

KSA 2: WATER-LINKED ECOSYSTEMS

SCOPE

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

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

In cognisance of the complex and evolving needs of the society and communities that the KSA's R&D serves, it was necessary for KSA 2 to adapt its portfolio in 2013/14 in order to remain relevant and appropriate.



Stanley Liphadzi: Executive Manager

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

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

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

OBJECTIVES

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

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

THRUSTS AND PROGRAMMES

THRUST 1: ECOSYSTEM PROCESSES

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

Programme 1:
River, wetland, ground-
water and dam processes

Scope: Programmes to investigate the ecosystem functioning, structure and processes of riparian zones, rivers and impoundments will be developed. This is an area in which South Africa needs improved capability to manage and, in the case of riparian zones, is a topic attracting international interest.

Programme 2:
Estuarine, coastal and
marine processes

Scope: Estuarine, coastal and marine systems are fragile, while they are highly productive ecosystems and are highly sought after as places to live and establish various enterprises. Catchment activities and land uses affect terrestrial water resources and ultimately the estuarine environment, while marine water conditions also have an impact on the estuarine environment and ecosystems. Projects in this programme will generate knowledge about the ecological processes, structure, and functions of ecosystems of these systems. The programme will also address the impact of land uses and marine conditions on ecological processes in the estuarine and coastal environment.

Programme 3:
Aquatic, riparian and
land connectivity

Scope: Research will be conducted to develop understanding of the interconnections among various ecosystems and ecological processes and functions of water resources, terrestrial systems (soil, air and vegetation) and to assess their value to both the catchment and people.

Programme 4:
Surface and ground-
water Interactions

Scope: Within this programme, the dynamics of groundwater-dependent ecosystems will be investigated in relation to the aquifers on which they depend. This will be related to exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1:
Ecological Reserve

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

Programme 2:
Rivers, wetlands, ground-
water, lakes, coastal and
marine (and estuarine)
ecosystems

Scope: Within this programme research will be conducted to develop an understanding of the effect of anthropogenic disturbance on aquatic ecosystems in various water resources. This understanding is then conveyed to stakeholders (tiers of Government, communities) as management guidelines to inform them on how to manage water resources sustainably.

Programme 3:
Land-use and aquatic
ecosystem management

Scope: This programme focuses on enhancing understanding of the effect of human interventions (land uses and decision making) on the environmental health of various water resources and/or ecosystems. As such the programme covers all water resource types, hence the inclusive name of National Aquatic Ecosystem Health Monitoring Programme is used, whereas the name River Health Programme focuses only on rivers.

Programme 4:
Integrated environmental
and drinking water
quality

Scope: Within this programme research will be conducted to develop integrated methods and procedures which will be employed to protect people and the environment from the effects of poor water quality. The programme will develop methods and competence to support issuing of water use licences. This will promote the use of research knowledge in managing environmental water quality as required in the ecological Reserve, and thus reduce drinking water treatment costs.

Programme 5:
Ecosystem risks and
disaster management

Scope: Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation. Tools and procedures will be assessed with the intention of developing them. The success of the programme will be achieved by working closely with water resource managers and relevant government departments.

Programme 6:
Biodiversity and
conservation

Scope: The overall objective of this programme is to develop and integrate knowledge needed by the country in efforts for protecting and preserving our unique biodiversity and natural landscapes. The projects will look at drivers (sociological, political and economic) that are critical in developing the understanding and competence necessary to sustainably manage the aquatic environment and its biodiversity. Collaboration and partnership with other institutions will be considered for this programme to achieve its aim.

Programme 7:
Ecosystem governance,
legal framework and
ethics

Scope: Implementation of research outputs and regulations require appropriate governance systems and structures. The overall objective of this programme is to develop understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this. The research under this programme should develop knowledge needed for good governance of water resources. The research will develop knowledge needed to support policy, planning and development that promote protection of ecosystems and water resources.

Programme 8:
Transboundary
ecosystem management

Scope: This programme will support projects that enhance ecosystem processes and functions, conservation and planning across regional and national borders. Transboundary research has gained some interest in recent years, and neighbouring countries or catchments will have to manage shared natural capital in an integrated manner. Collaborations with neighbouring countries and international funding agencies will be considered for research under this programme.

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Scope: This thrust addresses the rehabilitation, restoration and remediation of the aquatic environment (including both the abiotic and the biotic components) which has been degraded through anthropogenic activities, with the view to restoring, as far as possible, process, form and function in order to provide the stream of goods and services that a healthy aquatic ecosystem should provide. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. Support will be provided in building the capacity to implement the research findings. Remediation is the only addition to this portfolio. This is proposed to encourage innovative approaches that can be used in rehabilitation and restoration of water resources and their ecosystems. Research in this thrust will be carried out in collaboration with key stakeholders.

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

Scope: The research conducted within this programme aims to provide protocols for the rehabilitation of rivers and impoundments, with the emphasis on urban rivers and the impoundments that they feed, that have been degraded as a result of anthropogenic activities or invasive biota.

Programme 2:
Socio-economic
dynamics

Scope: The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment.

Programme 3:
Environmental risk
management

Scope: Environmental risk management programmes will be supported by research from this portfolio. Risk assessment methodologies and procedures will be developed and improved. The research will develop knowledge needed for environmental risk mitigation and adaptation.

THRUST 4: SUSTAINABLE ECOSYSTEM UTILISATION AND DEVELOPMENT

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

Programme 1:
Environmental econo-
mics (goods & services)
and accounting

Scope: The overall objective of this programme is to develop and integrate knowledge on the sociological and economic aspects of water-linked ecosystems with ecological knowledge, in order to develop the understanding and competence necessary to sustainably manage the aquatic environment. This programme investigates ways to evaluate economic benefits of ecosystem products (goods and services). Appropriate methods and their implementation to local conditions will be promoted by research in this programme. The economic opportunities that are presented by ecosystems will be evaluated so that they can be appropriately developed. Different evaluation and accounting methods and tools will be developed and adapted to local conditions.

Programme 2:
Ecosystem value-chain
and markets

Scope: Research in this programme will develop knowledge about developing and strengthening markets for ecosystem goods and services. The research will cover the whole value chain of the ecosystem services' market. There is a

growing interest in developing markets for ecosystem services to support local economies in rural and peri-urban areas. The development of tools or procedures to promote payment for goods and services needs to be further developed and implemented appropriately. Product development for various markets will also be the focus of this programme. For instance, environment-based business opportunities should be explored and developed since different ecosystems have different products and services that they offer.

Programme 3:
Gender, culture and
heritage for ecosystems

Scope: In their design or implementation, natural resource management (NRM) initiatives overlook critical socio-cultural dimensions of the challenge to advance sustainability. This programme will investigate relationships and associations of gender, culture, heritage and aquatic ecosystems. The relationships and tensions related to gender, ethnicity, population, age and socio-economic status are among the threads in the larger tapestry that comprises the socio-cultural dimension in natural resource management and access to ecosystem services. The programme will also investigate ideas and innovations from indigenous knowledge systems that relate to natural resource management.

Programme 4:
Green economy and
sustainable (green)
innovations

Scope: People in rural and peri-urban areas rely on ecosystems for their livelihoods. The research in this programme will support economic development that does not violate the sustainability of socio-ecological processes. Projects in this programme will encourage the production of green technologies and innovations supporting service- and commercial-based sectors. Outputs from research should contribute to improving the lives of people while also contributing to improving the conditions of water resources and the environment as a whole. The involvement of the business sector and other individual companies will be sought to fast-track implementation of the research output. The projects will contribute to the Water-Energy-Food Nexus Lighthouse of the WRC.

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

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

Programme 1: Ecosystems and population dynamics

Scope: The impact of social dynamics on ecosystems and the environment will be addressed in this programme. As human population increases, moves and changes in different areas, sociological studies in relation to ecosystems (environment) are needed to support planning and development of rural and urban areas. In most cases, informal settlements are established in the riparian zones of water resources, which exerts pressure on those resources as people demand more goods and services from those resources. In most cases, water resources such as wetlands and rivers become the only available service infrastructure for the homeless and for poor immigrants in urban and peri-urban areas.

Programme 2: Ecosystems and climate change

Scope: This programme will deal with all aspects of climate change in relation to ecosystems. The research will develop knowledge about mitigation of and adaptation to climate change by aquatic biodiversity. The impact of climate change on ecosystem processes, functions, and structure will be given attention in this programme. The knowledge generated will be used to inform policy makers, businesses, and water managers.

Programme 3: Ecological thresholds

Scope: Research aimed at determining ecological thresholds will be supported in this programme. These studies will assist in developing understanding about how much degradation the environment or ecosystems can tolerate before collapsing or losing resilience. The research will also analyse the costs of restoring ecosystems and their functionality after total collapse.

STRATEGIC CONTEXT

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

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

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

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

Sustainable development solutions

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

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

New products and services for economic development

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

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

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

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

Empowerment of communities

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

Inform policy and decision making

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

Links to Government outcomes

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

BUDGET FOR 2013/14

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

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

RESEARCH PORTFOLIO FOR 2013/14

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

COMPLETED PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Estuarine, coastal and marine processes

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

Nelson Mandela Metropolitan University (Botany); CSIR

No. 1982

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

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

Cost: R955 000
Term: 2010 - 2013

Programme 3: Aquatic, riparian and land connectivity

Linking hydrology and lateral riparian vegetation zones

Southern Waters Ecological Research & Consulting; University of Stellenbosch; CSIRO Land and Water; Water Matters; Aurecon Group; Ezemvelo KZN Wildlife; GroundTruth; Rhodes University; BioRiver Solutions cc

No. 1981

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

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

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

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

Cost: R1 765 310
Term: 2010 - 2013

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Environmental water requirements for non-perennial systems: Phase III

University of the Free State; Limpopo Province; Rhodes University; University of Cape Town

No. 1798

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

Cost: R3 000 000

Term: 2009 - 2013

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

AWARD; University of Pretoria; Rhodes University; University of the Witwatersrand; SANParks; Water for Africa (Pty) Ltd; Centre for Environmental Rights

No. 1920

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

Cost: R1 500 000
Term: 2010 - 2013

Programme 3: Land-use and aquatic ecosystem management

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

CSIR; Ground-Truth cc; University of KwaZulu-Natal (Pietermaritzburg); Aquagreen Consulting; Department of Water Affairs; independent consultants

No. 1984

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

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

Cost: R1 520 000
Term: 2010 - 2013

Hyperspectral remote sensing of water hyacinth: From plant physiology to landscape-level changes

University of the Witwatersrand; CSIR; Rhodes University

No. 2037

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

Cost: R610 561
Term: 2011 - 2013

Programme 4: Integrated environmental and drinking water quality

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

Rhodes University

No. 2184

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

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

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

Cost: R300000

Term: 2012 - 2014

Programme 5: Ecosystem risks and disaster management

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

Rhodes University; Walter Sisulu University

No. 2040

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

Cost: R1 000 000
Term: 2011 - 2013

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

Rivers of Life Aquatic Health Services cc; SANParks; De Beers Consolidated Mines; YRless International (Pty) Ltd; University of Johannesburg; North-West University (Potchefstroom)

No. 2111

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

Cost: R841 950
Term: 2011 - 2013

Programme 6: Biodiversity and conservation

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

University of Stellenbosch (Zoology); University of Victoria, British Columbia; University of the Western Cape; Okazaki Institute for Integrative Bioscience; University of Stellenbosch

No. 1680

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

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

Cost: R400 000
Term: 2006 - 2013

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

University of Stellenbosch; University of the Western Cape; Cape Nature; Florida University; Mpumalanga Tourism & Parks Agency; University of Pretoria; University of Victoria, British Columbia

No. 1932

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

Cost: R1 400 000
Term: 2009 - 2014

Programme 7: Ecosystem governance, legal framework and ethics

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

University of Johannesburg; Jeffares & Green (Pty) Ltd

No. 2190

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

Cost: R684 500

Term: 2012 - 2014

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

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

University of the Free State (Plant Sciences, QwaQwa); Ekolnfo; Coastec; Sivest Environmental; SANBI (Pretoria); Imperata Consulting; Cape Nature; Rhodes University; Mpumalanga Tourism & Parks Agency; Free State DTEEA; University of Cape Town; Department of Agriculture, Environment and Rural Development; Department of Environmental Affairs; University of KwaZulu-Natal (Pietermaritzburg); ARC; independent consultants

No. 1980

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

Cost: R1 951 000
Term: 2010 - 2014

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

University of KwaZulu-Natal (CEAD); Charles Breen and Associates; Eco-Futures; Duncan Hay and Associates
No. 1986

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

Cost: R800 000
Term: 2011 - 2013

Programme 2: Socio-economic dynamics

Setting objectives for urban river rehabilitation

Aurecon Group; Chris Brooker & Associates; University of the West of England; University of the Witwatersrand; Vulamanzi Water Law Advisers; Laughing Waters

No. 2036

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

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

Cost: R850 000
Term: 2011 - 2014

CURRENT PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 1: River, wetland, groundwater and dam processes

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

NWU

No. 2185

Following the construction of the Pongolapoort Dam in 1974, concerns related to the influence of the resulting changes in water flows into the Phongolo floodplain led to extensive studies by Heeg et al. As there is increasing pressure from local communities to access and utilize the ecosystem services of the Ndumo Game Reserve, it has become essential to determine to what degree this conservation area maintains the aquatic biodiversity of the floodplain as whole. In this project the quantity and quality drivers in the Phongolo system will be related to the ecological responses at different levels of biological organisation. The influence of aquatic ecosystem health will be assessed by determining the ecological status of the Phongolo River and associated floodplain through fish, amphibian and bird community studies. Collectively the knowledge derived from this project can be utilized within specific species conservation plans and broader-scale risk assessments. This will enable the relevant conservation authority,

Ezemvelo KZN Wildlife, to meet their mandates to establish conservation plans for the ecologically threatened species in the Phongolo floodplain. These management interventions will make a valuable contribution to the sustainable maintenance of the ecological services of this unique ecosystem that were originally identified in the early studies, i.e. the importance of the floodplain to the society, economy, health and ecosystem in general.

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

Programme 2: Estuarine, coastal and marine processes

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

Freshwater Consulting Group

No. 2183

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

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

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

CSIR NRE (Stellenbosch)

No. 2187

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

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

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

Identification of wetland processes impacting water resources at catchment scale

CSIR (NRE)

No. 2191

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

Estimated cost: R684 500
Expected term: 2012 - 2015

Programme 3: Aquatic, riparian and land connectivity

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

Rhodes University

No. 2186

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

Estimated cost: R1 700 000

Expected term: 2012 - 2015

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

Institute of Natural Resources (INR)

No. 2200

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

Estimated cost: R600 000

Expected term: 2013 - 2014

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

Biological temperature thresholds for the ecological Reserve

Freshwater Consulting Group

No. 2182

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

Estimated cost: R1 000 000

Expected term: 2012 - 2015

Programme 3: Land-use and aquatic ecosystem management

Biodiversity, conservation and management of Nelson Mandela Bay temporary wetlands

Nelson Mandela Metropolitan University

No. 2181

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

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

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

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

Eon Consulting
No. 2222

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

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

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

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

SANBI
No. 2281

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

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

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

Programme 4: Integrated environmental and drinking water quality

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

University of KwaZulu-Natal (Chemistry)

No. 1977

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

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

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

Rhodes University (Biochemistry)

No. 2038

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

Estimated cost: R800 000
Expected term: 2011 - 2014

Programme 5: Ecosystem risks and disaster management

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

University of Stellenbosch

No. 1712

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

Estimated cost: R370 000
Expected term: 2007 - 2013

Programme 6: Biodiversity and conservation

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

North West University

No. 2204

Whilst a lot of progress has been made towards developing various indices for assessing the ecological health of aquatic ecosystems, little is known about the organisation of genetic diversity in wetland and other ecosystems. There has been increased interest in rehabilitation of heavily impacted wetlands and in future this may require reintroduction of various biota. This study will focus on generating basic knowledge needed to strengthen 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

Programme 7: Ecosystem governance, legal framework and ethics

Nile crocodiles in north-eastern KwaZulu-Natal

University of KwaZulu-Natal

No. 2188

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

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

Estimated cost: R884 000
Expected term: 2012 - 2015

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

Biology, ecology and management of indigenous and invasive alien fish species in the Groot Marico River and Sundays River catchments

Consortium: SA Institute for Aquatic Biodiversity (SAIAB); Golder Associates Africa (Pty) Ltd

No. 2039

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

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

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

Freshwater Consulting Group

No. 2192

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

Estimated cost: R300 000

Expected term: 2012 - 2014

NEW PROJECTS

THRUST 1: ECOSYSTEM PROCESSES

Programme 2: Estuarine, coastal and marine processes

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

CSIR (Earth Observation)

No. 2268

Remotely-sensed information on the estuarine vegetation coupled with other ancillary information, e.g., topographic

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

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

Estimated cost: R100 000
Expected term: 2013 - 2016

Programme 3: Aquatic, riparian and land connectivity

Linkages between the hydrodynamic and biological drivers of the Mgobezeleni Catchment

Nelson Mandela Metropolitan University

No. 2259

The understanding gained from an integrated system will develop the tools and understanding to be able to predict the impacts of changes on the hydrology and ecology, and hence on the local communities in the area, in the Zululand Coastal Plain. The project brings together lead scientists with over 150 years of collective research experience, knowledge and management application in the different disciplines of hydrology, ecology, water quality and estuarine system dynamics. The knowledge generated is expected to be applicable to other communities, in particular, in Mozambique and Madagascar. The interaction between surface and subsurface water resources is dependent on many factors that influence the hydrodynamic processes and flow paths in various ways. The plethora

of pathways that water can travel from its source to the various points of departure within a catchment are too numerous to mention and impossible to measure. Consequently, the most pragmatic approach to understanding and describing these pathways is through the development and application of three-dimensional numerical models. However these models are very simplistic representations of the natural system. In the Zululand Coastal Plain, groundwater is an important component of the aquatic system and consequently the numerical model must provide a suitable representation of the groundwater hydrodynamics that include direct linkages to the surface water resources and the ecological system. The overriding aim of the project is to determine/understand the goods and services rendered to the ecological system by the hydrological system in a developing environment on a coastal aquifer with various surface water resources that are dominated by the groundwater. The specific aims are:

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

Estimated cost: R2 700 000

Expected term: 2013 - 2015

Investigating the impact of landscape connectivity on water-linked ecosystems

Rhodes University (Geography)

No. 2260

Connectivity is being embraced increasingly by hydrologists, geomorphologists and ecologists as a concept that

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

Estimated cost: R594 000
Expected term: 2013 - 2016

THRUST 2: ECOSYSTEM MANAGEMENT

Programme 1: Ecological Reserve

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

IWR Water Resource (Pty) Ltd

No. 2263

One of the key principles of integrated water resource management (IWRM) is sustainable management of rivers to preserve ecosystems. To address this need, ecosystem scientists are working to establish (or have established) environmental flows within rivers. To determine the future reliability (ability to consistently meet environmental flows in future) of environmental flows, there is need to integrate environmental flows into catchment-wide water resource management models. However, technical issues arise during integration which need to be resolved. Increasingly ecologists are demanding daily hydrological models to improve their understanding of the link between river flow

and ecological response. This issue was addressed in WRC Project K5/1979 and tools were developed to generate daily flow time-series which are consistent with monthly hydrological time-series currently used in water resource planning models. The next step is to integrate this daily aggregation tool into existing water resource models. The water resources planning models currently in use in South Africa all operate at a monthly time step. This is a major stumbling block in assessing the increasingly complex scenarios that ecologists require water resources modellers to evaluate. As an example, the recently published guidelines for the evaluation of estuarine flow requirements require estimates of flood frequencies and how these flood frequencies change under changing development scenarios. This is not possible with the existing monthly models. Within the context of river ecology, the frequency and flood magnitude of spills from dams is becoming increasingly important as catchments become increasingly impounded. Again, these crucial parameters cannot be assessed with the current monthly models. A secondary consideration within the framework of daily versus monthly modelling is that of sediment transport modelling. Geomorphologists have for many years only been able to provide broad guidelines to ecologists based on monthly hydrology. A recent positive development within the geomorphological realm of determining ecological flow requirements is WRC Project K5/1797 'Implementation of Strategic Adaptive Management for freshwater protection under the South African National Water Policy', commonly referred to as the *Breonadia* Model. The *Breonadia* Model is essentially a rule-based matrix population model coded in Visual Basic. It requires daily hydrological and rainfall data and starting proportions of different substrate types (which are defined by the site being modelled and which change with time depending on flows) as input data. Hence the provision of daily water resources modelling capabilities will be of huge benefit to the *Breonadia* Model. A logical extension of the *Breonadia* Model would be to incorporate sediment transport procedures into the proposed daily water resources model. This will then replace the rule-based substrate model with a more scientific approach with the added ability of scenario modelling. A specific request has been made by the *Breonadia* development team to carry out this development. Project aims are:

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

Estimated cost: R300 000

Expected term: 2013 - 2014

Programme 3: Land-use and aquatic ecosystem management

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

Sustento Developments cc

No. 2269

Wetlands are highly productive ecosystems and due to their ecological complexity and high biodiversity provide a

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

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

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

Programme 4: Integrated environmental and drinking water quality

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

Rhodes University, Zoology

No. 2262

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

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

Estimated cost: R275 000

Expected term: 2013 - 2014

Development of an immobilized receptor-based EDC detection kit

University of Stellenbosch (Zoology)

No. 2271

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

- Synthesis and modification of a PVP spacer arm
- Synthesis of a membrane surface chelating agent, PGEAH
- Assembly of SMA-PVP co-polymer affinity membrane
- Immobilization of ligand binding domains of the androgen and oestrogen receptors on SMA-PVP co-polymer affinity membrane

- Testing EDC binding by immobilized ligand binding domains of the androgen and oestrogen receptors
- Developing a colorimetric visualization method for detection of EDCs
- Validation of membrane based detection method against an ELISA-based method

Estimated cost: R1 070 000

Expected term: 2013 - 2015

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

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

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

SA Institute for Aquatic Biodiversity

No. 2261

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

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

- Determine how the Rondegat River ecosystem responds to the removal of alien fishes over a three-year period

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

Estimated cost: R445 320

Expected term: 2013 - 2016

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

Freshwater Consulting Group

No. 2270

In South Africa, water courses are increasingly degraded despite the plethora of legislation regulating use and affording protection of the country's water resources, with the National Freshwater Ecosystem Prioritisation Areas (NEFEPA) project reporting that more than 50% of South Africa's rivers are degraded. Among the most threatened reaches of South African rivers are foothill and lowland rivers, and those in urban areas are particularly degraded. Internationally, the science of river and wetland rehabilitation is relatively well-advanced, and a number of manuals and guidelines for river rehabilitation exist in the international literature. Some guidelines have been produced for South African systems too, with a recent large focus on wetland systems in particular. These manuals identify a wide range of possible rehabilitation options for watercourses, but none streamlines rehabilitation with South African legislation.

The main objective of this project is to provide guidelines as to the most appropriate rehabilitation solution that should be implemented in different circumstances. The methodology proposed here takes account of different social, economic, ecological and land-use issues, as well as looking at riverine degradation holistically, so that the roles of different drivers of impact or river function are not misinterpreted, leading to solutions that are not sustainable and may in fact be overtly damaging. Some of the key objectives for this project are:

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

Estimated cost: R1 000 000

Expected term: 2013 - 2016

Programme 2: Socio-economic dynamics

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

Freshwater Research Centre

No. 2264

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

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

Estimated cost: R934 900

Expected term: 2013 - 2015

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

CSIR (NRE)

No. 2267

We live in a time of unprecedented global complexity and change. Whilst exemplified most clearly by the effects of global climate change, the nature of the changing world we live in is far broader. The concept of 'global change' encompasses the interlinked effects of changes in climate, land use and human population demographics, social and

economic development, governance regimes and changes to the buffering capacity of the earth's ecosystems. The substantial changes that are happening in the social-ecological landscape are severely affecting the resilience of these systems and their ability to absorb, adapt and recover from disturbance. This in turn exposes society to a wide variety of increasing risks, so much so that contemporary societies have been termed 'risk societies'. Failure to understand and proactively respond to the risks and opportunities that are embedded in this dynamic social-ecological landscape can have grave consequences to society. Society's current trajectory is clearly not sustainable, and a series of social-ecological transformations are required to move social-ecological systems threatened by climate change towards an alternative, more desirable and more resilient state. This project focuses on integrated and systemic ways of approaching risk by linking the concepts of social capacity for governance and social capital to ecological infrastructure in order to build resilient landscapes.

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

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

THRUST 4: SUSTAINABLE ECOSYSTEM UTILISATION AND DEVELOPMENT

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

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

University of KwaZulu-Natal (Agriculture, Earth & Environmental Sciences)

No. 2266

Natural ecosystems provide key functions essential to the sustainable economic development of societies. Concerns about long-term sustainability and high environmental costs support the need for an increased understanding of the

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

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

Estimated cost: R2 907 000

Expected term: 2013 - 2018

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

Prime Africa cc

No. 2272

Degradation of aquatic ecosystems has negative impacts on the economy, and on the health of people and water resources through losses in ecosystems goods and services (EGS). In some cases, the use of the precautionary principle can prevent damage, but this can also prevent economic development. It is thus poor communities who are most often affected by changes in EGS. Rivers, the arteries of a catchment, reflect the health of the environment and the social-ecological system (SES). Any problems in a river basin are reflected in the health of the rivers. The DPSIR model (Driving forces, Pressures, State, Impacts and Responses) provides a framework which enables the drivers exerting the pressure causing the change in the state of the environment to be identified. This directs the response of management to address the drivers, so providing a long-term solution to degradation. There is a lot of research (research outputs include databases and scientific findings) on the degradation of inland waters, but this has not

been drawn together into a cohesive whole. The rigorous evidence-based methodology employed by E-BASES (WRC Project K5/1978) will provide a thorough review of the existing knowledge. This, combined with the ecosystem service valuation methods developed by WRC Project K5/1644, will indicate what the cost of environmental degradation has been to the SES. An important part of this work will be to develop a legal view on the standards and level of evidence that would be sufficient to prove liability for ecological degradation. By example, a recent EU directive (EU 2004) has developed a framework of environmental liability based on the polluter-pays principle to prevent and remedy environmental damage, which may provide a way forward in implementing this principle. Specific objectives are:

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

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

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Programme 2: Ecosystems and climate change

A climate change risk assessment of water hyacinth biological control

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

No. 2265

Alien weed control costs South Africa approximately R6.5 billion per annum, and climate change will impact the effectiveness of those efforts. This project seeks to develop a tool to help manage the outcome of future climate scenarios on alien weed control. Water hyacinth is one of the world's most invasive aquatic plants, originating from South America and invading many ecosystems; its control is crucial. Multiple methods such as mechanical, herbicidal, and biological control have been used against it. However, biological control is considered to be the best long-term, sustainable approach, and is potentially many times more cost effective than other methods, when successful.

With such an economic benefit, understanding and improving the success of biological control of water hyacinth is

essential. This study proposes to incorporate the effects of biological control by *Neochetina* weevils, with temperature and nutrients, into a model of water hyacinth growth which will give site-specific predictions of population growth of both weevils and water hyacinth, and have applications in climate change risk assessment and management, e.g., by Working for Water. The key project objectives are:

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

Estimated cost: R500 000
Expected term: 2013 - 2016

CONTACT PERSONS

THRUST 1: ECOSYSTEM PROCESSES

Dr Mbofho Stanley Liphadzi
E-mail: stanleyl@wrc.org.za
Tel: +27 12 330 9020

THRUST 2: ECOSYSTEM MANAGEMENT

Mr Bonani Madikizela
E-mail: bonanim@wrc.org.za
Tel: +27 12 330 9021

THRUST 3: ECOSYSTEM REHABILITATION, REMEDIATION AND RESTORATION

Mr Bonani Madikizela
E-mail: bonanim@wrc.org.za
Tel: +27 12 330 9021

THRUST 4: SUSTAINABLE ECOSYSTEM UTILISATION AND DEVELOPMENT

Dr Mbofho Stanley Liphadzi
E-mail: stanleyl@wrc.org.za
Tel: +27 12 330 9020

THRUST 5: ECOSYSTEMS AND GLOBAL CHANGE

Dr Mbofho Stanley Liphadzi
E-mail: stanleyl@wrc.org.za
Tel: +27 12 330 9020