



KSA 2: WATER-LINKED ECOSYSTEMS



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SCOPE

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

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

(instream, riparian and groundwater). This includes the research needs around the international conventions on environmental management (e.g. biodiversity) as well as human needs from the aquatic environment (e.g. sustainable management for equitable ecosystem resource utilisation, recreation and ecotourism by rural communities).

In the light of local needs and international trends in research, the portfolio of research by which the scope of this KSA is addressed will be adjusted when deemed necessary. However, the primary objective remains the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country, taking into consideration demographic dynamics and threats due to climate change, alien and invasive species.

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OBJECTIVES

Although the scope of the KSA has room for further growth to accommodate more thrusts and programmes, the primary and secondary objectives of this KSA are still relevant to address future research need scenarios appropriately. The main objective is the provision of knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water; and to develop an understanding of the ecological processes underlying the delivery of goods and services from water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

This is achieved through the following (secondary) objectives which aim to:

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

THRUSTS AND PROGRAMMES

The research portfolio for 2012/13 was organised within the following thrusts:

- Thrust 1: Ecosystem processes
- Thrust 2: Ecosystem management and utilisation
- Thrust 3: Ecosystem rehabilitation

The scope of the strategic thrusts and programmes within KSA 2 is as follows:

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THRUST 1: ECOSYSTEM PROCESSES

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

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

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THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

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

<i>Programme 1: Ecological Reserve</i>	Scope: Within this programme research will be conducted to develop and refine methods for determining and operationalising the ecological Reserve as required by the NWA. The programme will address the more strategic issues such as the development of new and improved methods as well as the shorter-term issues such as implementation of the Reserve. This programme is managed in close association with DWA.
<i>Programme 2: Estuary management</i>	Scope: Within this programme research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage estuaries sustainably. This programme is managed in close association with Marine and Coastal Management, DEA.
<i>Programme 3: Ecosystem health</i>	Scope: The River Health Programme (RHP: custodians are DWA, WRC and DEA) aims to implement nationally (at the level of provincial government and industry) a coherent bio-monitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and so are kept in the same programme. Research on the environmental health of wetlands, estuaries and impoundments is also included in this programme. As such the programme covers all water resource types, hence the inclusive name of: National Aquatic Ecosystem Health Monitoring Programme is used, with RHP focusing only on rivers. This programme links to the WRC impact area of Water and Society and includes resource management actions which may affect human health.

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<p><i>Programme 4: Environmental water quality</i></p>	<p>Scope: Within this programme research will be conducted to develop bio-assays (both in the laboratory and the field) which will be employed to protect people and the environment from the effects of poor water quality. It will develop methods and competence to enable the use of toxicology in effluent discharge licences as well as its use in environmental water quality as required in the ecological Reserve. This programme addresses the longer-term development and refinement of methods and the competence to use them, as well as the shorter-term competence required to implement policy in terms of the NWA. This programme links to the endocrine disrupter programme within the WRC impact area Water and Society.</p>
<p><i>Programme 5: Endocrine disrupting compounds</i></p>	<p>Scope: The overall objective is to characterise, and acquire information for assessing, the endocrine-disrupting effects of various chemicals and compounds in water (singly or in combination), both those occurring naturally and those resulting from pollution, which have the potential to cause detrimental health effects in humans, animals and the aquatic environment, as a guide to develop and implement cost-effective treatment and control strategies. Further emphasis is on the development of simple, rapid and cost-effective detection techniques. This programme will be implemented in three phases, of which the first phase is already completed.</p>
<p><i>Programme 6: Socio-economic Considerations</i></p>	<p>Scope: The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with the ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment.</p>
<p><i>Programme 7: Ecosystem governance</i></p>	<p>Scope: The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this.</p>

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THRUST 3: ECOSYSTEM REHABILITATION

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

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

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BUDGET FOR 2012/13

The approved funding of the research portfolio for 2012/13 led to a committed funding budget of R14 274 007. The consolidated research project budget is presented below:

<i>Research portfolio</i>	Approved 2012/13 (R)
<i>Current projects</i>	6 751 408
<i>New projects</i>	6 619 100
<i>Additional 2011 transfer</i>	903 499
<i>Total</i>	14 274 007

CORE STRATEGY

Healthy people depend on a healthy environment. This is particularly true in the case of the peri-urban and rural poor who rely directly on the environment for their livelihood. For instance, while poor quality water can be improved in treatment works (at increased cost), those directly dependent on the resource will suffer the consequences of drinking water containing pollutants or disease-causing organisms. At the same time, the flow of goods and services such as fish, fibres, cultivated and medicinal plants from a poor quality ecosystem will be less than it should be. For these and other reasons, sustainable management of the ecosystems making up the environment is central to an improved quality of life. The scale of ecosystem benefits varies from individual, for example, fibre for mat- and basket-weaving or medicinal benefits, to universal, such as good quality

water for abstraction and urban use and intact wetlands to aid in improvement of water quality and flood attenuation. In short, society cannot survive without the underpinning support from the environment.

The core strategy is fundamentally aligned to the WRC's mandate, with focus given to development of innovations that will address changing and expanding needs of society. The research funded within this KSA aims to address national initiatives and priorities such as Presidential priorities (Government MTEF), National Planning Commission priorities, and Government outcomes, and the three legs of sustainability (society, economy, and environment) as defined by the 2002 Johannesburg Summit and the National Water Resource Strategy, Water for Growth and Development, the requirements of legislation and international conventions (e.g. biodiversity conservation planning – Convention on Biological Diversity, and wetland integrity – Ramsar) of South Africa. The development of capacity for both research and implementation will receive special attention in the next five years.

Strategic context

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

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

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

The position of the WRC in funding research on ecosystems

The aquatic ecosystem comprises the resource and is a legitimate water user in terms of the National Water Act of 1998. Aside from this legal protection, aquatic ecosystems are important for a number of reasons. They provide a barometer of ecosystem health, and hence environmental quality, which is responsive to change and easy to interpret. They also provide a number of goods and services which are used by all sectors of the population.

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

planning, which supports Government legislation and other initiatives.

It is anticipated that sustainable management of ecosystems and their support of livelihoods will remain a priority research driver for the foreseeable future. Research in this area provides the basic understanding on which management decisions may be based.

Links to Government Outcomes

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

Outcome 10: Environmental assets and natural resources that are well protected and continually enhanced
Output 1: Enhanced quality and quantity of water resources

In support of this output, the WRC continues to support ongoing studies about evaluating the potential contribution of toxicity data to environmental water quality management in South Africa, as well as those on endocrine-

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disrupting compounds. The KSA continued to support a project on potential ecological and human health risks posed by persistent organic pollutants in aquatic ecosystems in a densely industrialised and urbanised area, as well as a study of the interactive endocrine disruptor effects of pesticide mixtures in water on selected species, and a study on developing sediment/toxicity guidelines, in support of this output.

Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality

To contribute to the body of knowledge on climate change and to assist in developing adaptive strategies, the WRC has completed a project that has produced a locally-made version of a miniature water-temperature logger. Long-term water temperature data are and will be required to model and manage challenges related to climate change. A new research project began in April 2012 on biological temperature thresholds for the ecological Reserve, with a particular focus on climate change and adaptation.

Output 3: Sustainable environmental management

The WRC will continue to enhance and promote our understanding, as a country, of the use of endemic biota for biomonitoring the health and integrity of water resources in South Africa. The WRC has an ongoing project on aquatic microbial diversity assessment of water resources in South Africa, which started in 2011, and aims to develop approaches that will be used to assess the health and functioning of

estuarine ecosystems. This will be important to enhance the protection and sustainable management of estuaries.

Output 4: Protected biodiversity

The WRC continued supporting a project on the assessment of the current biodiversity of amphibians associated with the major river systems of the Kruger National Park and the physical and chemical factors affecting their distribution. In collaboration with DWA, DEA and SANParks, the WRC supported a research study on biomonitoring of the fish health of two impoundments on the Olifants River, Limpopo Province. This study supports efforts to determine the cause of crocodile deaths that have been reported in the Kruger National Park and other areas. The death of crocodiles is seen as an indication of the greater threat that aquatic biodiversity and ecosystems are exposed to in rivers and other water resources. A new WRC research project to address the conservation needs of crocodiles began in April 2012. A suite of ecological, physiological, epidemiological and genetic data will be collected to expand current understanding of crocodylian biology and facilitate long-term protection of this species. Various other projects on control and management of alien and invasive species continued to be supported.

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

Output 2: Improved access to affordable and diverse food

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Most of the projects in this KSA contribute to ensuring that people have access water, food and natural medicines that are not contaminated. Most of the KSA 2 projects promote environmentally-friendly land-use practices, protection of water resources and aquatic life, and assessment of water quality, which bring about access to food (fish and vegetables) as well as natural medicines that are free from contaminants (enhancing water and food security). For example, the WRC has ongoing projects on: the management or prevention of non-point source pollution from different land uses to protect water resources and ecosystems, and a study on interactive effects of pesticide mixtures in water on selected species.

Output 4: Improved employment opportunities and promotion of economic livelihoods

The WRC continues to ensure that postgraduate and post-doctoral students are part of the project research teams or are employed to work on WRC projects. Although the employment, like research projects, is for less than four years, this is a good opportunity for most students who intend to pursue academic or consulting careers. Moreover, poor students are able to earn some form of a living. Employment within WRC projects also improves working opportunities of the involved students because they gain work experience and skills that the academic and consulting institutions require.

Needs analysis

This KSA closely supports the implementation of Government legislation and initiatives. The KSA translates the Government Outcomes into expressed needs that are addressed by the research portfolio.

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

Research is needed to address the processes and functions of various components of aquatic ecosystems. It is becoming increasingly apparent that with the

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switch to largely addressing the needs of management over the past decade and a half, we are reaching the limits of current knowledge. In recognition of this, the KSA has begun more research initiatives in selected areas in order to ensure that our knowledge remains ahead of the need to apply it. At the operational level, in addition to the issues around the implementation of legislation, there is a need to provide knowledge on the mitigation of the effect of development on ecosystems and the goods and services that they provide to people. The contributions and roles that aquatic ecosystems play in rural communities are enhanced by this KSA through rehabilitation and restoration programmes such as Adopt-a-River, Working for Water and Working for Wetlands. These national programmes also make an immense contribution to supporting job creation and water security. The KSA, in collaboration with DWA and DEA, continues to pay special attention to the effectiveness and efficiency of RDM methods and tools, particularly those used in the Reserve determination, with the intention to meet the needs of users and beneficiaries.

Overview of technological trends

Positioning of ecosystems as important resources and infrastructure

Research studies that develop and advance knowledge in this field are supported to enable the country to take advantage and gain benefits from its diverse natural resources. Healthy ecosystems play significant roles as natural infrastructure or capital. Some countries have begun to include natural ecosystems in cities' development plans as part of the infrastructure that supports and supplies goods and services to communities. The KSA will support efforts to position ecosystems as a resilient infrastructure that South Africans can depend on for the delivery of some of the

essential goods and services such as clean water, natural medicines, flood control, etc. The WRC, through this KSA, will continue to be innovative in promoting sustainable socio-economic development through research. The WRC actively seeks partnerships with all stakeholders to develop appropriate local-based innovations. Effort is made to engage social scientists in order to bridge the gap between research and society to create viable socio-ecological systems.

Ecosystems and sustainable cities

The KSA continues to work with municipalities such as eThekweni to create and implement knowledge that will enhance the ecological integrity of the landscape and water resources within and around the cities. There is need to improve degrading urban ecosystems to the benefit of all city dwellers. Improved healthy urban ecosystems are valuable recreational and educational resources, sources of water, medicinal plants, fruits and vegetables that poor and peri-urban communities can use. In collaboration with other stakeholders, the WRC will try to address issues relating to how urban and peri-urban ecosystems and biodiversity can be utilized and rehabilitated in an innovative manner to reduce vulnerability in cities and promote natural capital and resilience. Cities can also start generating many ecosystem services while at the same time reducing pollution footprints. Close relationships with municipalities and SALGA ensure that the research output from the WRC is effectively implemented.

Monitoring and assessment of eco-health

Long-term data, tools, methods, and expertise are needed to establish and support programmes aimed at protecting water resources and biota and to enhance sustainable development in the country. The conflict between water resource protection and socio-economic development should be abated. The KSA supports

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initiatives that protect and ensure sustainable utilization of water resources. The WRC works closely with DWA, DEA and other stakeholders to ensure that appropriate tools and approaches are developed for South African conditions, to monitor and assess the ecological health integrity of our estuaries, rivers, wetlands, lakes and groundwater ecosystems. A new research study on the methods and indicators needed to feed into the wetland monitoring network was begun in 2012/13. The study will result in the wetland national monitoring programme, a subset of the National Aquatic Ecosystem Health Monitoring Programme, which encompasses the River Health Programme, and the ecological integrity of estuarine and groundwater systems. With the exception of groundwater, all of these programmes are already in operation or being designed by DWA and, in some cases, in collaboration with SANBI and DEA. The WRC, through this KSA, will continue to support the process to develop a National Environmental Impact Assessment Management Strategy that gives effect to the objectives of integrated environmental management as contained in Section 23 of NEMA, within the context of the principles of sustainable development (Section 2 of NEMA).

Ecosystem goods and services

The KSA encourages studies that develop tools and methods of advancing payment for ecosystem goods and services. The KSA has already completed two research studies on ecosystem goods and services, and appropriate methodologies and tools will be tested and refined in coming years. Appropriate approaches designed and adapted in an African context will be pursued. Healthy ecosystems play critical roles in enhancing value in the ecotourism industry. Tourists prefer destinations that present a healthy environment with ecosystems that provides sufficient goods and services such as clean water, air, and food. More

knowledge is needed in profiling and understanding the key factors/drivers in different potential areas in South Africa to build on the outputs from a project on National Freshwater Ecosystem Priority Areas (NFEPA) that was completed and published in 2011/12. Developing this sector in poor rural areas can boost the economy and job creation in those areas.

Eco-terrorism and biosecurity

Eco-terrorism can be explained as an act of terrorism intended to damage another's natural environment. The country and the region have experienced ongoing destruction and degradation of critical endemic ecosystems and biodiversity. The degradation has mainly been as a result of pollution, and excessive abstraction and harvesting of natural resources. The WRC, through this KSA, continues to support studies that determine the sociological, economic and ecological impacts of this man-made destruction (ecoterrorism). The actual costs of environmental degradation are greater than what can be imagined. Eco-terrorism can be a bio-safety matter that affects community health and national food safety.

Global change and sustainability

The implementation of the Global Environment Facility (GEF) presents research funding opportunities for WRC projects addressing biodiversity. The KSA has established studies and activities that support the country's effort to adapt to climate change in consideration of the needs of local communities that are vulnerable to the adverse effects of climate change. Based on the Government outcomes, stakeholders' and the Board's views, the KSA continues to improve knowledge of the socio-economic aspects of sustainable ecosystem management. This requires increased effort toward enhancing knowledge about quality and quantity of water resources, biodiversity protection, and mitigation

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and adaptation to climate change, while at the same time using the knowledge to support rural communities and food security.

Water quality

Nationally, water quality continues to deteriorate and is a priority area (Government Outcome 10, Output 1). As such, the WRC, through this KSA, continued to support studies and efforts aimed at improving this situation. The KSA has realised that research focused on the complexity and management of this problem is needed, and a solicited study began in 2012/13 to investigate what has been done on this subject in South Africa and globally so that future research studies can be aimed at addressing the most critical areas or gaps.

Ecosystem health and environmental water quality

Knowledge of ecosystem health and environmental water quality provides the basis for balancing the use and sustainability of the resource. This research is a topical subject. The impact of deteriorating water quality, as shown by fish and crocodile deaths in the Olifants River, Kruger National Park, and anticipated acid mine drainage have drawn the attention of researchers and water managers to this field of research. The KSA will continue to support studies, in the foreseeable future, aimed at increasing understanding of the response of ecosystems to changing habitats and water quality.

Environmental water requirements (quantity)

Research studies initiated by the WRC on Reserve determination for non-perennial rivers are providing new understanding in the dynamics of rivers in the environment. Perennial rivers are largely limited to the well-watered east and the main stems in the arid west of South Africa. However, many of the tributaries, even in the well-watered east, are non-perennial.

Biomonitoring of water resources

The WRC, with DWA, DEA and SANBI, supports, through research, the development of biomonitoring tools and methods for rivers and wetlands. Tools that support the River Health Programme such as the South African Scoring System (SASS) have proved to be efficient and useful in the determination of the ecological integrity of rivers. To support implementation, the WRC has developed videos on the use of SASS as a biomonitoring tool. These videos were distributed to biomonitoring practitioners, schools and communities in 2012/13. The WRC has also supported the investigation of the potential of using diatoms as an indicator for wetland health.

Management of biodiversity

Research into the management of biodiversity (in terms of the recent legislation and Output 4 of Government Outcome 10) will continue to grow in the next few years and the current WRC research supports the country's initiatives on protection and sustainable use of our biodiversity and ecosystems. Besides numerous research projects related to sustainable utilisation of biodiversity, such as for wetlands, the KSA continues to support research about developing methods for control of alien and invasive fish from selected rivers. A research study on control of alien fish species began in 2011 in the Western Cape, and is developing effective methods of restoring river ecosystems that are degraded by alien invasive fish species. Alien and invasive species remain some of the top threats to biodiversity. The WRC, through this KSA, continues to collaborate with CAPE Nature, DEA, SANBI, NRF, SAEON and SAIAB in supporting this initiative and promoting public awareness.

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Ecosystem governance

Ecosystem governance has been identified as an essential component of sustainable management, as shown by the failure of some research programmes to achieve the results that the technology developed during these programmes promised. To this end greater emphasis is being placed on ensuring that this aspect is addressed during research, in order to provide technologies for implementation. Current ongoing research, for instance, the Shared Rivers project, will enrich the understanding regarding the above.

Key stakeholders

The key stakeholders remained largely unchanged in 2012/13. In addition to the Department of Water Affairs (DWA) and Department of Environmental Affairs (DEA), other Government departments such as Agriculture, Forestry and Fisheries (DAFF), Science and Technology (DST), and Rural Development and Land Reform (DRDLR), are of importance. Provincial and local government form another group of stakeholders, and the needs of the catchment management agencies (CMAs) which are currently being established influence research direction. Other end-users of the research are water boards, and rural communities and others living off the land.

Research providers

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

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

RESEARCH PORTFOLIO FOR 2012/13

This KSA focuses on the protection and sustainable utilisation of the aquatic ecosystems (abiotic and biotic) and the economic (livelihoods) and social benefits related to their use. More effort is being put into addressing land use impact and terrestrial ecosystem change that has an impact on water resources and aquatic ecosystems. It addresses national research needs (strategically of long- medium- and shorter-terms) as well as those of international conventions on environmental management (e.g. wetland conservation (Ramsar) and the Convention on Biodiversity). Work done within this KSA continues to contribute in the reviews of the National Water Act (NWA of 1998), strategies and associated policies, an example being the ecological Reserve. This has meant that work within this field has not only addressed the strategic needs of the country, which have increased in line with the increased global recognition of the importance of the role of sustainable environmental management, but has also addressed some of the immediate research needs related to the NWA and its implementation.

In essence, the implementation plan for 2012/13 has followed that of previous years in that the primary objective of this research portfolio is the provision of

knowledge to enable good environmental governance so as to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country during a time of demographic and climate change.

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Riverine processes

The relationship between periphyton, flow and nutrient status in Western Cape foothill rivers and the implications for management

University of Cape Town (Zoology Department); National Institute of Water and Atmospheric Research (NIWA); Nelson Mandela Metropolitan University
No. 1676

To address the objectives of the study, a quantitative assessment of the physico-chemical and biological conditions that potentially drive periphyton dynamics in the foothills of south-western Cape rivers was conducted. Temporal changes in abiotic and biotic factors under natural flow and nutrient conditions were studied over 21 months (October 2007 to May 2009) and these were compared with the patterns under altered flow conditions and nutrient enrichment. This study showed clear seasonal cycles in environmental conditions in the Berg and Molenaars Rivers that are typical of rivers in Mediterranean climates elsewhere. Temporal shifts in temperature and solar irradiation were used to define six seasons over an annual cycle, namely, winter, early spring, late spring, summer, early autumn and late autumn. The study managed to address natural seasonal changes in periphyton biomass and

community composition in the foothills of south-western Cape rivers, and the effects of enrichment and flow alteration. The factors or combination of factors, (i.e. hydrodynamics, temperature, light, grazing, habitat and water quality) which explain differences in periphyton communities under natural and altered conditions were studied further to identify their relative importance. Moreover, the differences in periphyton communities in biotopes typical of foothills in south-western Cape rivers were explored for different nutrient conditions and seasons. Periphyton communities with different pre-flood growth forms were compared in terms of their response to individual flood events of different magnitude. Recovery of a periphyton community following a flood was also monitored. This report constitutes the first detailed assessment of periphyton community structure and biomass in South African rivers. It explains how periphyton responds to flow regimes and nutrient enrichment, and reveals the importance of understanding periphyton dynamics in water resources management. It contributes to the body of knowledge that should be used in determinations of the ecological Reserve and can help guide future monitoring of aquatic ecosystem health.

Cost: R1 000 000

Term: 2006 - 2012

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

Bioassets cc; University of Venda; SANParks; University of Johannesburg
No. 1928

KSA 2: WATER-LINKED ECOSYSTEMS

The study was conducted based on 45 sites, representative of the ecoregions of the Kruger National Park (KNP). The sites were selected to cover as much vegetation, geological and habitat types as possible. All 45 sites were surveyed in summer, while 14 of them (being rivers) were surveyed in winter as well. Sampling was done twice a year at all summer sites. As part of the frog diversity survey, frogs and tadpoles were physically collected and night surveys conducted. During the night surveys, calls were recorded and frogs crossing roads were collected. Where water was present a water sample was collected and in-situ water parameters measured. Sediment samples to use for sediment classification and chemical analyses were collected from all the sites. Historic surveys in KNP resulted in 33 frog species being recorded. During the current survey 30 frog species were recorded. A combination of historic and recent field surveys resulted in 34 frog species being recorded from KNP. The results of this survey indicate that long-term monitoring projects specifically focused on amphibians are required within the KNP pan systems. The water quality tests, including for acid rain, as well as histopathological tests, revealed no conclusive results, though some organs (kidney, liver, etc.) showed pollution impacts in some frog species.

Cost: R1 037 500
Term: 2009 - 2012

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

University of Limpopo; University of Venda
No. 1929

The water quality between the two impoundments was shown to be significantly different, but the water chemistry parameters were more important in driving

the differences, rather than the metal concentrations. The metal content in the sediments of Flag Boshielo Dam are significantly higher than those of the Phalaborwa Barrage, with iron and aluminium contributing more than 99% to the dissimilarity between the two impoundments. The study found that there is a significant difference in metal concentrations in the muscle tissue of fish from the two impoundments. Considering each impoundment, a significant difference in the metal concentrations in muscle tissue was found for Flag Boshielo Dam. A significant, but weak, relationship was identified for both dams, the metal concentration of the muscle tissue and that of both the water and the sediment. The fish populations from both dams seem to be in overall good health. Further, the HAI indicated that the four fish species were in relatively good health at both dams. The study contributes to establishing the zoogeographical ranges and reduces the information deficit for some parasites. For instance, the monogeneans of most fish species, especially cichlids, are not well documented in South Africa. The *Enterogyrus* sp. from the stomach of *O. mossambicus* is a new species and record for South Africa. *Paradiplozoon* sp. recorded from the gills of *L. rosae* and *Gyrodactylus* sp. from the gills of *C. gariepinus* are new locality records and possible new species. One digenean parasite found in the orbit of *L. rosae* is a new host and locality record for South Africa (and possibly a new species). The *Ergasilus* sp. recorded from three different hosts is a new species as well as new host and locality records for South Africa. The sixth new species recorded during this study is *Lamproglena* sp. from the gills of *L. rosae*. None of the parasites identified from the hosts from both dams reached alarming infection levels. These parasites reached such intensity levels without affecting the host condition, thought to be an adaptation that probably ensures that the larvae survive to reach the final host without killing the

intermediate host. Fish health (including parasite burden) is important as freshwater fish are consumed by humans on a regular basis, especially in rural areas. The digenean larvae, including *Clinostomum*, *Euclinostomum* and possible the digenean cysts from the gills and muscle, are of zoonotic importance and these larvae have the potential to develop in humans. Overall, though the fish health was good, parasitic infection rates were high. The risk to human life through consumption was determined and needs to be communicated clearly.

Cost: R674 500
Term: 2009 - 2012

Programme 3: Wetland processes

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

Dames; University of Waterloo
No. 1857

The effects of changes in climate or landscape on wetland ecosystems need to be considered within the context of natural processes. Hydrological processes are a key component in the development and maintenance of wetlands and the source of water determines a wetland's vulnerability to a changing landscape and environment. The overall objective of the proposed research was to investigate the ecosystem processes that regulate water supply in the St Lucia wetland complex, with specific reference to the Mfabeni Peatland. The specific objectives were:

- To construct a rigorous water balance on the Mfabeni Peatland-coastal dune complex
- Quantify the nature, magnitude and persistence of water efflux to the estuarine system

- Evaluate the potential effects of changing climate and land use practices, especially plantations, on the water dynamics of the system.

Wetlands, including peatlands, in general, and coastal peatland swamp forests in particular, are being threatened by various land use changes. These include expanding *Eucalyptus* plantations; subsistence- and commercial-scale cultivation practices in and around the iSimangaliso Wetland Park and infrastructure development such as roads and tourism-related activities (e.g. lodges, boardwalks and trails). A set of general and specific guidelines were drafted to support sustainable management of peatlands in Maputaland. These guidelines will need another round of workshopping with interested parties, such as DAFF, iSimangaliso Wetland Authority, KZN Wildlife and local plantation owners and farmers, in order to validate them, to establish ownership and institute a sound cooperative management framework for involved roleplayers. Conservation management of these ecologically sensitive areas needs to take cognisance of the sensitive nature of these ecosystems and at the same time incorporate sensible land-use practices to accommodate the socio-economic needs of impoverished communities depending on these ecosystems for survival.

Cost: R859 750
Term: 2008 - 2012

KSA 2: WATER-LINKED ECOSYSTEMS

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

University of Cape Town (Freshwater Research Unit); Department of Water Affairs; North-West University (Potchefstroom Campus)
No. 1921

As soon as more wetland water quality data have been collected, the boundary values formulated in this project should be refined. It may then be possible to develop boundary values for all five Ecological Categories (A-E) rather than the three levels developed here. The results from this study have shown that there is natural variation in water quality between different wetland types and specifically that depressions have naturally higher levels of constituents than other wetland types. These findings, however, were not taken into account during derivation of this set of guidelines, as it was felt that more investigation is first required. Once this has been done, the boundary values may need to be revisited and different values derived for depressions. Similarly, the results from this study have also shown that water quality varies naturally with region and that pH, and possibly nitrates plus nitrites, are lower in wetlands of the Fynbos biome. More work is required to develop and validate the diatom assessment index for wetlands.

Cost: R1 070 064
Term: 2009 - 2012

Regional wetland processes of the Maputaland coastal aquifer on the Zululand coastal plain
ARC (Institute for Soil, Climate and Water); University of Waterloo; Ezemvelo KZN Wildlife; iSimangaliso Wetland Park
No. 1923

The interaction of environmental factors and processes on a broad scale, such as climate, geology, geomorphology (including topography) and hydrology, and the influence thereof on wetland distribution and function on the Maputaland Coastal Aquifer (MCP) is poorly understood. Furthermore, it is unclear how land-use and the inter-annual variation in seasons affect the extent and distribution of wetlands on the MCP. Land-use activities such as agriculture, forestry and water supply schemes on the MCP and prolonged periods of drought have led to reduced availability of groundwater. The local communities on the MCP depend on the wetlands for their daily livelihood and during drought periods the above-mentioned factors intensify, leading to degraded or vulnerable wetland ecosystems. There is a need to determine spatial and temporal changes in the distribution and function of these wetlands and to understand the controlling processes. The following research questions need to be addressed:

- What types of wetlands are found on the MCP?
- What factors control their distribution?
- What are the impacts on the MCP wetlands?
- How should MCP wetland types be managed?

The aim of this project was to understand the regional processes that control the different wetland types and their distribution on the Maputaland Coastal Aquifer in north-eastern KwaZulu-Natal. The primary focus of the study was to classify wetlands on the Maputaland Coastal Plain; characterise the relationships between hydrogeomorphic setting (climate, geology, geomorphology and hydrology) and the nature and distribution of wetland types; and land-use/land-cover changes caused by climatic variability and land-use changes in recent decades. In South Africa the potential evapotranspiration exceeds precipitation (primarily

rainfall). Wetlands in these conditions are often dependent on groundwater as the key driver. Rainfall provides the main recharge to the aquifer. The rainfall amount and variability are influenced by synoptic processes including frontal winter systems, convective thunderstorms and significant cyclonic rainfall events, and relatively infrequent rainfall events associated with advancing moist air from the Indian Ocean crossing the MCP. The freshwater recharge to Lake St. Lucia on the MCP is highly variable. Seasonal rainfall patterns as well as year-to-year variation in rainfall have a significant impact on water levels of isolated wetlands. However, rainfall interception and replenishment of soil moisture limit recharge to those rainfall events exceeding 10 mm. The results indicate that the Walkley-Black method is the most suitable to measure soil organic carbon in order to determine the hydroperiod for the delineation and classification of permanent, seasonal and temporal wetlands on sandy coastal aquifers. Should cost not be a factor, the dry combustion method can be considered as an alternative. This study contributed in understanding the relationship of a wetland to its water table and how this relates to the HGM type and landscape position. Not only were wetland patterns established in wet and dry years, but the link with the environmental factors that influence the wetland processes was also determined. The different wetland types in the landscape clearly relate to depth and fluctuation of the water table. The results can help to emphasise the function and vulnerability of wetlands based on the inter-annual variability and seasonal/extreme events that could help guide sustainable agricultural practices associated with them. The process driver on the MCP is rainfall coupled with the geological and geomorphological template of the area.

Cost: R893 364
Term: 2009 - 2012

Evapotranspiration from the Nkazana Swamp Forest and the Mfabeni Mire
CSIR (Natural Resources and the Environment, Pietermaritzburg); University of Waterloo
No. 1926

The health and future conservation of Lake St. Lucia is strongly dependent on the water level and salinity of the water within the lake, which is controlled in part by freshwater inflows. During droughts, the rivers to the west (Mkuze, Mzinene, Hluhluwe and Nyalazi) provide limited inflow into the lake. Freshwater seepage from the groundwater mound of the Embomveni ridge on the Eastern Shores area into the Nkanzana and Tewater Rivers, as well as other seepage zones along the shoreline, become the most important contribution to the lake. This groundwater seepage from the Eastern Shores area has significant ecological importance and provides refuge sites where localised freshwater inflows enable many species to survive during periods of high salinity, preventing extinction and loss of biodiversity. For improved management of the system, accurate water-balance studies were required but were impossible without reliable estimates of ET. The solution was to apply the most appropriate and up-to-date methods to determine the long-term ET for this key strategic wetland and to use these results to verify existing meteorologically-based models for future use. This would not only reduce uncertainty in the water-balance study of the Mfabeni Mire, but also provide guidance in terms of seasonal ET rates over wetlands and lead to an improved understanding of the processes that define how the surface energy balance in wetlands is partitioned. This study clearly showed the invaluable contribution that can be gained from field-based measurements. Prior to this study, there was no ET information for the five dominant landscapes of the Eastern Shores area, which is now provided in this report. This will certainly assist in the future management

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of the iSimangaliso Wetland Park water resources to ensure the sustainability of the invaluable ecosystem. It was also shown that the different vegetation types have significantly different water use. This implies that changes in land use brought about by climate change or management of the system (by fire for example) will impact the water-balance of the area. The implications of land-use and climate change should therefore be a consideration in the management plans of the area.

Cost: R908 000
Term: 2009 - 2012

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

University of Stellenbosch; University of the Western Cape; SANBI
No. 1927

The results of this study support the hypothesis that invasion by *Acacia* species has an impact on soil and microbial processes, and also that these processes can recover when invaders are cleared. The results find key application in the Working for Water Programme, in that removal of *Acacia* species may assist in restoration of riparian ecotones. While plant structure and diversity have not been studied to a great extent in this research, aspects of function that received attention suggest a trajectory back towards the natural state after removal of *Acacia* species. However, more than seven years after removal of *Acacia* species, legacy effects still remain, and these legacies (e.g. high available N) need to be carefully considered in managing clearing and follow-up activities.

Cost: R1 800 200
Term: 2009 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

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

SANParks Scientific Services; Fluvius Environmental Consultants; South African Environmental Observation Network (SAEON); University of the Witwatersrand
No. 1797

Water resource management is becoming complex, requiring an adaptive, learning-by-doing approach, and the rivers of the Kruger National Park (KNP) are no exception. This research aimed to consolidate Strategic Adaptive Management (SAM) process, widely used in SANParks, for freshwater management in the KNP, focusing on the flow component of the ecological Reserve. The Rapid-Response-System developed during this work consisted of the defining of 'worry levels', each of which requires defined actions and a management log detailing actions taken and their outcomes, information essential for the evaluation phase of the SAM model, enabling refinement of the model over time. Outcomes of the project include detailed documentation of TPC development, application, assessment and refinement occurring within the KNP river SAM system over the past decade and in particular over the project period, 2008 – 2011. A number of feedback processes, an important component of SAM, are described in the case studies of the Crocodile (East) and Groot Letaba. Future research needs are detailed.

Cost: R1 355 725
Term: 2008 - 2012

Decision support software development for integrated flow assessments

Southern Waters Ecological Research and Consulting; Beuster, Clarke and Associates; AJ Greyling; Water Matters
No. 1873

DRIFT is a process that was developed in South Africa to aid management and future planning of water-resource developments, rehabilitation of rivers or any other management activity that could affect the flow or inundation patterns of an inland water ecosystem. Development has taken place through extensive application of the process within South Africa, in southern and eastern Africa, and on other continents, mostly Asia and South America. The overall process contains three main steps:

1. Set up
2. Knowledge capture, comprising:
 - a. Hydrological modelling of present day, naturalised and possible future daily flow regimes (scenarios)
 - b. Predictions of the response of relevant physical, chemical, biological and socio-economic variables to described changes in the future scenario flow regimes
 - c. Predictions of the economic implications of the scenarios
3. Analysis

The DRIFT Decision Support System (DSS) holds the input data for Steps 1 and 2b, makes the predictions in Step 2c and receives data from outside on Step 2a (the hydrological modelling). It provides the information upon which the outside economic analysis is based (Step 2c) and brings all the information together for the summary reports (Step 3).

Cost: 1 800 000
Term: 2009 - 2013

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

Anchor Environmental; Coastal Research Unit of Zululand; Consortium for Estuarine Research & Management; University of Stellenbosch; CSIR; Marine and Estuarine Research; Nelson Mandela Metropolitan University; independent consultant; South African Association for Marine Biological Research (SAAMBR); SA Institute for Aquatic Biodiversity. Southern Waters Ecological Research and Consulting
No. 1930

The National Water Act of 1998 requires the implementation of Resource Directed Measures (RDM) in order to make optimal use of our country's water resources while minimising ecological damage. The main focus of RDM is the determination of the Reserve, which is the water quality and quantity required for the protection of basic human needs and aquatic systems. The latter component, or ecological Reserve, is the quality and quantity of water required to maintain a desired level of structure and function, or quality, of a specific aquatic system (e.g. river reach, wetland, estuary). The desired quality of the water resource will be defined by its Ecological Category which can be A, B, C or D on a health scale of A to F (Table 1.1). While scientists are allowed to make recommendations for this category, the Recommended Ecological Category; (REC), the final decision will be based on ecological, social and economic criteria in a participative process called the National Water Resource Classification System's Classification Process (Dollar et al., 2010; gazetted in 2010). The Department of Water Affairs is responsible for the classification of all significant water resources in the country, including estuaries, and these

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decisions will be re-evaluated at intervals. Although the Classification Process was gazetted only recently, the Reserve determination methods were devised in 1999 (DWAF, 1999) and have been in use since then, though having evolved over time following increased experience and understanding of the methods in practice. This method will continue to be part of the more formalised Classification Process. In the Reserve determination process for estuaries, the method involves (a) estimating the present health status of an estuary, (b) setting an REC on the basis of this and its importance using a simple set of rules, (c) setting an EC based on the ecological, social and economic criteria, (d) predicting how health changes under a range of flow scenarios, and then (e) finding the flow scenario that most closely matches the REC in order to define the ecological Reserve. The Estuary Health Index (EHI) is central to the Reserve determination method.

Cost: R604 400
Term: 2009 - 2012

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

IWR Water Resource (Pty) Ltd; Association for Water and Rural Development (AWARD); University of KwaZulu-Natal (Pietermaritzburg)
No. 1979

Water resources model development and model application within South Africa has focused on monthly time step models, probably because monthly hydrology has been readily available through ongoing research initiatives, commencing with the Hydrological Research Unit in the 1970s. Also, a considerable amount of additional effort is required to expand modelling

to a daily time step, without necessarily adding any value, hence the reluctance of practitioners to move towards daily modelling. However, ecologists involved in determining the ecological water requirements of rivers and estuaries are increasingly requesting estimates of flood frequencies and magnitudes from hydrologists and water resource modellers. While daily hydrology models are available in South Africa (for example, the ACRU (Smithers and Schulze, 1995) model), these models have seldom (if ever) been used in ecological water requirement studies, while development on the monthly water resource models to support ecological studies is ongoing. There is clearly a need to address the concerns of ecologists relating to floods and short-duration events. One way of doing this is to integrate the daily times series produced by a daily hydrology model (e.g. ACRU) with a monthly water resources model (such as the Water Resources Modelling Platform (Mallory et al, 2011)). While efforts have been made in earlier studies to generate daily flows in ungauged locations using different sources of information, including monthly flow data, this has been seen as a challenging and non-trivial scientific issue (Smakhtin and Hughes, 1996; Smakhtin, 2000). This project has developed a methodology to disaggregate monthly time series into daily time series using ACRU (Smithers and Schulze, 1995) daily hydrology to provide the daily variability while maintaining the statistical signature of the original monthly time series. The method has been tested on four pilot catchments. The four selected catchments are:

- Sabie: This catchment was selected due to the interest shown by SANParks in daily modelling of the Sabie River catchment as part of ongoing ecological studies
- Upper Breede: This catchment was requested due to the formation of the Breede Catchment Management Agency

- Mokolo: This catchment was requested by riverine ecologist following on from a recently completed ecological study using monthly flows
- Seekoei: This catchment was selected due to its ephemeral nature in order to test the methodology on ephemeral rivers.

While the goal of this project is to produce plausible daily time series, the purpose of the pilot studies is to evaluate these time series and assess whether they meet various statistical criteria.

Cost: R378 000
Term: 2010 - 2012

Programme 2: Estuary management

The application of choice modelling techniques to guide the management of estuaries in South Africa – case studies at the at the Sundays, Kromme, Nahoon and Gonubie River Estuaries
Nelson Mandela Metropolitan University
No. 1924

The primary aim of this project was to generate information that assists managers towards making efficient choices on matters identified to be of current demand interest. This goal was pursued by setting up focus groups of people and experts with interest in and knowledge of selected estuaries, and tasking them to identify and select strategies and investment/operational options on behalf of society – with the goal of improving the recreational appeal of these estuaries. The selected estuaries were the Sundays, Kromme, Nahoon and Gonubie River estuaries. For all the above-mentioned options (specific to each estuary), marginal willingness-to-pay (WTP) values were calculated by applying the Choice Experiment (CE) method. The

calculation is made from estimates of choice models. Three different choice model specifications were estimated for these estuaries: a conditional logit (CL) model; a heteroscedastic extreme value (HEV) model, and a random parameters logit (RPL) model. In the case of the Sundays River Estuary, the results from the RPL, HEV and CL models revealed that recreational users were willing to pay more for an estuary management strategy which enabled higher physical size of the fish stock; lowered the amount of boat congestion; and improved the amount of public access available. In the case of the Kromme River Estuary, the results from the RPL, HEV and CL models revealed that recreational users were willing to pay more for an estuary management strategy which enabled higher levels of navigability; reduced the amount of boat congestion; and lowered the amount of access for jet ski and wet bikes. In the case of the Nahoon and Gonubie Estuaries, the results of the RPL, HEV and CL models revealed that recreational users were willing to pay additional rates for improved water safety, protection from criminal activity and support services. However, tests for multi-collinearity were positive, indicating the possibility that orthogonality of the experimental design was compromised. For this reason, no conclusions for management intervention were drawn on the basis of these results. Demonstration of the application of the method to guide management interventions, was therefore restricted to the examples of the Sundays and the Kromme Estuaries. The particular management advice generated and reported above, for the Sundays and the Kromme Estuaries, cannot be extrapolated to all other estuaries because the situations of each estuary differ.

Cost: R770 000
Term: 2009 - 2012

Programme 5: Endocrine disrupting compounds

Development of a Sampling Guide, Volume 2, of the Manual of Guidelines for the Management of EDCs in water resources

Golder Associates Africa (Pty) Ltd; Department of Water Affairs and Forestry; University of Pretoria
No. 1983

The aims of this project were to develop a guide to correct sampling and sample preparation in the context of endocrine disrupting chemicals (EDCs). This project also produced the overall introductory chapter for the current series of EDC management volumes (of which the sampling guide is one). The sampling guide provides an overview of the issues that should be considered when designing a sampling programme (i.e., the how, when, and where). The guide addresses four media, namely, water, sediment, air and biota (typically fish). Quality assurance and quality control are described. Sampling procedures are described for each of the four media. These include pre-field preparation, sampling site selection, actual sample collection, as well as sample storage and transport. The introductory volume advocates a precautionary approach to EDC management. It notes the importance of concepts such as 'duty of care' and reduction of EDCs at source as much as this is possible. It also provides 10 useful one-page 'Fact Sheets' addressing frequently asked questions.

Cost: R495 000
Term: 2011 - 2012

Programme 6: Socio-economic considerations

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

University of Venda; University of the Free State;
University of Limpopo; BioAssets Consultants
No. 1925

This project has shown that over the period of sampling the numbers of fish had declined and this can be ascribed to the uncontrolled harvesting that is taking place. Over and above quotas in the form of harvested biomass being important, the correct use of the correct fishing gear is cardinal. The results of this project indicate the selectivity of the nets used. It is proposed that net selectivity is applied in such a way that no harm is done to the population structure of the target species. This will ensure that a viable breeding population will be maintained. Water quality issues should also be addressed as a matter of urgency. The results of this project have shown that pollution in the Dzindi and Mvudi river catchment existed and that this was reflected by the decline of water quality at the inflow. It is however important to take cognizance of the fact that this decline will extend throughout the dam if no action is taken. It is therefore imperative that water quality monitoring, and plans for corrective actions, should form part of any management plan.

Cost: R773 200
Term: 2009 - 2012

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

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

Ground-Truth cc; University of KwaZulu-Natal (Pietermaritzburg)
No. 2035

Assessment of the long-term response of two wetlands, Killarney and Kruisfontein, to Working for Wetlands rehabilitation is seen as contributing significantly towards the wetland rehabilitation field of practice as it allows one to reflect on challenges. This reflection assists in 'closing the loop', informing future rehabilitation planning, with recommendations documented for wetland rehabilitation implementation, planning, and monitoring and evaluation. In addition to documenting lessons learnt and refining wetland rehabilitation efforts in South Africa, this study introduces two indices to objectively and defensibly utilise vegetation to quantify changes in long-term wetness and habitat quality. This is the first time that these indices have been applied in South Africa, and based on their application in the study it appears that these indices have particular value for measuring wetland ecosystem response to rehabilitation. In addition, the indices are likely to have much broader application, e.g., for wetland delineation and the assessment of current impacts on wetlands. Another finding that emerged was that the objectives of rehabilitation must be very clear and success or failure must be based on whether these objectives were achieved or not; not all wetlands when rehabilitated will be able to provide the same services and goods – the outcome will be site-specific, i.e., differ from one wetland to the next.

Cost: R256 510
Term: 2011 - 2012

Programme 2: River and impoundment rehabilitation

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

DH Environmental Consulting; Koekemoer Aquatic Services; Muller Environmental; Rhodes University; SA Institute for Aquatic Biodiversity
No. 1918

This research project examined the food web structure of the Rietvlei Dam in order to determine the possibilities for fishery biomanipulation as a tool for attenuating the impacts of eutrophication. This concept presumes that the phytoplankton comprises species that are edible by zooplankton, and that the fishery comprises obligate zooplanktivorous species. This linear feeding pattern is not always the case, especially in non-natural water bodies, such as impoundments. To track the Rietvlei food web, the study employed stable isotope analysis (SIA) techniques for the first time in a South African reservoir. None of the findings gleaned from this study suggested that zooplanktivory has a significant influence on zooplankton community structure and abundance levels. The evidence obtained using SIA indicates that trophic pathways leading to fish primarily follow benthic, rather than planktonic routes. As such caution should be taken in South Africa to assume manipulation of fishery will result in the attenuation of eutrophication.

Cost: R1 500 000
Term: 2009 - 2012

Conservation of tigerfish, *Hydrocynus vittatus*, in the Kruger National Park with the emphasis on establishing the suitability of the water quantity and quality requirements for the Olifants and Luvuvhu Rivers

University of Johannesburg; University of Venda; BioAssets Consultants; SANParks
No. 1922

Tigerfish do respond to the presence of low levels of pollutants. Their highly mobile nature enables them to avoid exposure to debilitating stressors, and, since one of the key criteria for the choice of a bioindicator is that it should represent the ambient conditions, the tigerfish may not be an ideal indicator species for water quality. However, results from the flow assessment done as part of this study clearly showed that tigerfish have very specific flow and habitat requirements, thus making them an excellent indicator species of water quantity. Furthermore, all fish species from the Olifants River have identifiable habitat preferences that were successfully used to evaluate the effects of reduced flows. Low flow discharges of approximately 17 m³/s in the Olifants River may begin to show higher levels of stress in fish due to reductions in habitat diversity and abundance. Below a flow of 4.9 m³/s the resulting reduction in flow-dependent habitat types would become severe.

Cost: R1 486 000
Term: 2009 - 2012

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

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

Nelson Mandela Metropolitan
University (Botany Department)
No. 1982

The study will provide knowledge of the processes that regulate nitrogen and phosphorus cycling in a temporarily open/closed estuary. The previous Great Brak Ecological Water Requirements Study recommended that further studies are needed to determine the loads of nitrogen and phosphorus flowing through the estuary and to determine how effective the estuarine flora, macro-algae and macrophytes, are at trapping and removing these nutrients from the system. Understanding this aspect has become critical in view of the increased water requirements from PetroSA and Mossel Bay and the related decreased inflow to the estuary. Less river inflow to the estuary translates into more closed mouth conditions, which in turn will cause more nuisance algal blooms in the system impacting on both the sense of place and biota of the estuary. The main aims of the study are: to identify the sources and determine the loads of nitrogen and phosphorus entering the estuary, through point-source discharge (e.g. river, sea and storm drains), diffuse discharge (e.g. groundwater seepage from septic tank overflow and golf course irrigation water), atmospheric deposition (rain water) and remineralisation from organic material trapped in the sediment; measure the flux of nutrients between the water column and the benthos; measure the nitrogen and phosphorus content in living plant material; describe the environmental conditions in

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the estuary that favour macro-algal blooms; provide recommendations to be included in the Great Brak Estuary Management Plan; and to compare results from the Great Brak Estuary, an estuary dominated by macrophytes and macro-algae, to estuaries dominated by phytoplankton (e.g. the permanently open Sundays Estuary).

Estimated cost: R955 000
Expected term: 2010 - 2013

Programme 2: Riverine processes

Linking hydrology and lateral riparian vegetation zones

Southern Waters Ecological Research & Consulting
No. 1981

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

to identify the number and composition of lateral zones in riparian vegetation communities in a selection of rivers around South Africa; suggest standardised names for the identified lateral vegetation zones; explore the relationships between these lateral vegetation zones and aspects of the daily flow hydrology and, if possible, link the identified zones to flows of particular return periods; and to seek simple methods for the identification of the lateral vegetation zones.

Estimated cost: R1 765 310
Expected term: 2010 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 1: Ecological Reserve

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

Fluvius Environmental Consultants
No. 1788

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

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

Environmental water requirements for non-perennial systems: Phase III

University of the Free State

No. 1798

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

Estimated cost: R3 000 000

Expected term: 2009 - 2012

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

AWARD

No. 1920

There are conflicting views among communities with regard to the use and management of water resources, which has complicated the implementation of trans-boundary water resource management, particularly the ecological Reserve, in RSA. In spite of all the challenges, there are situations where implementation of the ecological Reserve has been successfully executed. There are also situations where implementation has not been successful. Effective planning needs to

critique these case studies, to identify the strengths and weaknesses (gaps) of the implementation approaches and methods and the policy itself. The results or output will be used to design 'a new way of doing things' as far as implementation of the Reserve is concerned. The output may also suggest refinement of the policy if need be.

Estimated cost: R800 000

Expected term: 2010 - 2013

Programme 3: Ecosystem health

Osmoregulation in freshwater invertebrates in response to salt pollution

Rhodes University (Institute for Water Research)

No. 1585

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

Estimated cost: R201 160

Expected term: 2005 - 2009

KSA 2: WATER-LINKED ECOSYSTEMS

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

University of Stellenbosch

No. 1712

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

Estimated cost: R370 000

Expected term: 2007 - 2013

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

Sinelwati Scientific Research & Management

No. 1976

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

Estimated cost: R1 650 000

Expected term: 2010 - 2013

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

University of the Free State (Plant

Sciences, QwaQwa campus)

No. 1980

This is a follow-up of a scoping study (based on three provinces; K8-789) on building a national database on wetland vegetation. It addresses the critical need for baseline data on the biodiversity of South Africa's

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wetlands. Furthermore, it will support the Working for Wetlands Programme by establishing a method by which wetland biodiversity can be monitored after rehabilitation. In that sense it will supplement the Wetland Health and Integrity Programme already produced.

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

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

Rivers of Life Aquatic Health Services cc
No. 2111

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

Estimated cost: R841 000
Expected term: 2011 - 2013

Programme 4: Environmental water quality

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

University of KwaZulu-Natal (Chemistry)
No. 1977

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

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

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

CSIR; Ground-Truth cc; University of KwaZulu-Natal
No. 1984

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

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

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

Rhodes University (Biochemistry)
No. 2038

The aim of this study is to employ high throughput pyrosequencing of the 16S rRNA genes to characterise estuarine microbial diversity with a view to assessing ecosystem health and functioning in selected estuaries along the Eastern Cape coastline. The intention is to use

the data from this pilot study to establish criteria for an early warning system to monitor aquatic ecosystem health based on changes in microbial diversity. The overall objective is to apply this technology in assessing the function and health of both freshwater and marine ecosystems in the future. The project will offer a unique opportunity to characterise the microbial biodiversity in aquatic/estuarine systems.

Estimated cost: R800 000
Expected term: 2011 - 2014

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

Rhodes University (Centre for Environmental Water Quality)
No. 2040

The overall aim of this study is to investigate the impact of suspended sediment particles (particulate) as a physical water quality variable on the macro-invertebrates. The project will focus on investigating the impact of suspended sediment particle size and not the bed-load, though the latter is likely to cause more abrasive effects on invertebrates. Utilising the existing data and literature on sediment effects, a generic framework of sediment water quality guidelines will be developed. The microcosm nature of the investigation may need field or experimental mesocosm verification in order to establish a credible and scientific basis for development of sediment water quality guidelines. This project must be conducted hand-in-hand with a sediment bio-toxicity study commissioned by the WRC.

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

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Programme 5: Endocrine-disrupting compounds in water resources

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

University of Stellenbosch (Department of Zoology)
No. 1680

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

Estimated cost: R400 000
Expected term: 2006 - 2009

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

University of Stellenbosch
No. 1932

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

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

Estimated cost: R1 600 000
Expected term: 2009 - 2012

Programme 7: Ecosystem governance

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

AWARD
No. 1920

Research conducted will develop a dynamic synthesis of the reasons for the lags in the implementation of the National Water Act (NWA) of 1998, focusing on the ecological Reserve. It will not be a blueprint for solving the problem, but it will provide the principles and framework to guide water practitioners and managers in solving context-specific problems. Key to the whole programme is the building of capacity amongst the people involved in all levels of water resource and service management (relevant spheres of government, agriculture, mining, etc.) through action research. A means of working in this study is through collective action, networking, self-organisation and practice-based feedback loops, the aim being to develop these features where they do not already exist. It is anticipated that this will be a collaborative process and some of the outcomes will need to be negotiated. The overall aim

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of the Shared Rivers Initiative is to understand and effect change in the implementation of policies and legislation, specifically the ecological Reserve, relevant to the wise use of the Lowveld river systems. In addition, the study will design and implement a series of actions that will build capacity and confidence in the legal competence to enforce obligations associated with environmental water requirements in the region and specifically the ecological Reserve in South Africa. This must be done in such a manner as to allow a generic way of introducing ongoing change which is consistent with adaptive learning.

Estimated cost: R2 500 000
Expected term: 2010 - 2013

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

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

University of KwaZulu-Natal (CEAD)
No. 1986

Wetlands are highly productive and are important for the conservation of biodiversity as well as water resource protection. They are also used by people in both formal and informal (subsistence) agriculture as well as for various forms of recreation. Wetlands are susceptible to alteration through various forms of land use and upstream activities such as water abstraction and mining. Ecosystem goods from wetlands such as fisheries have been shown to be closely correlated to the area flooded, and so knowledge of the environmental water requirements (both quantity and quality) of

wetlands is important. Recognising that certain uses impact negatively on the ecosystem goods and services that these wetlands provide, this project aims to define those ecosystem goods and services, to indicate the management activities (including rehabilitation where necessary) required to deliver the goods and services on which various activities (for example: those mentioned above) depend, and to describe interventions for the rehabilitation of impacted wetlands to suit specific uses and users.

Estimated cost: R800 000
Expected term: 2010 - 2012

Programme 2: River and impound rehabilitation

Setting objectives for urban river rehabilitation

Aurecon Group
No. 2036

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

Estimated cost: R850 000
Expected term: 2011 - 2013

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

To have better water hyacinth management, infested sites must be monitored so that the growth trajectory of the weed population is understood, and also to be able to predict what intervention will be required, and by when. This project therefore intends to develop remote sensing as a tool to make predictions; firstly to measure growth and the effects of biological control agents on the weed at a landscape level, and secondly to investigate the impacts of heavy metal water pollutants on biocontrol agents of water hyacinth. Because hyperspectral remote sensing (RS) can detect heavy metals and the effects of insect herbivory on the plants, measurements will be instantaneous and eventually cheaper than laboratory analysis of the plants. Depending on the deployment of the RS sensor, either hand-held or airborne, the weed population can be assessed as a whole, not just as a small sub-sample.

Estimated cost: R610 561
Expected term: 2011 - 2013

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

The management of invasive fish and conservation of biodiversity is a high priority in the National Environmental Management Act (1998) and the Environmental Management: National Biodiversity Act (2004). In order to effectively conserve the indigenous

ichthyofauna and manage the impact of alien invasive fish species an understanding of the distribution, biology, ecology and impact of both the alien and the indigenous fish species in the system is needed. The research will also investigate and assess the role that the water-utilisation infrastructure of the SRIS plays in the ongoing invasion of the Sundays River catchment.

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

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: Estuarine processes

The resilience of South Africa's estuaries to future water resource development based on a provisional ecological classification of these systems
CSIR NRE (Stellenbosch)
No. 2187

Estuaries form the interface between land and sea and are strongly influenced by runoff, sediments, wind, wave action, air and water temperature and constitute some of the most heavily utilised and productive zones on the planet. A coarse, national-scale preliminary health status assessment of South African estuaries has recently been undertaken as part of the National Biodiversity Assessment (NBA) 2011 of the South African National Biodiversity Institute (SANBI). However, the NBA status assessment was based on very limited hydrological information (a key determining factor in the health status of many SA estuaries). While the NBA study did provide a 'desired state' for each estuary based on its

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

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

Programme 2: Riverine processes

Biological temperature thresholds for the ecological Reserve

Freshwater Consulting Group
No. 2182

The refinement of upper thermal limits and the formulation of biological temperature thresholds for incorporation into the water temperature component of the ecological Reserve is considered critical for the protection of aquatic ecosystems. Existing stress on aquatic resources, including both water quantity and quality, is likely to increase in response to demand for water (Dallas and Rivers-Moore, 2009). There will likely be an increase in impacts on water temperature as a result of climate change, hydrological changes (e.g. water abstraction, low flows, river regulation, dams, interbasin water transfers), changes in rainfall patterns, etc. The links between water temperature and flow

and flow and ecosystem response are well known. How much change is acceptable to society? Increased thermal stress is likely to lead to homogenisation of freshwater communities, loss of specialist species, and lowered system resilience. As a signatory to the Convention on Biological Diversity, South Africa has an obligation to meet conservation and biodiversity targets. Thermal stress is also likely to exacerbate water quality issues such as increased outbreaks of algal blooms and spread of disease vectors. Such water quality effects have obvious health and economic impacts for society. Understanding of the biological consequences of thermal stress, and incorporation of this stress in the form of biological temperature thresholds, applied within the context of the ecological Reserve, will provide a valuable tool for managing aquatic resources.

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

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

NWU
No. 2185

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

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

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

Connectivity through allochthony: Reciprocal links between adjacent aquatic and terrestrial ecosystems in South Africa
Rhodes University
No. 2186

Central to issues of quality and availability of water is the question of whether organisms (including humans) are under threat due to pollution, food limitation, or over-harvesting in both fresh- and salt-water systems. The dynamics of nutrients in ecosystems is captured in the concept of allochthony, whereby material produced outside a given area is transferred elsewhere, hence providing links between adjacent habitats and communities that established ways of thinking do not routinely consider to be connected. Different forms of nutrients and energy move across the conceptual boundaries of ecosystems via organism activities or physical processes such as wind or water currents,

and these transfers can represent important food subsidies. The study is aimed at understanding the trophic connections between adjacent habitats that are usually conceptually partitioned and considered in isolation (land, stream, river, estuary and ocean). Human activities constantly reshape these connections, with consequences for both humans and the natural environment. A key challenge is to create a vehicle through which several different aspects of transfer can be studied concurrently within the same region (at least at the scale of a hydrological catchment), with the ultimate aim towards creating a reliable large-scale flux budget.

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

Programme 3: Wetland processes

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

The unpredictable rainfall makes temporary or ephemeral wetlands more cryptic and difficult to delineate. The combination of broad-scale desktop analyses and fine-scale site level field and laboratory data will bring new understanding of the types of wetlands in this region, their vegetation and aquatic invertebrate communities and biodiversity, including interactions between physical structure and chemical processes. Much needed data about the wetlands of this region will aid in conservation planning, in particular that of the Nelson Mandela Bay (NMB) municipality, which would help protect vulnerable and rare wetland ecosystems and assist in the management of development within in the municipal boundaries. It is, equally, an important test of the new national classification system that will

provide feedback into the NWCS and either support the desktop method for this region or modify the existing system appropriately. Through this research programme not only will the existing tools used in wetland evaluations be tested, but new and critical baseline information on the functioning of these systems will be added. This baseline data will be able to assist in the prioritization of wetlands in the NMB metro for conservation, protection and rehabilitation. This work will help gain insight and improve understanding with regards to mitigating the challenges associated with climate change and important ecological drivers responsible for system alterations.

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

Trajectories of change of wetlands in the Fynbos Biome: Part A. Habitat transformation, water quality and diatom response

Freshwater Consulting Group

No. 2183

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

will be updated to encompass the current ecostatus approach. The framework developed can be adopted and applied anywhere in the country.

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

Nile crocodiles in north-eastern KwaZulu-Natal

University of KwaZulu-Natal

No. 2188

The recent die-off of crocodiles in the Kruger National Park (KNP) and at Loskop Dam have revealed the vulnerability of the species and highlighted the need for urgent study of Nile crocodile populations in Southern Africa. The KZN population is second in size only to the Kruger population, and the governing conservation organisation, EKZNW, has the obligation to conserve this important population effectively. As a top predator the Nile crocodile is a valuable ecosystem component but also a source of management concern, as individuals can cause problems when they leave protected areas. If crocodile populations are sick or in decline, it is a serious reflection on the health of their associated water bodies and other organisms in the food web. Mitigation of threats to crocodiles is important for protection of aquatic habitats at an ecosystem level and has a positive trickle-down effect on sympatric aquatic species. Lake St. Lucia and environs represents one of only three major breeding areas for the Nile crocodile in South Africa. Crocodiles require large areas of undisturbed wetland (e.g., Lake St. Lucia) to maintain large, stable populations. As water levels fluctuate, movements of crocodiles within and out of particular areas become ecologically important to individuals and populations. Environmental fluctuations are suspected to affect the demographic stability of crocodile populations because of their direct and indirect influences on recruitment,

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mortality and food availability. This project aims to address the aforementioned conservation needs of Nile crocodiles in the study area by gathering sound data on a suite of ecological, physiological, epidemiological and genetic components for the species. Additionally, it aims to analyse the specific threats to crocodiles (human-, environmental- and disease-related) while simultaneously generating novel solutions of risk reduction for both sides of the crocodile-human interface. Information from field and laboratory studies will be used to produce predictive models of population viability and change that are needed to support proper long-term management of Nile crocodile populations in the study area.

Estimated cost: R884 000
Expected term: 2012 - 2015

Identification of wetland processes impacting water resources at catchment scale

CSIR (NRE)

No. 2191

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

Estimated cost: R684 500
Expected term: 2012 - 2015

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

Programme 3: Ecosystem health

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

Freshwater Consulting Group
No. 2192

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

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recommendations made regarding improvement of existing tools will also pave the way for improvement of existing methods.

Estimated cost: R300 000
Expected term: 2012 - 2014

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

Eon Consulting
No. 2222

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

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

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

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

SANBI
No. 2281

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

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

Programme 4: Environmental water quality

Critical analysis of water quality in South Africa: historic and current trends

Rhodes University (Institute for Water Research)

No. 2184

South Africa is widely recognised as having an admirable water law, and as being a leader in granting a right to water, in terms of quality and quantity, to the environment. However, the water quality of South African water resources is deteriorating rapidly although good water quality management structures, strategies, approaches, programmes, instruments, and tools have been developed and implemented nationally over the past decade. The question is: Where do the problems lie, and how can we change them? In order to address this question, we need to understand what environmental water quality (EWQ) is. Management of water resources links the complexity of biophysical and ecological systems with the complexity of human social systems. As such, an understanding of how management interventions may impact on the resource requires a transdisciplinary approach in order to holistically incorporate aspects traditionally considered by different disciplines. This approach is reflected in proposals for an integrated approach to water resource management. Several programmes exist in South Africa, monitoring the individual components of EWQ. The integrative EWQ approach is used by water resource managers, for example, for setting and monitoring progress towards appropriate ecospecs (ecosystem requirements), userspecs (water user requirements) and Resource Quality Objectives (RQOs: a combination of ecospecs and userspecs). EWQ is explicitly included in the Reserve, where water in sufficient quantity and of sufficient quality is set aside for basic human needs and for the protection of aquatic ecosystems to secure ecologically sustainable development and use thereof.

Furthermore the EWQ approach is used for meeting water licence criteria, for the management of acid mine drainage, and in the Green Drop status compliance for wastewater treatment works. Some of the issues around the decrease of environmental water quality have been attributed to difficulties in meeting goals in water resource management through management practices and institutional and stakeholder cooperation and coordination. The project aims to understand and characterise South African environmental water quality management approaches, instruments and programmes; to characterise the long-term trends of environmental water quality in South Africa. This will require analysing the historic and current state of environmental water quality; to identify shortcomings in environmental water quality management approaches, instruments and programmes by correlating these with trends in environmental water quality; and to make specific recommendations in the form of developing future research priorities.

Estimated cost: R300 000

Expected term: 2012 - 2014

THRUST 3: ECOSYSTEM REHABILITATION

Programme 1: Wetland rehabilitation

The classification of endorheic wetlands (pans) and the effect of acid mine drainage on the hatching success of the egg banks of selected invertebrates communities within pans

University of Johannesburg

No. 2190

With many of the endorheic wetlands (pans) in South Africa occurring in areas where there has been an increase in mining activities, it has not been unexpected

that the number of environmental impact assessment (EIA) and monitoring programmes has also increased. As many of these systems are already (or will in the future) be affected by mining activities, the effect of AMD on the biota is also of particular concern, especially at Ramsar sites. The effect of AMD on the hatching success of egg banks has not been well studied, especially in South Africa. This study will thus contribute to our knowledge of the effect of water quality changes in particular on the branchiopod communities within these systems. This is very important as these branchiopod crustaceans are specifically adapted to these endorheic ecosystems. Many branchiopods (especially Anostraca) are also classified as being endangered or threatened according to the IUCN Red List. A dormant egg phase is a dominant feature of most large branchiopod taxa. After production, eggs are deposited on the substrate ultimately forming egg banks. The conditions required to end this dormant stage vary between species and can even vary amongst a population of the same species. As a result, a population of a particular species of branchiopod can often consist of different generations. Some may have hatched from eggs that were deposited the previous season while others can be from eggs that were deposited a decade ago (or more). Studies have shown that the metals alone can have an effect on the hatching success of dormant egg stages. Changes in water quality may thus influence the hatching success of these branchiopods and, with conductivity and pH having a major influence on hatching, AMD may lead to a loss in the biodiversity of branchiopod crustaceans.

Estimated cost: R684 500
Expected term: 2011 - 2015

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

Institute of Natural Resources (INR)

No. 2200

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

Estimated cost: R600 000
Expected term: 2013 - 2014

Programme 2: River rehabilitation

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