term benefits of the research include enhancing public participation in water management and the voices of local people, and alleviating tensions and conflict in water management institutions so that they can ultimately function more efficiently and sustainably.

Estimated cost: R390 400
Expected term: 2006 - 2009

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

Sinelwati Scientific cc; Scientific and Technical Services Institution

No. 1855

KSA 1: Water Resource Management

This project aims to interrogate and derive lessons from international (regional) experiences with respect to sustainable use of water to meet the needs of historically-disadvantaged individuals and the poor; to evaluate immediate past interventions designed to achieve redress, establish reasons for success or failures and derive lessons; to evaluate each of the current processes and instruments for water allocation reform and investigate the conditions under which they can meaningfully redress race and gender inequities; to develop discussion documents and guidelines to inform and improve future implementation of the water allocation reform processes and instruments; to participate and share lessons with the department as the water allocation reform is implemented; and to develop a learning journey manual for the water allocation reform experience in South Africa

Estimated cost: R1 050 000
Expected term: 2008 - 2010

Development of the AWARE model for the Inkomati CMA

University of KwaZulu-Natal
No. 1935

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

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

Programme 3: Pricing and financing WRM

Econometric model to predict the effect that various water resource management scenarios would have on South Africa's economic development

Conningarth Economist
No. 1570

Water being a limited resource, it is accepted that its availability will constrain the economic development of South Africa. At present it is very difficult to predict which unforeseen negative effects well-intended management decisions may have on development. Australia developed a model of the Australian economy that relates the present and future water demands to potential growth in production in 55 industry groups across 18 regions. This model is used to predict how the Australian economy would be affected under different scenarios of water resource management. The model that will be developed under this project will do the same for the South African situation.

Estimated cost: R2 000 000
Expected term: 2005 - 2009

Programme 5: Future scenarios

The water sector institutional landscape by 2025

CSIR; Barbara Heinzen (independent consultant); HSRC
No. 1841

The implementation of institutional reforms in South Africa is moving ahead despite a number of challenges and an environment that is changing constantly. The purpose of this investment is to project to the future and paint a futuristic picture of the organisational landscape for both the management of water resources and for the provision of services. A good set of scenarios should leave the reader wondering which one is more likely or more probable. That forces the reader to think more, and that is the whole point of a scenario - to learn more about alternative futures, so that one can make better choices today. In this exercise, the scenario building must be conducted in a participatory and inclusive manner, and very systematically so that it could make a major contribution to refining the future outcomes in institutional rationing and to build new capacities in the country.

Estimated cost: R2 000 000
Expected term: 2008 - 2011

NEW PROJECTS

THRUST 1: WATER RESOURCE ASSESSMENT AND PLANNING

Programme 1: Catchment data and information systems

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

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

Delineating Quinary catchments for South Africa and modelling their associated hydrolog

CSIR

No. 2020

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

Estimated cost: R295 000
Expected term: 2010 - 2011

Programme 2: Surface water /groundwater hydrology

Hydrology of South African soils and hillslopes (HOSASH)

University of the Free State

No. 2021

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

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

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

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

CSIR

No. 2022

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

Estimated cost: R800 000
Expected term: 2010 - 2012

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

University of the Western Cape

No. 2023

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

Estimated cost: R300 000
Expected term: 2010 - 2011

Programme 3: Water resource planning

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

Pegram and Associates (Pty.) Ltd.

No. 2024

This study aims to address the acute need for accurate

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

Estimated cost: R1 423 000
Expected term: 2010 - 2013

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

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

THRUST 2: MANAGEMENT OF NATURAL AND HUMAN-INDUCED IMPACTS ON WATER RESOURCES

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

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

Flooding caused by extreme rainfall often results in fatalities, damage to and loss of property and infrastructure.

The project is aimed at identifying attributes of extreme rainfall and historical trends thereof. Then relate the extreme rainfall data to synoptic mode of circulation, identify geographic regions that have experienced extreme rain and develop a framework for application of extreme analysis to downscaled projections of future climate.

Estimated cost: R420 000
Expected term: 2010 - 2012

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

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

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

Estimated cost: R175 000
Expected term: 2010 - 2014

The 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

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

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

Programme 2: Managing human-induced impacts on water quality and quantity

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

North-West University

No. 1966

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

Estimated cost: R1 204 800
Expected term: 2010 - 2012

Investigations into the existence of unique environmental Escherichia coli populations

University of Pretoria

No. 1967

A variety of pathogenic and non-pathogenic Escherichia coli are found in association with the gastrointestinal tracts of warm-blooded animals. The presence of E. coli in other environments is apparently maintained by the constant input of isolates from the primary habitat. For this reason E. coli is used as an indicator of recent faecal contamination. This is the basis for using presence of faecal coliforms as indication of faecal pollution. A number of studies have shown that specific E. coli strains are capable of surviving in sand and sediments of freshwater systems for longer pe-

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riods than previously thought. Further evidence suggests that *E. coli* multiply in both tropical and colder waters in the apparent absence of any faecal contamination. These recent findings question the use of *E. coli* as an effective indicator organism of faecal pollution. The overall goal of the proposed study is to investigate whether natural populations of *E. coli* are structured according to habitat, and if so whether unique environmental strains of *E. coli* exist in nature. It is hypothesised that any imposed separation in terms of habitat would reflect at the genetic and genomic levels.

Estimated cost: R600 000
Expected term: 2010 - 2013

THRUST 3: WATER RESOURCE PROTECTION

Programme 1: Protection and management of surface water and groundwater quality

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

University of Fort Hare

No. 1968

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

Estimated cost: R680 000
Expected term: 2010 - 2012

THRUST 4: WATER RESOURCES 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 optimisation of available human, institutional, technical and financial resources to strategically approach deteriorating water quality in SA through innovative and collective effort focussing on sources of pollution in prioritised fashion

Golder Associates Africa (Pty) Ltd

No. 1970

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

Estimated cost: R500 000
Expected term: 2010 - 2012

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

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

University of the Witwatersrand
No. 1972

This project aims to establish the potential for stakeholder-initiated catchment management agencies and related arrangements, and to determine the knowledge and perceptions of stakeholders about their opportunities to establish catchment management agencies and related arrangements. The project will determine the factors that would influence stakeholders to initiate the formation of a CMA or to oppose such a process as well as identify interventions that could address obstacles that may be identified to the establishment of stakeholder-based catchment management agencies, specifically measures to ensure that the interests of disadvantaged communities are adequately addressed, and will eventually produce recommendations to guide decisions of different stakeholders and regulatory authorities about the establishment of stakeholder-initiated CMAs.

Estimated cost: R600 000
 Expected term: 2010 - 2012

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

Jeffares & Green (Pty) Ltd
No. 1973

The aim of this project is the optimisation of the operationalisation of integrated water resource management through: fostering of successful cooperative governance in the water sector of the pilot catchment, capacity creation and development in IWRM within the water sector of the pilot catchment, fostering stakeholder buy-in and active participation in the IWRM strategy for the Mega-Reserve, identification of problems with IWRM implementation, identification of solutions to problems identified with IWRM implementation and production of an IWRM implementation guide.

Estimated cost: R442 750
 Expected term: 2010 - 2011

Programme 3: Pricing and financing WRM

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

University of the Western Cape
No. 1974

This research is intended to produce knowledge regarding the socio-economic value of groundwater that is derived from the TMG Aquifer through various use and non-use activities. This will be achieved through identifying and quantifying direct use value, indirect use value, option

value, existence value, bequest value and altruistic value generated by the TMG Aquifer to determine its Total Economic Value.

Estimated cost: R300 000
 Expected term: 2010 - 2012

Programme 5: Future scenarios

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

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