WATER
RESEARCH
COMMISSION

WRC Strategic Plan

2012/13 – 2016/17

WRC Draft Strategic Plan

2012/13 – 2016/17

for Ministerial Approval

The WRC Vision

To be a globally recognised leader in providing innovative sustainable water management solutions to meet the changing needs of society and the environment

WRC Mission

To be a dynamic hub for water knowledge, innovation and intellectual capital. To provide leadership for research and development through the support of knowledge creation, transfer and application. To engage with stakeholders and partners in solving water related problems that are critical to South Africa's sustainable development and economic growth with a continued and reinforced commitment to promoting a better quality of life for all.

WRC Values

Service orientation
Innovation and Learning
Respect for human rights
Care for people, society and the environment
Integrity and ethical behaviour
Dedication to quality
Fairness to all

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EXECUTIVE SUMMARY

Now in its forty-first year, the Water Research Commission (WRC) continues to vigorously pursue its vision to be South Africa's premier water knowledge resource. This five-year strategic plan focuses on the period 2012/13-2016/17 in line with new Treasury directives.

The water milieu has entered an exciting period, both nationally and internationally, with looming uncertainties around issues such as climate change and its potential effect on water resources and the persistent need to provide sustainable services to a growing, urbanising population while pursuing a greener economy. The WRC itself is seeing a number of changes, among others, the appointment of a new CEO and Board. Thus, the Commission has organised its strategic plan to respond very directly to the challenges outlined through its various mechanisms and instruments.

The Commission remains committed to arming the South African water sector with the right technology, capacity and skill to tackle its present and future challenges through, among others, a meaningful contribution to coordination, cooperation and communication in the area of water research and development; enhancing knowledge and capacity building in the water sector, and promoting the effective transfer of information and technology. Specifically the WRC will use it capabilities to support the Minister of Water and Environmental Affairs in ensuring the outcome of "Environmental assets and natural resources that are well protected and continually enhanced" with the highest emphasis on the first output of "Enhanced quality and quantity of water resources" and significant contributions of the water components of the other three. These being:

- Reduced greenhouse gas emissions, climate change and improved air/atmospheric quality,
- Sustainable environmental management, and,
- Protected biodiversity.

This Strategic Plan is based on the South African Government's outcome-based approach, where the WRC strives for impact. The Commission aims to support the various outcomes and outputs through its research portfolio. In addition, it continues to support the Department of Water Affairs (DWA) – the WRC's shareholder – in its call for mainstreaming of water as the basis to allow for economic growth and sustainable development. The WRC strategic plan is designed to add value to the DWA's actions to achieve its six strategic outcome oriented goals through the WRC's research and development enterprise. The DWA six strategic goals being:

- To contribute to economic growth, rural development, food security and land reform,
- To promote sustainable and equitable water resources management,
- To strengthen the regulation of the water sector,
- To support local government to deliver water services,
- To contribute to international relations, and,
- To build capacity to deliver services.

The Commission's Strategic Framework has been designed around the WRC Knowledge Tree, with every project being designed to enable the achievement of as many of the tree 'branches' or outcomes as possible and reasonable. Among the core components of the WRC Knowledge Tree are to:

- Inform policy- and decision-making
- Create new products and services for economic development
- Develop human capital
- Empower communities
- Support transformation and redress
- Develop sustainable solutions

The WRC supports Government's outcomes with special reference to Outcome 10 as well as Outcomes 6, 7 and 9. The Commission also aims to continue to support the National Planning Commission where and when required. Special emphasis is put on Outcome 10, which addresses the protection and enhancement of the country's environmental assets and natural resources. The WRC work-plan is geared to the improvement of the quality and quantity of South Africa's water resources through both its research projects as well as its innovation and technology development activities. Examples include technologies and strategies to reduce water loss in distribution systems, better sanitation solutions and improved wastewater treatment.

The second priority outcome is Outcome 6, which addresses the need for an efficient, competitive and responsible economic infrastructure network. WRC-funded projects support water availability through examining and finding solutions for issues related to bulk water supply and supporting the development of appropriate regulations regarding water quantity, quality and usage. Another focus is Outcome 7, which focuses on vibrant, equitable and sustainable rural communities and food security for all. This is carried out through a number of projects addressing water utilisation in agriculture as well as projects focusing on informal settlements and peri-urban communities.

Lastly, Outcome 9 aims at establishing a responsive, accountable, effective and efficient local government system. The WRC supports this outcome through research focused on improving basic services with special emphasis on the delivery of water and sanitation services.

In addition to its linkages with Government outcomes, the WRC has identified three impact areas to which knowledge creation is geared, namely Water and Society; Water and the Economy; and Water and the Environment. These impact areas are linked to almost all of the Government's outcomes.

Government Outcomes 10, 9, 7, and 6 are supported through the WRC's research portfolio via four key strategic areas (KSAs): Water Resource Management; Water-Linked Ecosystems; Water Use & Waste Management and Water Utilisation in Agriculture. The research portfolio addresses the scope and main objectives within the identified research areas that will be focused on by the WRC during the period covered by this Strategic Plan. There is a strong link between the research portfolio, the budget and the key performance areas of the WRC. In addition to the activities of the main KSAs, The Knowledge Dissemination KSA of the WRC maximises impact of its research products and scientific knowledge through effective communication to all stakeholders.

The WRC's five-year budget plan supports the translation of its strategic plan into operational actions. This plan is guided by the organisation's strategic targets and follows a number of key financial ratios. The WRC has assumed a conservative increase in levy income for future years, which is linked to inflation. Ultimately, the aim is to maintain a high ratio of research funding and other research-support activities as a percentage of total income. The WRC plans to invest around R128.7 m. in research funding during the next financial year (2012/13). The investment in research amounts to about R146.1 m. The distribution of research project funds to the various types of providers is, in general, similar to that of the previous year, where higher education institutions (universities) are the major recipients.

Key performance areas (KPAs) and indicators have been set for the next five years. These KPAs are based on the strategic context and the challenges identified above, as well as specific strategic risk areas. The KPAs address both internal and external issues and are aimed at assisting the WRC in serving the country in accordance to its mandate, and in support of Government outcomes.

1. INTRODUCTION

This five-year strategic plan focuses on the period 2012/13 to 2016/17, in line with new Treasury regulations. This expanded planning period offers one an opportunity to take a longer-term perspective and the period covers very important national and international milestones. This is also the first year of the WRC's fifth decade, having celebrated its 40th anniversary in 2011, as well as the appointment of its first Black CEO.

The fifth decade of the WRC begins in a very interesting international context. Some of the characteristics of these next five years will be the increased intensity of the global climate change dialogue post-COP-17 and the broadening and deepening of the increased realisation of the dire impacts of variable climate and extreme weather events around the world, together with the further embedding of national level institutionalisation of a Green Economy, including the expected finalisation and commencement of implementation of South Africa's Climate Change Response Strategy. A further feature of this period will be the battle of human population growth against a background of decreasing resource availability and increasing biodiversity loss. This all happens against the backdrop of a continued global economic challenge, with even the more rapid growth rates of the Asian giants and Africa still struggling to catalyse a significant global economic recovery. The important marker of 2015 looms large and will focus the mind over the next three years on the achievement of the Millennium Development Goals. On the local front the launch of the revised National Water Resource Strategy in 2012, together with the New Growth Path and the National Development Plan 2030, sets the scene for the water sector in this planning period.

The WRC has organised its Strategic Plan to respond directly to the challenges outlined through its various mechanisms and instruments.

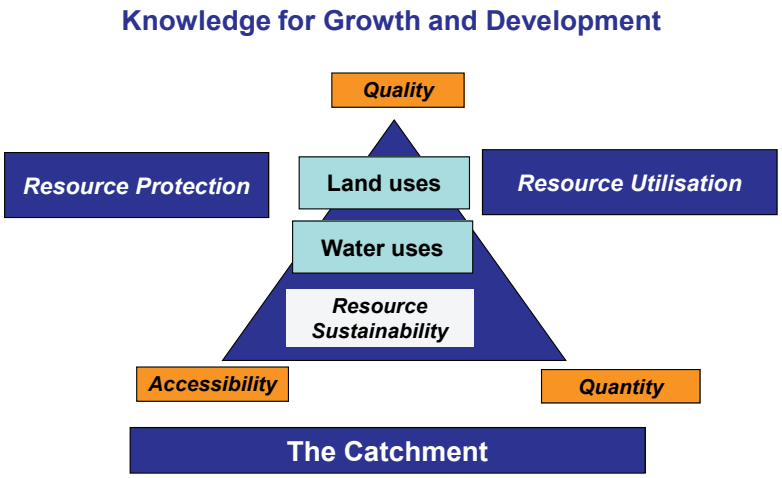
1.1 The Mandate and Core Business of the WRC

The mandate of the WRC (Water Research Act, Act No. 34 of 1971) highlights the following functions to be carried out by the organisation:

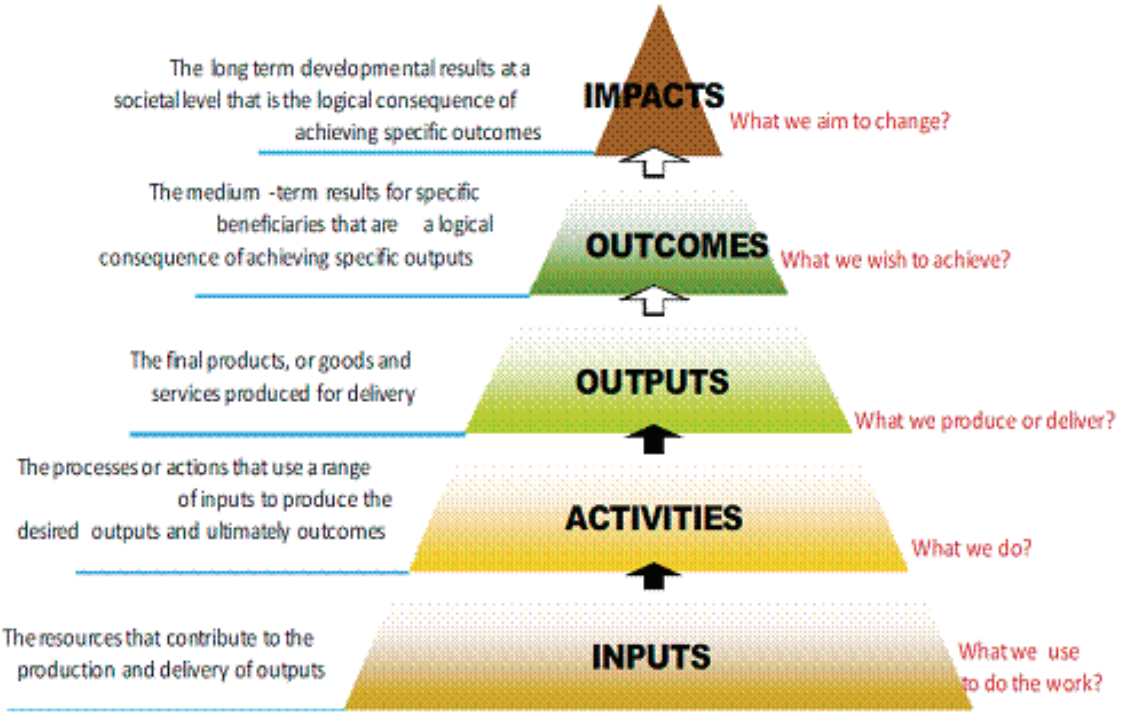
- Promoting co-ordination, co-operation and communication in the area of water research and development
- Establishing water research needs and priorities
- Stimulating and funding water research according to priority
- Promoting the effective transfer of information and technology
- Enhancing knowledge and capacity building within the water sector

The WRC, as the research and development partner of the sector leader, the Department of Water Affairs, as part of the Ministry of Water and the Environment, provides the sector with knowledge and capacity to ensure sustainable management of the water resources and enhance water services. The WRC strives to be South Africa's premier water knowledge resource. A combination of anecdotal evidence and one sector-specific survey indicates that the WRC funds and manages approximately 50% of South Africa's water research in general and 70% of South Africa's water research in the agricultural sector.

The WRC works on the premise that the crux of the water challenge in South Africa is a capacity and capability challenge, the WRC addresses the three dimensions of this challenge, viz., New Knowledge, Human Capital and Technological Solutions. It will endeavour in its projects to create a high concentration of activities that support each of these pillars.



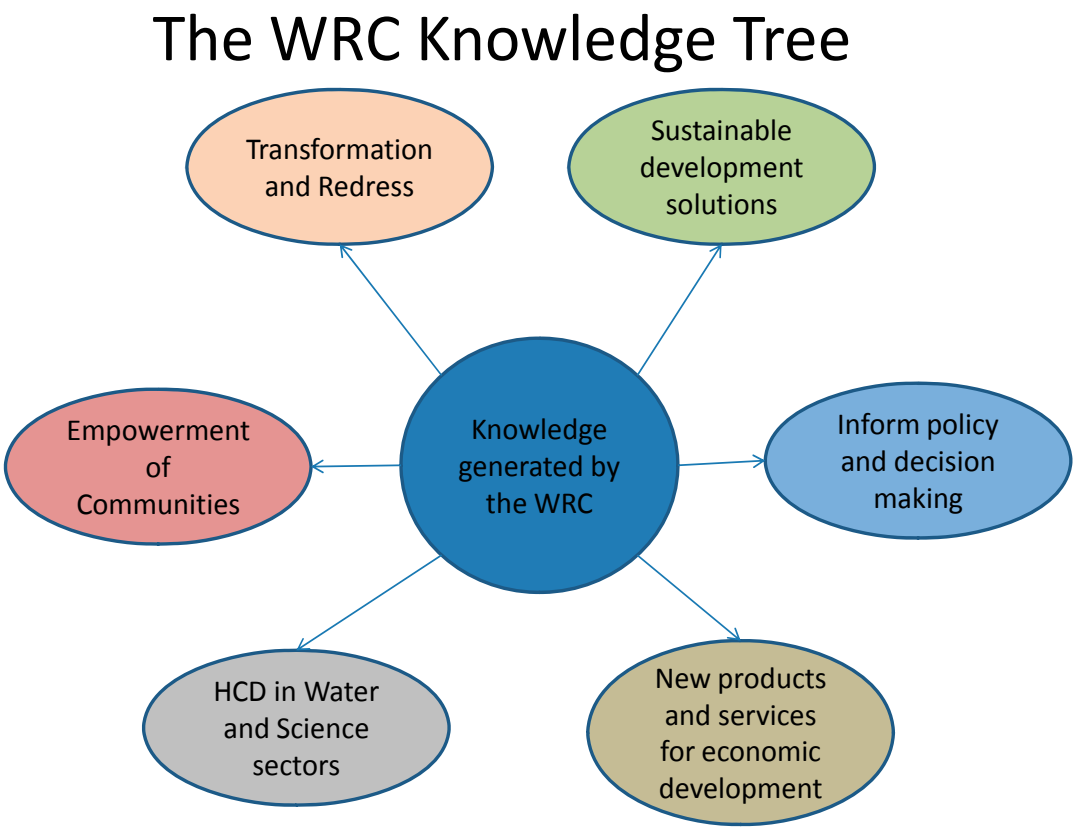
The strategic approach developed by the South African Government, using an outcome-based approach (see below) while striving towards an impact, was adopted by the WRC. The WRC aims to support the various outcomes and outputs through its research portfolio. The WRC will continue to support the Department of Water Affairs (DWA) in its call for mainstreaming of water as the basis to enable and catalyse economic growth and sustainable development. The WRC is actively involved in the key DWA initiatives including the legislative and policy review, the institutional realignment programme as well as the development of the National Water Resource Strategy. The outcomes of research projects provide scientific knowledge which informs initiatives such as water pricing and water infrastructure management. Research will continue to create and disseminate knowledge that can support Government's outcomes and outputs.



Government Guide to Outcome Approach May 2010; www.thepresidency.gov.za

1.2 The Strategic Framework

A fundamental part of the operations of the WRC at the beginning of its fifth decade is the construct of the WRC Knowledge Tree.



The goal is that every WRC project will be designed to enable the achievement of as many of the WRC Knowledge Tree outcomes as possible and reasonable, both within the project and, where needs be, post-project, as either further actions or, where useful, a completely new project.

The core components of the WRC Knowledge Tree as illustrated above are as follows:

Inform policy and decision-making
The WRC will reinforce its efforts to commission appropriate research projects to actively inform both policy development by Government partners and decision-making by all parties in the water sector. In addition, special efforts will be made to orient technical and policy briefs from as many WRC R&D projects as possible to further contribute to this endeavour.

A significant four-year study called the integrated 'Water Resources of South Africa 2012' study (WR2012), will commence in April 2012. These studies provide the cornerstone of baseline national water resources assessment and planning for South Africa as required in the National Water Act and the National Water Resource Strategy. The main purpose of the study is to update the WR2005 System by including groundwater and certain aspects of water quality into the assessment.

The WRC will also support government it its drive to increase the sustainable use of groundwater. A project was commissioned that aims to develop a methodology and atlas of favourable target zones

for groundwater development for priority municipal areas to simplify decision making for groundwater use based on aquifer yield, infrastructure costs and treatment costs.

Decision makers responsible for sanitation solutions at local level can look forward to the outcomes of a study that documents the constraints on providing sewerage in South African informal settlements from a social and institutional management perspective. In order to assist government to understand water service delivery protest in South Africa, a new study was commissioned to provide an in depth understanding.

The comprehensive suite of health related studies (including pathogenic and toxicity risks) promise to generate new knowledge that will inform decision making which will be summarised in various technical and policy briefs.

There are many projects on good environmental governance to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country during a time of demographic and climate change. More effort is being put into addressing land use impact and terrestrial ecosystem change that has an impact on water resources and aquatic ecosystems. New site specific projects include the ecosystem functioning, sustainable utilization and management of aquatic resources of the Lower Pongolo River and studying the biodiversity, conservation and management of Nelson Mandela Bay temporary wetlands.

New products and services for economic development

Many of the WRC projects have the potential to develop new intellectual property or to introduce such innovations to create new or improved technologies, products and services to be used in the real economy. These activities span the innovation value chain, all the way from IP mining of the existing WRC portfolio to performing due diligence on new products and services, appropriate intellectual property protection, further product development and commercialisation. In order to enable this, a strategic partnership between the WRC and the Technology Innovation Agency (TIA) will be implemented in the 2012/13 financial year.

Important examples include the use and protection of groundwater. The WRC will develop an interactive vulnerability map and preliminary screening level monitoring protocol to assess the potential environmental impact of hydraulic fracturing activities affecting groundwater in particular. Furthermore, the WRC will also develop reference documentation for improved knowledge on technologies to remediate contaminated groundwater. The race to find economically viable and sustainable acid mine drainage solutions continues. Technological development focuses on both active and passive treatment systems. Newly started investigations also promise to deliver risk criteria for water management aspects of mine closure.

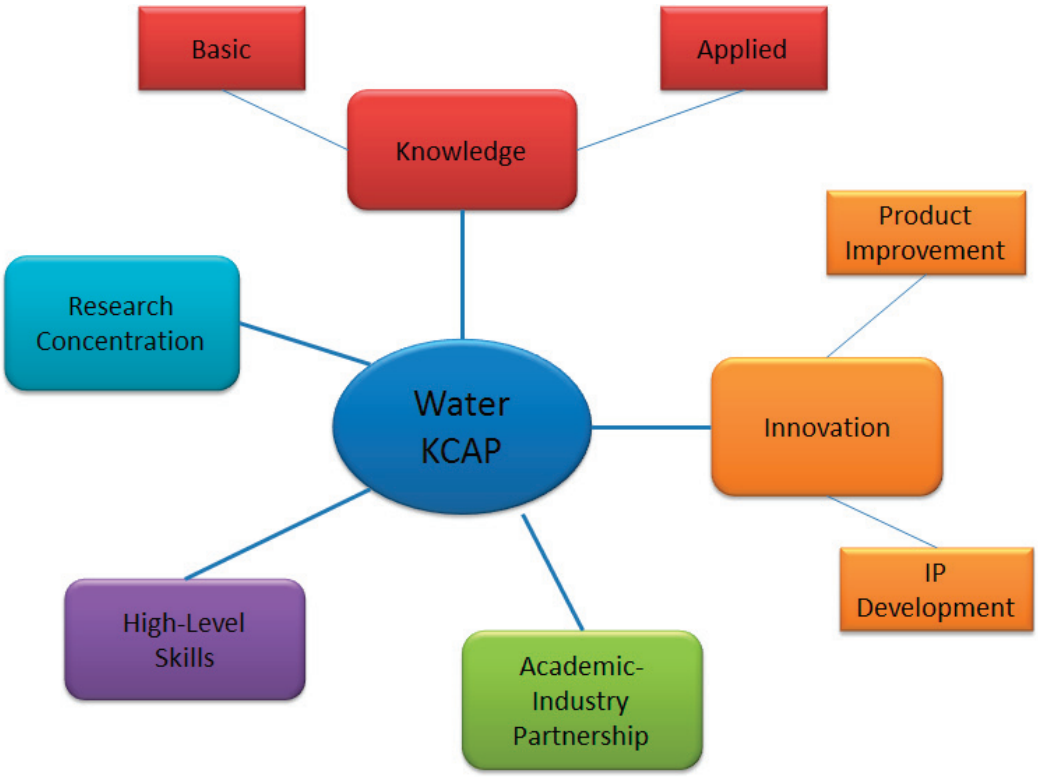
At the same time, several new projects have potential for up-scaling and possible commercialisation such as the advanced oxidative treatment process for water disinfection using an electrohydraulic discharge reactor and TiO2 immobilised on nano-fibres. Further development and demonstration of the innovative woven-fabric immersed-membrane bioreactor (WFIMBR) package plant for decentralized sanitation is planned for 2012/13. In addition, the near market ready integrated algae ponding technology's performance and efficacy will be tested for water reuse and cost recovery through biomass valorization.

Supplying knowledge products to enhance service delivery continues to be a priority. Newly commissioned research include identifying efficiency and inefficiency in municipal water service provision, developing municipal guidelines for implementing water demand management, compiling a single reference document which compares actual cost and water quality data from various South African desalination projects to establish a knowledge base for desalination and reuse for the

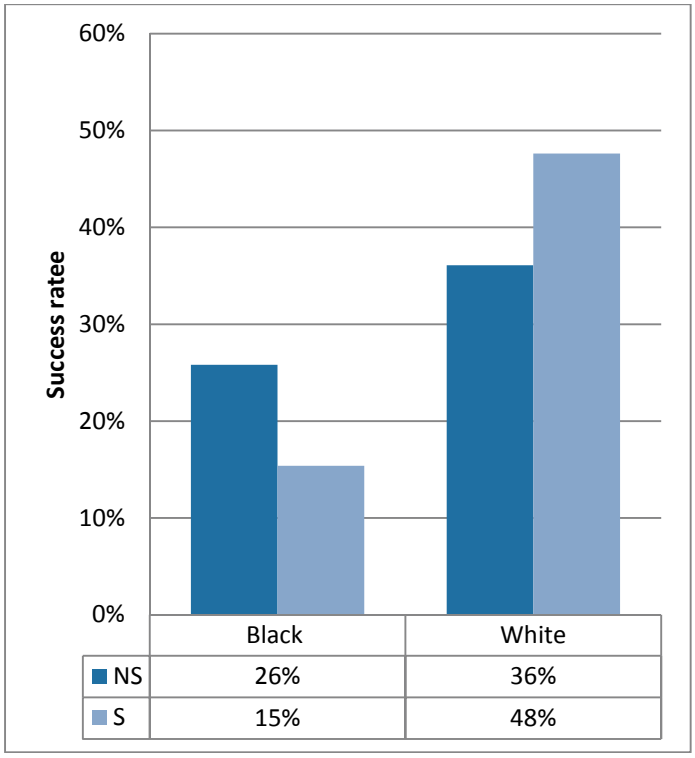
augmentation of water supply in a South African context and developing a decision-support model for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery.

Human capital development

Currently all WRC projects are encouraged to have a component of student participation where possible. The majority of WRC projects are able to comply. The WRC will continue this practice in this five- year period and in addition will initiate two very important programmes if the required resources are obtained through engagements with DWA and Government. The first is a Water Knowledge and Capacity Building programme (WaterKCAP) to facilitate an academia-industry partnership in R&D and human capital development. The figure below indicates the expected outcomes of WaterKCAP-funded projects: human capacity development, research reports, peer reviewed papers and PhD and Master's graduates. In addition there will be technology development and improvement as well as strengthened academic/industry partnerships.



The figure below indicated the participation rate of black versus white project leaders as a percentage of successful projects versus overall number of project proposals received from that race in the last call for proposals. In order to improve the success rate of black project leaders, a special programme of short-term projects will encourage and empower project leaders from the designated groups to be sufficiently enabled and empowered to participate in the mainstream WRC portfolio.



NS, Non solicited; S, Solicited

Empowerment of communities

The WRC and its partners will accelerate the development of its portfolio of projects that both have a direct impact in the lives and livelihoods of communities through water-related interventions and build sufficient capacity to assist with the post-project sustainability of those interventions.

Various completed projects are already having a positive impact on the lives of South African communities, including the transfer of knowledge regarding techniques and practices for rainwater harvesting in homestead food gardens as well as water use of indigenous crops; nitrate removal for groundwater supply to rural communities; water safety plans for small water treatment systems; as well as the restoration of wetlands' ecological processes to support rural livelihoods. Current and future research includes water use skills development of women to reduce rural poverty; and further training; further knowledge transfer in water use for homestead gardening; and optimisation of entrepreneurial development paths for irrigated smallholder farming.

New projects are designed to guide improved governance models and practical implementation of rural development projects, centred around the productive use of water. It will also start a project to develop recommendations and guidelines for the functioning of catchment forums that are sustainable, inclusive, legitimate and effective.

Transformation and redress

This five-year strategic plan has transformation and redress as a central driver. The actions will include a further diversification of the WRC portfolio in the following dimensions – project leadership, student participation, institutional participation, project selection and project site selection. Further actions are associated with the WRC's own internal demographics and work dynamics. The WRC will engage with the project leaders for new projects to consider moving the research sites to areas of low activity.

Sustainable development solutions

All of the WRC's projects and activities are geared toward sustainable development solutions and, in particular, empowering the implementation of the National Climate Change Response Strategy from a water perspective and sustainable infrastructure management.

In this regard, the WRC has several ongoing and new projects addressing climate change in the context of water including enhancing predictability of water quality and quantity, climate change risks, vulnerability and adaption and developing planning tools for adaptation by applying scientific climate change projections to local social realities.

Regarding sustainable infrastructural management, the WRC started a project to provide the South African engineering community with their own South African standard for the design of water retaining structures, taking account of local conditions and materials.

Key elements of the five-year plan

The five-year strategy has at its core the goal of contributing to the sustainable management of water for sustainable development achieving both economic growth and improved quality of life for all in South Africa. In order to achieve this, the WRC will engage in the following initiatives:

The elements of the proposed 5 year strategy include a drive to expand the budget and increased support for research and human capital development. The proposed mechanism to increase the WRC research budget availability include new research, technology and human capital development partnerships. This will enable the WRC to partner and/or lead the implementation of priority water R&D components.

The second element will focus on increasing the research and human capital development profile in the sector. Desired outcomes will include increasing the number of publications in peer reviewed

journals from WRC sponsored research projects and expanding post graduate student output. The Water Knowledge and Capacity Advancement Programme (WaterKCAP) detailed above will ensure funding to achieve these objectives.

The third element ties in with the vision of establishing a Water Technology Convergence Centre. The programme will ensure up scaling and demonstration of new technologies balancing social innovations and classical competitiveness.

The fourth element focuses on increasing the political profile of water research and development and the WRC. The vision is to become the premier point of water knowledge in South Africa and the continent and a significant bus-stop in the global water knowledge route. This will be achieved through Water Dialogue Series, the State of the Water Research Report and Leadership Forums.

The firth element expands the profile of South African water science and technology internationally. The vision for the WRC is to become a globally significant player in international projects and initiatives around water and development.

The last, very important element has an internal focus: Ensuring a proud, empowered WRC team. The WRC needs to be a good place to work and ensure development of people. This will include a programme to empower, develop and recognise staff, facilitate a better work/life balance and a better work environment.

1.3 Links to Government's Outcomes

The WRC as a national public entity strives to support the Government of South Africa in achieving its strategic outcomes with particular reference to the Strategic Plan (Annual Performance Plan) of the Department of Water Affairs and the performance agreement of the Minister of Water and Environmental Affairs. This section is directly aligned with the outcomes, with emphasis on Outcome 10 specifically. This addresses the protection and enhancement of the country's environmental assets and natural resources. The WRC work-plan is geared to the improvement of the quality and quantity of South Africa's water resources through its research projects as well as its innovation and technology development activities. Some examples include technologies and strategies to reduce water loss in the distribution systems, better sanitation solutions and improved wastewater treatment. The WRC has invested in studies on climate change and related energy issues with the aim of providing South Africa with methodologies and knowledge to allow for both mitigation and adaptation strategies regarding climate change, specifically where water-related issues are of concern. Biodiversity issues related to aquatic life and ensuring healthy ecosystems and river health, as well as protecting and restoring wetlands, are supported by a number of research studies. Research aims to ensure ongoing provision of ecosystem services, such as clean water, through good catchment management. The portfolio of projects in the water resources domain, including groundwater, is a key contributor.

The second priority outcome is Outcome 6. This addresses the need for an efficient, competitive and responsive economic infrastructure network. The WRC projects support water availability through examining and finding solutions for issues related to bulk water supply and supporting the development of appropriate regulations regarding water quantity, quality and usage. This includes aspects of water pricing and allocation as well as examining different sectoral needs and individual solutions, e.g., irrigation and food production. The research will continue to address the challenges of efficiency and new institutional arrangements.

Outcome 7, which focuses on vibrant, equitable and sustainable rural communities and food security for all, is carried out through a number of projects addressing water utilisation in agriculture, and projects focusing on informal settlements and peri-urban communities. The use of water by small-scale farmers (smallholders) and water allocation reform have been addressed by research projects. The WRC will continue to support the wise use of water for agriculture, aiming to support the target of reducing water demand from irrigation. Research has also addressed the issue of improved productivity and quality (nutritional value) of food. Homestead gardens and the use of rainwater harvesting will continue to be addressed. The research also focuses on the development of technologies for the provision of clean water and sanitation to rural areas. The implementation of these technologies will support the target of increasing the proportion of households with clean water from 74% to 90% as well as the proportion of households with access to improved sanitation from 45% to 65%.

Outcome 9 aims at establishing a responsive, accountable, effective and efficient local government system. The WRC supports this outcome through research aiming to improve basic services, with special emphasis given to the delivery of water and sanitation services. Other related areas are finance and development planning related to the above, as well as disaster management.

Detailed links to Government outcomes are provided for each of the research key strategic areas (KSAs) at a thrust level (see below).

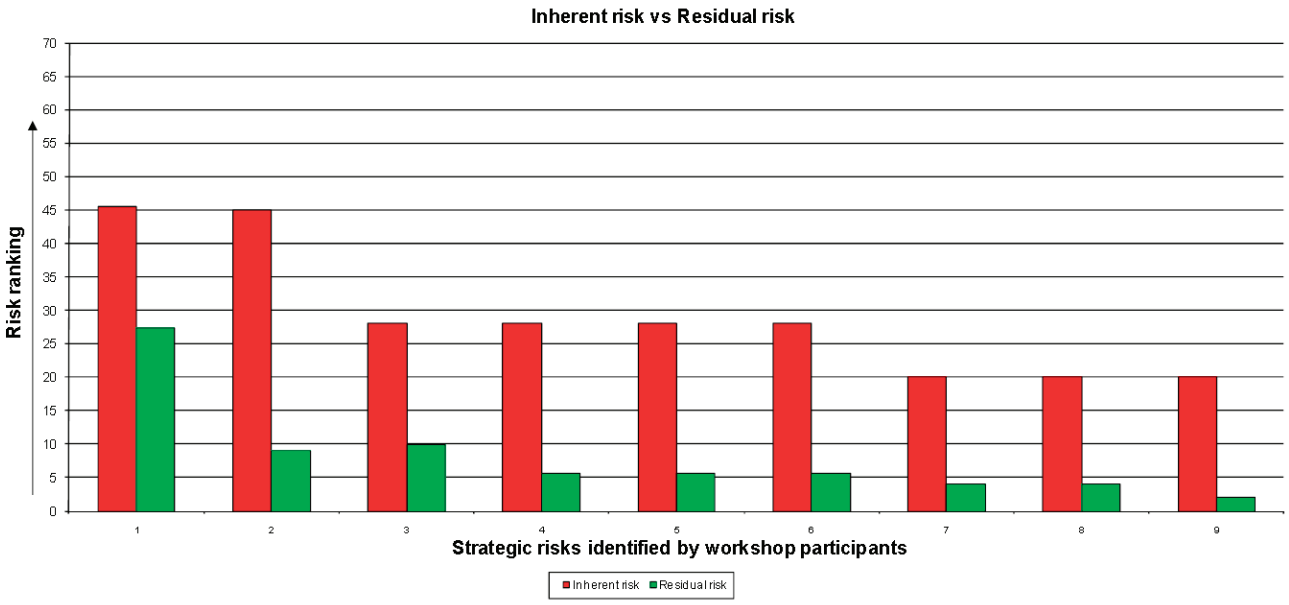
1.4 Risk Plan – Identified Risks

The WRC (Board and Management) identified nine strategic risks that it will be required to attend to during the period set for this Strategic Plan. The risks presented below have each been assessed in terms of impact and likelihood, i.e., inherent risk exposure. The WRC also identified the existing controls (mitigations) which are in place, and assessed the perceived control effectiveness of the identified controls. Each risk was allocated to a risk owner. These risks were also linked to the strategic objectives of the WRC. A risk rating was assigned from both an inherent risk and a residual risk exposure perspective.

1. Insufficient research capacity (fields, quality, and quantity in the country)
2. Insufficient funding
3. Decreasing quality and relevance of research portfolio
4. Instability of levy funding
5. Negative response to research outputs/results
6. Inability to attract, retain and develop skills within the WRC
7. Non-adherence to Government practices and regulations
8. Business interruption/disaster
9. Fraud and theft

Only the first risk was categorised as a high inherent/priority 1 risk while the other risks were found to be of a moderate nature. These risks are mitigated and managed through internal processes and controls. In addition, strategic risks identified inform this Strategic Plan and will be included directly or indirectly in the key performance objectives of the WRC where appropriate.

Refer to **Appendix I** for further in depth details with regards to the individual risk linkage to the appropriate strategic objective, root causes, consequences of the risk, impact, likelihood, inherent risk exposure, current controls/business processes to manage the risk exposure, perceived control effectiveness and residual risk exposure. Below please find the gap analysis between inherent and residual risk exposure for the various risks identified.



The larger the difference between the inherent and residual risk factors the more effective the controls in place are perceived to be, and therefore reliance placed on the controls. The smaller the difference between the inherent and residual risk factors, the more management actions and improved control effectiveness is needed to ensure that the risk is properly managed.

1.5 Links to Strategy

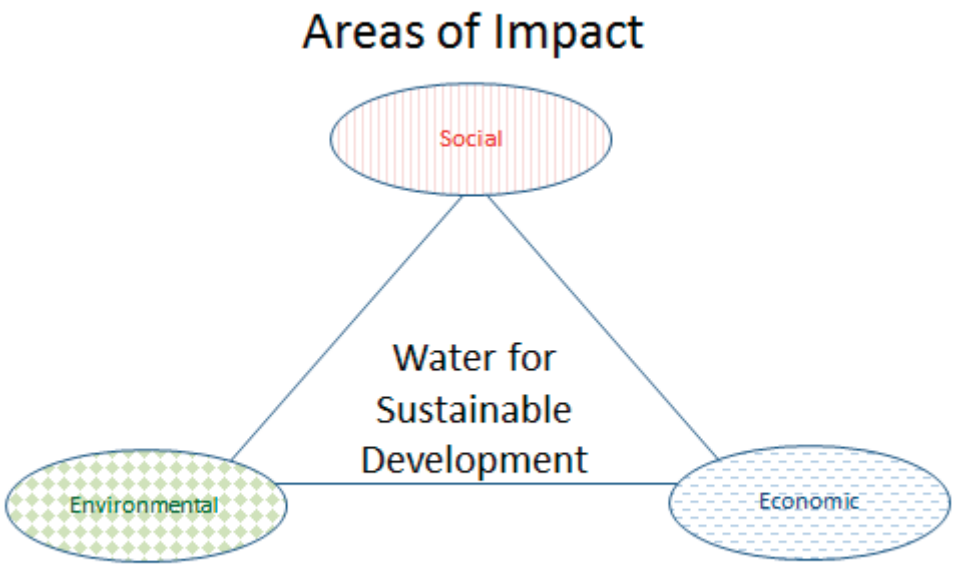
This Strategic Plan is informed by the strategic context and takes into account the needs and views of the WRC's shareholder and stakeholders, the identified strategic risks as well as Government's outcomes and strategic objectives and targets. Based on the above, the WRC has fine-tuned its overarching objectives, its future research portfolio and its key performance areas (indicators and targets). The WRC will closely link its future research portfolio to Government's outcomes and will continue to put strong emphasis on knowledge sharing and dissemination.

2. OVERARCHING GOALS – IMPACT AREAS

In line with the above strategic context, and with close linkages to Government's outcome-impact approach, the WRC identified three impact areas that form its overarching objective to make a difference through knowledge creation. These impact areas are linked to almost all of the Government's outcomes but are closely linked to Outcome 10 as well as Outcomes 6, 7 and 9. These are directly linked to the national objective of economic growth and sustainability. Each of the impact areas has a clear scope and sub-objectives.

The WRC strives to create knowledge which will contribute to making a difference (impact) on key issues related to:

- Water and Society
- Water and the Economy
- Water and the Environment



2.1 Water and Society

The WRC aims to have an impact on society by improving the understanding of the role water plays in societal aspects and dynamics. Of special interest is the role that water may play in achieving social transformation and justice in the context of deepening democratic practices, the extension of water services and redressing the wrongs of the past. This is further complicated by the country's commitment to ecological sustainability, the effects of climate change, HIV/AIDS and the daily realities of households living in poverty. The WRC aims to include a social perspective, where appropriate, in all aspects of water research. This includes issues of gender, class, disability, urban or rural location, culture and religion. Research will integrate a variety of methodologies to provide a holistic view while emphasising respect for people's rights, and will encourage participation in monitoring and decision making as entrenched in the country's Constitution.

The objectives are to:

- Develop a greater understanding of social dynamics in the water sector and people's needs for and views of water; encourage people's participation in water management and decisions about water
- Search for ways of using water for transformation and social justice
- Enable water users at all scales and in different localities to meet the challenges of utilising water as a shared and scarce resource in a sustainable manner
- Provide water services which are socially acceptable, affordable and available to all
- Ensure ready access to water for the poor and disadvantaged members of society

The WRC aims at improving the quality of life of all South Africans through improved health. Health-related water research is therefore undertaken with the aim of improving water quality and hygiene practices in order to save lives and reduce the cost and effort involved in treating diseases and their symptoms. Health impacts associated with microbial or chemical contamination, or transferred via water-associated vectors, are addressed. The WRC supports the development and utilisation of methodologies to identify and quantify the occurrence of pathogens and other contaminants in water, as well as the provision of the tools for risk assessment and epidemiological studies. Knowledge that will contribute to the protection of human health by investigating the sources,

persistence, and control of water-related diseases and other water-related health problems should focus on:

- Obtaining adequate understanding of the origin, survival and persistence of, and inter-relationships between, microbial, chemical and other biological and toxic pollutants in water
- Assessing the impacts (actual and potential) of pollutants on human health by performing epidemiological investigations and developing health-risk assessment tools
- Developing methodologies to identify and quantify the occurrence of pathogens and contaminants in water, as well as risk assessment and epidemiological studies
- Investigating the effects of environmental change on health (e.g. the impact of global warming on the spread of malaria; the link between climate variability and epidemics caused by water-borne diseases)
- Developing scientifically-sound educational material on health, hygiene, the effects of pollution and the prevention of pollution, and the relationship between these
- Providing guidance for appropriate communication, awareness-building and management strategies
- Contributing to the general health of animals and of the environment in pursuing all of the above objectives

2.2 Water and the Economy

In the South African context, water is, first and foremost, treated as a common (social) good. Water is recognised as being essential for sustaining life and is a commodity to which people and the aquatic environment have a legally-protected right. However, water is also recognised as an economic good, the use of which has a major impact on the creation of wealth and the wellbeing of people. Almost without exception, there is an increasing interest in assessing the economic value of water, using water as a catalyst for the generation of wealth and prosperity, and using economic instruments to increase efficiency and effect desired behavioural change among water users. The use of water tariffs to effect changes in water consumption and the use of waste discharge charges to internalise pollution costs and, in so doing, effect pollution reduction and desirable improvements in water quality, are examples of management options that are being implemented along with the selling of water-use licences under specific circumstances. There is also recognition of the need to deal with complex water-economy systems such as catchments and to determine how sensitive socio-economic activities and their associated values are to the impacts of extreme events, such as floods or droughts, or to gradual changes over the longer term, such as global climate change.

Through its research portfolio the WRC aims to determine the role of water in economic development, the use of economic instruments for improved water management and the economics of dealing with complex systems at the appropriate micro-, regional and national levels.

The WRC aims to provide knowledge regarding:

- The role of water in economic development
- The use of economic instruments for improved management of water
- Improved understanding of complex water-economy systems

2.3 Water and the Environment

The WRC aims to improve the understanding of linkages between all natural environmental components (atmospheric, marine, terrestrial, aquatic, subterranean) within the hydrological cycle, as well as improving the knowledge on how this is linked with the anthropogenic environmental

components (developed infrastructure and other land uses). By establishing and applying best practices in mitigation of damage to the water environment sustainability will be achieved.

The WRC aims to enhance the understanding of whole-ecosystem functioning in the context of the broader environment and its effects on water resources, and supports the development and application of good environmental governance systems. This will result in achieving a situation where our governance systems, our understanding of environmental processes, and the functioning within the hydrological cycle are aligned to support sustainable water management. The selection and application of sustainable techniques in water governance and water projects that are aimed at addressing human development needs are key to long-term environmental sustainability.

3. THE RESEARCH PORTFOLIO – LINKS TO GOVERNMENT'S OUTCOMES

The WRC will, through its research portfolio, support Government's outcomes. The challenge of allowing for a balance of short-, medium- and long-term research is ongoing. The WRC will also continue to place more emphasis on social sciences and will continue to improve its ability to support integrated research between the many disciplines of both natural and social science. The WRC will continue to support South Africa in its endeavours to combat water scarcity and manage its water resources, through the creation and dissemination of water-centred knowledge. The research portfolio of the WRC addresses, through four key strategic areas (KSA), four of Government's outcomes, i.e. Outcomes 10, 9, 7 and 6. The research portfolio addresses the scope and main objectives within the identified research areas that the WRC will focus on during the period covered by this Strategic Plan. There is a strong link between the research portfolio, the budget and the key performance areas of the WRC.

Knowledge Creation – Key Strategic Areas

- **Water Resource Management**
  - Water resource institutional arrangements
  - Water resource assessment and planning
  - Water quality management
  - Water resource protection
  - Water resources and climate
- **Water-Linked Ecosystems**
  - Ecosystem processes
  - Ecosystem management and utilisation
  - Ecosystem rehabilitation
- **Water Use and Waste Management**
  - Water services
  - Water supply and treatment technology
  - Sustainable municipal wastewater management and sanitation
  - Industrial and mine-water management
  - Sanitation, health and hygiene
- **Water Utilisation in Agriculture**
  - Water-efficient production methods
  - Fuel-wood and timber production
  - Poverty reduction and wealth creation
  - Resource protection and reclamation

3.1 Water Resource Management

3.1.1 Scope

COP 17 in Durban, South Africa, was a major event that took place in 2011, although it was associated with significant scepticism about whether or not any agreements would be reached. However, certain agreements were reached: (i) to launch a **new negotiating process** that will develop a new 'protocol, legal instrument or agreed outcome' by 2015 with implementation by 2020 and covering all countries, (ii) to establish a **second commitment period under the Kyoto Protocol** beginning in January 2013 and ending in either 2017 or 2020 (to be determined by COP18) and (iii) to implement the new **Green Climate Fund**.

At the same time, some 20 years on from Rio, the principles and commitments on sustainable development will be reaffirmed in 2012. The 6th World Water Forum is calling for time for sharing solutions. There is also geopolitical pressure to achieve the set 2015 MDG targets to integrate the principles of sustainable development into country policies and programmes and reverse the loss of environmental resources (Target 9) and to halve the proportion of people without sustainable access to safe drinking water (Target 10).

These will be among the main international drivers for the next five years that will influence decisions around water resources internationally, regionally, nationally and locally. The direct bearing on the region will be greatly influenced by the rate of economic growth in Africa, which seems to have been higher than the world average for a few consecutive years. Despite this positive outlook, droughts in Kenya and Ethiopia, possibly due to climate change, have displaced more than 1 million people. A solution proffered by a recent study by the African Development Bank (ADB) shows that "to achieve a balance in water allocations, scaling up the water development process to a river basin level will require stronger integration of national processes with regional economic and social growth and development to meet the projected temporal and spatial water decline challenges; in effect the convergence of national and regional economic processes is a key step towards stronger shared river basin management".[1]

Apart from the problems of water resource limitations and induced scarcity, South Africa has specific challenges relating to inequities in the physical, social, administrative as well as institutional access to this important resource. This applies especially to the poor and disempowered majority, whose ability to pay for water is limited. Being part of the MDG targets, access to water as a social good, as well as an economic good, is now recognised. In South Africa, the idea of water as a human right has informed the development of the **Freedom Charter**, which in turn greatly influenced the development of the **Bill of Rights** that forms Chapter 2 of the **Constitution**. This sets out the citizen's rights and commits Government to fulfilling them.

The mainstreamed right to water has been translated into delivering water services in some provinces (Free Basic Water). However, access to water as a resource for productive use, e.g. for emerging farmers in rural areas, has not fared as well. Accordingly, Government has dedicated an 'outcome' to this, Outcome 7: 'Vibrant and sustainable rural communities and food security for all'. Output 1 associated with this Outcome, namely, 'Sustainable agrarian reform', is a major focus for the KSA dealing with Water and Agriculture, but in this KSA the main focus is from the perspective of enhancing local water management and water management institutions in implementing water allocation reform.

[1] AfDB's Regional Paper for Africa (2009) notes, "regional integration is essential not desirable"

Reform in the water sector can be better expressed as 'Transformation' of legal, economic, organisational and social parameters which sometimes have external loci of control. For example, a completed study points to the fact that water allocation reform cannot achieve its objectives unless addressed with land reform, since some water set aside in Prof. Kader Asmal's time cannot be productively used by emerging farmers because they lack access to land.

Demands placed on water resources arise from a combination of factors: growth and development, increased human and animal populations, increased urbanisation, and climate change and variability. Strategies for reducing demand, increasing efficiency on a catchment basis, and creating new sources of water resources from, for example, desalination, fog harvesting, targeted recycling, reuse, artificial recharge, etc., provide complementary strategies within the National Water Resource Strategy that can form part of Outcome 6 of Government's key focus for 2014, namely, 'an efficient, competitive and responsive economic infrastructure network', which relates directly to water resource assessments, planning and development of infrastructure. Output 4: 'Maintenance and supply availability of our bulk water infrastructure', is directly addressed by these strategies.

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

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

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

3.1.2 Objectives

The main objective of research in this KSA is to provide water resource management tools for addressing the above challenges, fundamentally driven by increasing water scarcity in the face of increasing and competing demands, all of which have social, economic and environmental consequences. This therefore necessitates proactive, innovative, scientific, technological and

institutional experientially-based solutions. A better understanding of water resources and their management requires a more holistic conceptual framework encompassing regional-scale hydrological systems, land-atmosphere interactions and the biogeochemical cycles that control contaminant transport. This unit operates in five thrusts, the management of which is specifically designed to meet this need. These thrusts inevitably have areas of overlap which are described below in their respective scopes. Holistic approaches to water resource management are particularly pertinent in this area of research and must take account of all sources of water from quality, quantity and accessibility perspectives.

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

In view of the above, the thrusts have been revised to allow for full articulation of water quality issues as well as climate change aspects. 'Resource protection' has been changed to 'source protection' in line with international practice.

Thrust 1: Water Resource Institutional Arrangements
Thrust 2: Water Resource Assessment and Planning
Thrust 3: Water Quality Management
Thrust 4: Resource Water Protection
Thrust 5: Water Resources and Climate

3.1.3. Thrusts and Programmes

THRUST 1: WATER RESOURCE INSTITUTIONAL ARRANGEMENTS

This thrust focuses on articulating the thinking for the new roles and responsibilities of the various stakeholders, based on catchment and water management area boundaries. The marked shift from central management of resources to a more localised scale is critical to the main founding concepts of integrated water resource management (IWRM). The defined management boundary based on watershed boundaries is another fundamental provision in IWRM as a concept. This thrust is one of those cross-cutting areas which can also deal with the legal, institutional and financial aspects relating to broad water quality, quantity, protection and climate change aspects. Being a cross-cutting thrust, it also straddles a number of Government outcomes and certainly can pertain to more than one output.

Achievements: completed research

- Regulation of water in South Africa
- Towards the assessment of impact of IWRM on the lives of women and the poor
- Career success of women in the water sector
- The institutional landscape of water in South Africa by 2025
- The philosophy and strategy of CMAs as learning organisations
- The financial allocation pathways for water infrastructure in local government
- Defining the appropriate level of governance for South Africa
- Towards the lowest appropriate level of governance in South Africa

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network
Output 1: Improving competition and regulation

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

Output 3: Rural services and sustainable livelihoods
Output 5: Enabling institutional environment for sustainable and inclusive growth

OUTCOME 9: A responsive, accountable, effective and efficient local government system

Output 1: Implement a differentiated approach to municipal financing, planning and support

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 3: Sustainable environmental management

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

Water governance and institutional reforms

The principle of subsidiarity, or, as sometimes referred to, democratisation of water resource management, has brought about challenges, both conceptually and in terms of application. Although current reforms in South Africa are based on sound IWRM principles, to date the implementation thereof continues to break new ground, proving that institutional engineering cannot provide a one-size-fits-all solution to the new management paradigm. Further understanding and research are hence needed to learn and decide on best practice as defined in the South African or similar socio-economic settings.

Compliance and enforcement

For the implementation of state-of-the-art legislation like the NWA, a matching enforcement and compliance regime needs to be in place to ensure effective implementation. The regulatory environment in the South African water sector is in its infancy and requires substantial support from research in creating the understanding and knowledge for informed decision making. Benchmarking and best-practice are crucial here to accelerate learning.

Pricing and financing WRM

The issues of financial sustainability, affordability of charges by users, transparency and corporate governance are becoming central in the decentralisation era. The new infrastructure agency responsible for new developments and maintaining national assets provides good ground-breaking research opportunities, especially to assess if water tariffs can indeed pay for managing and sustaining water resources. Does pricing water and introducing the water resource charge exclude the poor and will it further cripple local government from delivering services? The waste discharge charge is another serious introduction to the water sector fraught with considerable challenges. This programme can project and assess such issues.

Transboundary water resources

This programme will provide tools and guidelines for resolving potential water-centred conflicts for the management of shared international rivers and transboundary aquifer systems, including development of appropriate institutional forms and functions, development and harmonisation of policy and regulation in shared river basins, and strategies for knowledge-sharing and joint management of shared river basins. A need has been identified to define the roles and interrelationships between local WRM institutions and international basin organisations.

Future scenarios

This activity has been warranted a separate programme to ensure that local South African expertise is qualified to explore future scenarios and answer the 'what if' questions in support of reflection on and evaluation of national policy applications. Projecting the water resource management and development institutional arrangements landscape 10 or 15 years from now would be of interest to decision makers in order to define policy reviews and enhance decision making. Further complexity can be added through introduction of the water services institutions. Mapping of the processes for tariff setting between both water resources and water services could allow further investigation into service delivery affordability and efficacy. This programme is likely to have a phased programmatic approach, by adding more and more layers to the scenarios and customising them for localised aspects that need not be of national interest.

Future research

- Advancing Strategic Adaptive Management (SAM) as a framework for implementation of IWRM by CMAs
- Change-oriented learning and water management practices: knowledge flows and mediation tools
- Developing approaches to engage basin risk and the political economy of water in the Western Cape system
- Considering alternative dispute settlement practices for water resource management in South Africa
- An analysis of water pricing instruments governed by the South African Water Pricing Strategy and its potential for generating revenue for CMAs
- Embedding property rights theory in cooperative approaches to the management of aquatic ecosystem services in South Africa
- Economic conceptualisation of international water management and cooperation

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 1: Improving competition and regulation

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

Output 3: Rural services and sustainable livelihoods

Output 5: Enabling institutional environment for sustainable and inclusive growth

OUTCOME 9: A responsive, accountable, effective and efficient local government system

Output 1: Implement a differentiated approach to municipal financing, planning and support

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 3: Sustainable environmental management

THRUST 2: WATER RESOURCE ASSESSMENT AND PLANNING

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

Achievements: completed research

- Generation and application of data and knowledge from process hydrology and climatic processes
- Development of water resource assessment tools and their application at national and regional levels
- Improved evaporation monitoring, thus improving the water use calculations used in forestry licensing and the accuracy of water resource accounting
- Development and implementation of real-time rainfall monitoring and flood event forecasting
- The national gridded database of rainfall and other hydroclimatic variables (DWA, business, consultants and universities use this product)
- Water Resources of South Africa 2005 (WR 2005)
- Development of an improved sediment yield prediction methodology, i.e., Sediment Yield Prediction for South Africa - 2010 Edition
- The development and calibration of South Africa's National Standards for Water Retaining Structures
- Near real-time soil moisture monitoring from satellites: daily rainfall maps over RSA, for flash flood forecasting, drought monitoring, catchment management and agriculture
- Ecohydraulics for South African Rivers: A Review and Guide

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 1: Improving competition and regulation
Output 4: Maintenance and supply availability of our bulk water infrastructure

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources

The following programmes are addressed:

Catchment data and information systems

This programme will support the provisions of Chapter 14 of the National Water Act, especially Part 2: National information systems on water resources. This programme is focused on supporting the national initiative for improving the available water resource information, better management of the information and improved information dissemination to stakeholders. It will establish direct linkages to the national information systems as well as identifying and resolving water resource information gaps. In this programme researched water resource information will be integrated into the national information system that is being established by DWA. The programme will also support the process of decentralising identified water resource data and information from broader national perspectives to detailed and highly-resolved local and catchment scales.

Surface water / groundwater hydrology

This programme focuses on developing and utilising integrated hydrological approaches in surface water and groundwater assessments, water resource explorations, planning and management. It will take advantage of gains made in improved understanding of groundwater and surface water hydrological processes as well as the availability of better hydrological data, especially the various forms of more accurate remotely-sensed data with better coverage. Through this programme, strategic partnerships with international expertise in both groundwater and surface water hydrological research will be encouraged to flourish. Hydrological tools that have been developed in the past are expected to be upgraded, re-developed or replaced by tools that are more suited to the current data availability, the improved knowledge and the recent technological advances in hydrological modelling. In this programme, the continued deterioration of hydrological gauging

processes and other installed earth measurement devices will be addressed through the intensive use of new data sources from remote sensing coupled with the limited earth-based measurements.

Water resource infrastructure

There is an increasing need to develop systems for the efficient maintenance of the aging water resource infrastructure as the demand for the development of new and expensive water resource infrastructure is increasing due to the growing economy and population growth. This programme will seek to develop strategies and priorities for water resource infrastructure development and management to address the uncertainties and risks associated with climate change. While **built** infrastructure developments, such as dams, reservoirs, irrigation and flood barriers, are important options for addressing these issues, this programme will also explore the potential use of **natural** infrastructure, such as wetlands, floodplains, artificial recharge (to aquifers), etc., to complement built infrastructure (but with an added advantage of healthy ecosystems).

Water resource planning

This programme will address water resource planning for the purposes of improved water allocation, better management of water use activities and to ensure secure, sustainable and adequate national water resources. It is also focused on the development of tools that will address planning gaps, such as the absence of reliable information in un-gauged areas and the persistent record gaps which exist in present data sets. The programme will promote a deliberate shift towards the development of water system plans that will benefit from real-time, historic and stochastic data on a countrywide basis. Impacts of climate change on water resources and the planning processes will be accounted for, so as to ensure a proactive approach and allow for national preparedness. Integration will also be achieved through aligning this programme to wider national water resource planning needs as expressed in the objectives of Water for Growth and Development, as well as through accounting for other factors, which include poverty alleviation, economic benefit, empowerment and the importance of meeting the Millennium Development Goals. Research on the planning of water resources will also address the information gaps in the understanding and subsequent utilisation of seawater in building water resource security. Saline water, brackish water, and other water bodies that can be purified and made available for regular water use will be investigated and included as part of future water resource plans.

New water

This programme will improve the understanding of national needs for water resource development, existing water resource infrastructure maintenance and rehabilitation. The equitable allocation and access challenges, and economic growth target of 6% of GDP per year, will require thorough understanding and assessment of alternative sources of water. Such sources could be built into future projections for new water, virtual water and water transfers, be they national or international, from desalination, etc. The programme will also promote the integration of social, economic, and environmental considerations as key components of sustainable water resource development.

The initial development of research under the new theme of Water and Energy will be initiated through this programme. Within this water and energy research theme, the improvement of power supplies through the utilisation of water in various forms will be addressed. Also through this research theme, the investigation of the distribution, transport and transformation of water and energy within the national boundaries will receive attention, to improve knowledge on the water and energy cycle. The research will aim to take advantage of the natural forces of the water and energy cycle to address water resource management objectives.

Future research

- Institutionalisation of water resource monitoring and reporting systems
- Review of potential use of remote-sensing data for hydrological and water resource assessment as well as water resource monitoring
- Addressing knowledge gaps in water resource infrastructure development and maintenance to improve water resource availability and reduce risk of water resource shortages
- Water resource augmentation options assessment guide to meet new demands
- Water resource accounting framework
- Good wastewater and bad wastewater

The above projects will contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 1: Improving competition and regulation
Output 4: Maintenance and supply availability of our bulk water infrastructure
Output 5: Communication and information technology

OUTCOME 9: A responsive, accountable, effective and efficient local government system

Output 4: Actions supportive of the human settlement outcomes

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources

THRUST 3: WATER QUALITY MANAGEMENT

This thrust acknowledges the significant water quality problems in our natural water resources. Water quality is generally reflected in concentrations of substances and microorganisms, physico-chemical attributes, radioactivity, as well as biological responses to these. Within each of the programmes within this thrust, research will focus on two broad fronts, namely, (i) consolidation and knowledge transfer and (ii) alertness to emerging issues. Consolidation of the vast amount of existing water quality-related research outputs in priority domains is necessary. The primary aim will be to distil effective decision support for management of our water quality problems. Emphasis will therefore be more on formulating solutions than on formulating problems. By actively sharing knowledge with decision makers, and working closely with them, the decision support must explicitly address their absorptive capacity in its broadest sense. On the one hand, solutions need to be based on a thorough holistic and realistic examination of likely consequences of implementation of those solutions. This must create confidence that risks of unintended consequences will be minimised. However, on the other hand, solutions must cater for the inherent complexity (and hence uncertainty) of both the organisational and natural environment. The consolidation research will prioritise research on eutrophication and microbial pollution. Research will also be encouraged that heightens awareness of, and/or recommends management approaches for, important emerging issues, i.e. those potential or recognised concerns that are either not addressed, or are only partly addressed, in current water quality management practice and research. High priority issues include those of national concern, those for which the frequency or probability of adverse conditions occurring is high, and the consequences thereof severe, and so on. Water quality necessarily cuts across various KSAs as well as thrusts within this KSA. The scope of this particular thrust focuses primarily on water quality of inland surface waters and its management. Programmes that will support this are reflected below.

Achievements: completed research

- Development and testing of a health risk assessment framework to derive guidelines for endocrine disruptors (EDCs) in drinking water
- Remote sensing as a tool for resource assessment and determination of the legal compliance of surface and groundwater use
- Development of a conceptual framework for the regulation of water quality within the context of an integrated, preventative management approach
- Investigation of the positive and negative consequences associated with the introduction of low-P detergents

The relationship between completed research and Governments' performance outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

The following programmes are addressed:

Water quality monitoring

Sound water quality monitoring data are crucial to sustainable management because they provide information on the current status and trends. Creative yet soundly-scientific approaches to monitoring are required that optimise information and minimise costs. All phases of monitoring design need careful consideration, from data acquisition, data storage and management, information generation and dissemination, through to realistic implementation strategies.

Water quality modelling

The programme will encourage a move to open-source modelling platforms that benefit individual model developers, while allowing effective interfacing with other modelling modules in a way that provides integrated, scientifically-defensible water quality information. Business models of such platforms must be as much in the interests of users of such information (e.g. catchment management agencies) as the service providers and modellers.

Impacts on and of water quality

This programme will focus on identifying, characterising, and understanding (i) the changes in the state of water quality in our water resources associated with either point or non-point pollution sources, and (ii) the associated impacts of such compromised water quality.

Future research

- The manual of guidelines on the management of endocrine-disrupting compounds (EDCs) in water resources
- A large scale study of the human-induced impacts on the microbial and physico-chemical quality of ground- and surface water in the North-West Province
- Assessment of the prevalence of human viral and bacterial pathogens in some rivers and dams in the Amathole District Municipality of the Eastern Cape Province
- Verification and validation of analytical methods for testing the levels of PPHCP (pharmaceutical and personal health care products) in treated drinking water and sewage

The above projects will contribute to the following Government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food
Output 3: Rural services and sustainable livelihoods

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

THRUST 4: WATER RESOURCE PROTECTION

A reliable supply of good quality water is required for the environmental, health, social and economic wellbeing of the country. The National Water Act of 1998 recognises that protection in relation to a water resource means: (i) maintenance of the quality of the water resource to the extent that the water resource may be used in an ecological sustainable way; (ii) prevention of the degradation of the water resource and (iii) the rehabilitation of the water resource. There are significant gaps in our knowledge on how to protect our water resources in an integrated manner. While Thrust 3 will look mainly at the quality of the water within our systems this thrust focuses on protecting the water resources, by reducing the quantity of harmful materials reaching the water resources, within a broader framework for all uses. Broadly, research in this thrust focuses on the generation of knowledge and understanding of the catchment processes and land use activities that influence the quality and quantity, negatively or positively, of the water resources. Scientific, technological and institutional approaches that will help to characterise and address these problems include: (i) assessment, monitoring and prediction; (ii) tools and control strategies; (iii) innovation to assist with prediction and control; and (iv) implementation and technology-transfer options.

Achievements: completed research

- Nitrate removal for groundwater supply to rural communities
- Field investigations to study the fate and transport of light non-aqueous phase liquids (LNAPLs) in groundwater
- Creating a map of stable isotopes in tap water across South Africa for hydrological, ecological and forensic applications
- Preliminary vadose zone classification methodology
- Updating and revision of current groundwater Reserve methodologies

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 9: A responsive, accountable, effective and efficient local government system

Output 2: Improving access to basic services
Output 6: Administrative and financial capability

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management

The following programmes are addressed:

Source water protection

Source water protection refers to protecting source water (water from dams, wetlands, rivers, aquifers, etc.) from contamination and overuse. Specific driving forces, or a combination thereof, which have an impact on water resources will be researched. Integrated protection strategies and approaches will be researched and tested. The development of source water planning, control and response strategies, to minimise adverse impacts on source waters by reducing pollution risks and securing water availability, is a key component of this programme. The source water protection approach will look at, among others, land use (see Programme 2 below), vulnerability assessments and catchment plans and strategies (for both surface and groundwater).

Land-water linkages

This programme will enhance our knowledge on the interaction of water and land at various scales. This programme will focus on the driving forces (new developments, emergency spills, erosion, leaks, soil enhancements, etc.) that can impact water resources from land-based activities. The programmes also aims to research, evaluate and develop common regulatory tools to overcome different technical and procedural approaches for water resources and land use management in order to enhance our water resource protection capabilities. Techniques to delineate, protect and remediate areas and/or the activities occurring within these areas will be researched. Research will also be bi-directional, where potential impacts on water resources from land-based activities or processes are investigated as well as the impact of water resources on land-based activities (e.g. floods and droughts).

Future research

- Towards a roadmap for a single water resource protection strategy
- Innovative approaches to identify pollution sources
- Rural water supply management and protection

The above projects will contribute to the following Government outcomes and outputs:

OUTCOME 9: A responsive, accountable, effective and efficient local government system

Output 2: Improving access to basic services
Output 6: Administrative and financial capability

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management

THRUST 5: WATER RESOURCES AND CLIMATE

Global environmental change, including climate change, has potential deleterious effects on systems, resources and society. These also superimpose on existing stressors such as unsustainable use of water, deteriorating water quality, land use and demographic changes in time and space. The resultant lack of access to water of acceptable quality is also likely to have undesirable impacts on economic growth, food security, health, ecosystem goods and services, as well as community livelihoods. South Africa is vulnerable to these effects. Adaptation that reduces this vulnerability is critical. Accordingly, this thrust focuses on developing understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales. Research will also include developing appropriate quantitative understanding, tools and strategies for managing the

impacts of climate variability and change as well as human interventions in the hydrological cycle and related water resources. These aim to support the development of policy responses, at regional, national or catchment scale, to existing and emerging problems. This includes, but is not limited to, the development of tools and systems (e.g. weather forecasts, model scenario projections or early preparedness). These should be for, among others, managing floods and droughts and the effects thereof on resources and the people who rely on those resources, with special emphasis on water quality (e.g. trophic waters) and quantity (due to increased evaporation rates and other factors) impacts.

Achievements: completed research

- Classification system for defining hydrological zones to provide more representative rainfall-runoff response in ungauged catchments
- Development of a practical methodology for assessing the potential impacts of climate change on the yield characteristics of reservoirs
- Endocrine disrupting chemical (EDC) activity and health effects of identified veterinary growth stimulants in surface and ground water.
- Potential climate change impacts on Karoo aquifers
- Soil moisture from satellites: daily rainfall maps over RSA, for flash flood forecasting, drought monitoring, catchment management and agriculture
- A methodology for near real-time estimation of evaporation
- Hydro-pedological interpretation of the soils of selected catchments with the aim of improving efficiency of hydrological models
- Multidisciplinary analysis of hydro-climatic variability at the catchment scale
- Secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change

The above projects contribute to the following government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food
Output 3: Rural services and sustainable livelihoods

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality

The following programmes are addressed:

Predictive tools

The need to prepare the country to cope with global climate change and regional climate variability is of paramount and strategic importance. With water such a key resource in South Africa, there is a need to adapt water resource management progressively as global climate change progresses, in order to maintain optimal levels of both resource protection and beneficial use of water for society. The development of coping strategies will require the development of informed, quantitative scenarios of potential impacts, at regional and catchment level, on rainfall regimes and rainfall variability, hydrological and geohydrological regimes, water availability and reliability, water quality, ecosystem structure and functions and ecological processes. This programme will therefore focus on

the following key issues: selection and use of Global Climate Model (GCM) generated scenarios of global climate change of an appropriate confidence level as a basis for development of model projections; improvement of techniques for downscaling of scenarios from global (GCMs) to regional and catchment scales to enable or support management at higher resolution and to ensure a high level of reliability and robustness; improvement of detection and attribution of anthropogenic impacts of climate change in the Southern African context in order to distinguish these from natural climate variability and change-related impacts. The programme will also deal with: the choice of relevant and appropriate climate indicators and variables as well as monitoring systems that need to be in place in this regard; use of existing conceptual and numerical models to utilise global change-related, downscaled, hydro-climatic information effectively, to provide information regarding likely inter-related land-use, ecosystem, hydrological (including geohydrological), water yield and water quality changes at regional/catchment level; modification of existing management strategies and tools for adaptation purposes; determining the likely socio-economic impacts for a given structure of society in Southern Africa; and appropriate technological, social and political coping strategies. Another area addresses improving understanding of and forecasting of the variability of rainfall, flow and groundwater recharge. The ability to forecast at very short time scales would greatly benefit flood management and disaster mitigation and adaptation activities. A final possible area looks at improving the understanding of global climate change impacts and vulnerability for the purposes of better informing the nation on permanent changes of the climate which require long-term solutions and adaptation actions.

- **Climate change risk, vulnerability and adaptation**

Climate change risk management seeks to promote sustainable development by reducing vulnerability associated with climate risks. The approach involves a range of actions including reduction of vulnerabilities or enhancement of resilience amongst people and societies, protection of ecosystem goods and services, early response systems, strategic diversification, and improved institutional capacities. Climate adaptation refers to the ability of the system to adjust to climate change, variability or extreme to moderate potential damage or to cope with the consequences. This programme is aimed at reducing vulnerabilities among communities and people through development or implementation of systems, tools, approaches and strategies (some of which may have been developed under Programme 1). Protection or restoration of ecosystem goods and services that are vulnerable to climate variability and change, as well as strengthening capacity of people and institutions, are some of the techniques that will be investigated under this programme. Climate risk management strategies to be developed under this programme also aim to maximise opportunities in climate-sensitive economic sectors even under uncertain climatic conditions of high variability. The programme could also deal with implementation of capacity building and awareness programmes including sharing of climate information as part of broader adaptation programmes.

- **Integrated flood and drought management**

Flooding and drought are major natural hazards to human society and have important influences on social and economic development. The most vulnerable communities are often those who are poorly resourced. They do not have the means to cope and also often live in informal settlements notorious for being drought or flood prone. This programme focuses on research that will result in the development and implementation of integrated institutional frameworks and technological tools to mitigate the effects of floods while maintaining or enhancing flooding patterns that are important to natural ecosystems. Research related to drought management will focus on integrated tools and strategies for early identification and mitigation of the social and economic impacts of drought, with the aim of supporting collaborative, multi-institutional processes and programmes. Hence the programme will also be aimed at determination of the frequency and magnitude of resultant extreme rainfall and flow events; and establishing weather and climate disaster mitigation programmes at various levels (i.e. at regional, national, provincial as well as other, more localised, scales).

Future research

- Impact-related coping strategies, such as early preparedness and early warning systems for extreme climatic events
- Adaptation and adaptability of responses to impacts due to, for example, climate change and water quality impacts on the ecosystem, institutions' and communities' adaptation actions, adaptation options to support water for growth and development, guidelines for vulnerability assessment and adaptation requirements for rural communities, and modelling rain-gauge network
  under changing climate scenarios
- Streamlining water in climate change: Development of Water Sector Climate Response Strategy
- Water-energy nexus in the context of climate change: investigating trade-offs between efficient water use and renewable energy
- Application of climate model projections at higher resolution (local) scales in support of policy practice
- Economics of climate change adaptation actions – quantitative estimation of costs of adaptation measures
- Upscale climate change adaptation to national or regional level including collaboration with relevant international organisations

The above projects can contribute to the following Government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food
Output 3: Rural services and sustainable livelihoods
Output 4: Actions supportive of the human settlement outcomes

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality

3.2 Water-Linked Ecosystems

3.2.1 Scope

Water-linked ecosystems are defined as instream (fully aquatic), riparian (dependent on water stored in the river banks and linked to the river) and water table-dependent (dependent on a water table, but not on surface water). This KSA focuses on the protection and sustainable utilisation of the aquatic environment and biota (instream, riparian and groundwater). This includes the research needs around the international conventions on environmental management (e.g. biodiversity) as well as human needs from the aquatic environment (e.g. sustainable management for equitable ecosystem resource utilisation, recreation and ecotourism). Research undertaken within this KSA will continue to address the conservation of aquatic ecosystems in order to provide the knowledge necessary for their sustainable management and functioning. This will be done in terms of the national and international commitments ensuring that there is ongoing protection of ecosystems and provision of goods and services which people rely on ecosystems to deliver. This research portfolio will contribute to the delivery of Government outcomes, putting more emphasis on the following outcomes:

- Environmental assets and natural resources that are well protected and continually enhanced (Outcome 10)
- Vibrant, equitable and sustainable rural communities and food security for all (Outcome 7)

Although special attention will be given to the Government outcomes, gradual changes in strategic direction are envisaged in the next five years to accommodate the changing needs of the country and society. The KSA has taken into consideration the research needs reflected in emerging long-term strategies, such as the National Development Plan of the National Planning Commission. The current research portfolios are structured in such a way that they address both current and future needs of our country and continent. To be more effective, the above will be achieved by expanding the scope of this portfolio, developing technologies and methodologies, adaptive management processes and capacity to protect the resource and to sustain the flow of goods and services in a time of both demographic and climatic change in the African context. Technologies and methodologies will be developed within this KSA to support the implementation of the national water policy to ensure protection and sustainable resource use and to enhance opportunities to deliver on Government outcomes. The KSA will work closely with KSA 5 to support the WRC's Water Knowledge and Capacity Advancement Programme (WaterKCAP) to empower historically-disadvantaged individuals (HDIs).

Some of the key issues that the KSA will pursue in the next strategic cycle (five years) include: (i) positioning healthy ecosystems on the sustainable development agenda of the country and the region; (ii) consideration of ecosystems as a resource and infrastructure for cities and in other developments; (iii) support for long-term monitoring of ecosystem health; (iv), advancing knowledge and tools on payment for ecosystem goods and services; (v) knowledge support for ecotourism and prevention of eco-terrorism. Research on climate change and sustainable development will also be pursued to develop appropriate mitigation and adaptive measures for the local water resources and communities depending on those resources. However, the research portfolio will continue to support all efforts that support the creation and implementation of knowledge to promote the sustainable use and management of aquatic ecosystems. This will involve looking for avenues to re-engineer the KSA's research portfolio so that it can accommodate the changing and expanding needs of communities, the country, region and continent.

In essence, the implementation plan of this research portfolio will be focused on the provision of knowledge to ensure the utilisation and sustainable management of water-linked ecosystems in a water-scarce country. To advance the objectives of this portfolio and of the WRC, the KSA will, among many others, facilitate the formation of the Society for Ecological Restoration & Rehabilitation of South Africa (SERRSA); host a conference session on Wetlands Governance and Legal Framework at the 9th Intecol International Wetlands Conference in Florida, USA, from 3 to 8 June 2012; organise national workshops on 'ecosystems and livelihoods', and a book, *Sustainable Use of South Africa's Inland Waters: A Situation Assessment of Resource Directed Measures 12 years after the 1998 National Water Act*, will be published and launched in April 2012.

3.2.2 Objectives

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

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

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

3.2.3 Thrusts and Programmes

The research portfolio presented here does not deviate materially from that presented in the 2011/12 Plan. As indicated above, the thrusts and programmes will be expanded in this strategic cycle, to accommodate changing needs of society. A general description of thrust and programme structure is presented below. New initiatives and current projects have been grouped into strategic thrusts and programmes which directly address the abovementioned objectives and are summarised as follows:

THRUST 1: ECOSYSTEM PROCESSES

This thrust includes research addressing the biophysical processes, form and function of ecosystems. The aim is to generate knowledge to inform policy and management.

Achievements: completed research

- Evapotranspiration from the Nkazana swamp forest and the Mfabeni Mire
- Establishing ranges of water quality variables in wetlands and their relationship to land use and ecosystem response: towards refining the ecological Reserve
- Deriving conservation targets for freshwater ecosystems

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

The following programmes are addressed:

- **Estuarine processes**
  Estuaries are fragile and highly productive ecosystems and are highly sought after as places to live. Projects in this programme address the ecological processes occurring in estuaries.

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

- **Wetland processes**
  Within this programme, research will be conducted to develop an understanding of the ecological processes and functioning of wetlands, and to assess their value to both the catchment and the people living adjacent to them.

- **Groundwater-dependent ecosystems:**
  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 the exploitation of the groundwater. Special attention will be given to the vulnerability of these systems.

- **Impoundments**
  Research within this programme covers ecological functions and processes within impoundments with a view to improving our ability to manage these.

Future research

- The resilience of South Africa's estuaries to future water resource development based on a provisional ecological classification of these systems;
- Biological temperature thresholds for the ecological reserve
- Ecosystem functioning, sustainable utilisation and management of aquatic resources of the Lower Phongolo River
- Connectivity through allochthony: Reciprocal links between adjacent aquatic and terrestrial ecosystems in South Africa
- Nile Crocodiles in north-eastern KwaZulu-Natal
- Identification of wetland processes impacting water resources at catchment scale
- Trajectories of change of wetlands in the Fynbos Biome: Part A. Habitat transformation, water quality and diatoms

The above projects can contribute to the following Government outcomes and outputs:

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

Output 4: Improved employment opportunities and promotion of economic livelihoods

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources

OUTPUT 3: Sustainable environmental management

Output 4: Protected biodiversity

THRUST 2: ECOSYSTEM MANAGEMENT AND UTILISATION

This thrust includes research which specifically addresses the management of ecosystems for sustainable utilisation. Central to this is the need to manage the social and economic requirements of society from ecosystems and the implementation of policy and legislation. Capacity will be built to implement the research findings.

Achievements: completed research

- Decision support system for IFR Review and update of resource directed measures (RDM) for estuaries
- Water temperatures and the ecological Reserve
- Environmental assessment in an area where ongoing DDT spraying occurs
- Extracting scientific evidence for the development of ecosystem service production functions for the Resource Directed Measures
- Identifying and enabling protection of national freshwater heritage ecosystems for South Africa

The above projects contribute to the following Government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

The following programmes are addressed:

- **Ecological Reserve**

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

- **Estuary management**

  Within this programme, research will be conducted to develop an understanding of the ecological processes within estuaries, and the effect of anthropogenic disturbance on these. This understanding is then conveyed to stakeholders (tiers of government, communities) as management guidelines to inform them on how to manage the sustainability of estuaries. This programme is managed in close association with Marine and Coastal Management, DEA.

- **Ecosystem health**

  The River Health Programme (RHP: custodians are DWA, WRC and DEA) aims to implement, nationally (at the level of provincial government), a coherent biomonitoring programme with well-defined indices. Much of the R&D is done within this programme. Additional issues on the management of river health, although they may not directly be part of the RHP, link closely with it and are, consequently, housed within the same programme. This programme links with the cross-cutting impact area Water and Society and includes the research being done on endocrine-disrupting contaminants (EDCs). Further enhancement of the programme is the initiative launched by the Deputy Minister of Water and Environmental Affairs focused on voluntary public participation in water resource management, called Adopt-a-River.

- **Environmental water quality**

  Within this programme, research will be conducted to develop bio-assays (both in the laboratory and in the field) which will be employed to protect people and the environment from the effects of poor water quality. This will develop methods and competence to enable the use of toxicology in effluent discharge licences as well as its use in environmental water quality as required in the ecological Reserve. This programme addresses the longer-term development and refinement of methods and the competence to use them, as well as the shorter-term competence required to implement policy in terms of the NWA. This programme links to the endocrine disrupter programme within the cross-cutting impact area Water and Society.

- **Endocrine-disrupting compounds (EDCs)**

  The overall objective is to characterise, and acquire information for assessing, the endocrine-disrupting effects of various chemicals and compounds in water (singly or in combination), both those occurring naturally and those resulting from pollution, and which have the potential to cause detrimental health effects in humans, animals and the aquatic environment, as a guide to developing and implementing cost-effective treatment and control strategies. Further emphasis will be placed on the development of simple, rapid and cost-effective detection techniques. This programme will be implemented in three phases, the first of which is already complete.

- **Socio-economic considerations**

  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.

- **Ecosystem governance**

  The overall objective of this programme is to develop an understanding of what is required for the successful governance of aquatic ecosystems and how to build the necessary capacity to implement this.

Future research

- Consolidation and optimisation of wetland health assessment methods through development of a Decision Support Tree (DST) that will provide guidelines
- Assessment of locally manufactured radio telemetry equipment for manual and remote behavioral monitoring of fish in lentic and lotic freshwater ecosystems in South Africa
- Critical analysis of water quality in South Africa: historic and current trends

The above projects can contribute to the following Government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

THRUST 3: ECOSYSTEM REHABILITATION

This thrust addresses the rehabilitation of aquatic environments (including both abiotic and biotic components) which have been degraded through anthropogenic activities, with the view to restoring process, form and function. This will be done in terms of both relevant international conventions and national legislation, and seeks to restore biodiversity where possible. This thrust includes research addressing the processes and functioning of ecosystems, dealing more specifically with the biophysical process and form of ecosystems as well as the rehabilitation of these ecosystems. Knowledge generated by research within this thrust will be used to increase the national capability to sustainably manage ecosystems and the impact of people on these. Efforts will be made to build capacity necessary to implement the research findings.

Achievements: completed projects

- Wetlands and livelihoods: Restoration of wetlands' ecological process, form and function to provide the ecosystem goods and services necessary to support livelihoods
- Conservation of tigerfish, *Hydrocynus vittatus*, in the Kruger National Park with the emphasis on the establishment of management plans for the protection of its riverine habitat

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management

The following programmes are addressed:

Wetland rehabilitation

Within this programme, research will be conducted to develop methods to rehabilitate wetlands, which will address both abiotic and biotic components, and seek to rehabilitate ecological processes and restore biodiversity as far as possible in degraded wetlands. This will be done in terms of both the international conventions to which South Africa is signatory as well as recent legislation from both DEA and DWA. The programme will also develop the competence to implement rehabilitation. Projects in this programme link closely with each other, and are managed as a unit.

River rehabilitation

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

Influence of instream-constructed barriers

This programme investigates ways to ameliorate the effects of barriers such as weirs and impoundments on natural river systems.

Future research

- The classification of endorheic wetlands (pans) and the effect of acid mine drainage on the hatching success of the egg banks of selected invertebrates communities within pans
- The effect of orthophosphate removal at two waste water treatment works on the uMdloti Estuary

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quality and quantity of water resources
Output 3: Sustainable environmental management
Output 4: Protected biodiversity

3.3 Water Use and Waste Management

3.3.1 Scope

This KSA focuses mainly on the domestic, industrial and mining water sectors. It aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for these sectors. This KSA also supports studies on institutional and management issues, with special emphasis on the efficient functioning of water service institutions and their viability. Research on infrastructure for both water supply and sanitation is included. A further focus is on water supply and treatment technology serving the domestic (urban, rural, large and small systems) as well as the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors, with the aim of improving productivity and supporting economic growth while simultaneously minimising the negative effects on human and environmental health.

This KSA continues to build on and strengthen the strategic direction implemented over the recent years, as well as with foresight orientating the portfolio to emerging and new issues.

The KSA's continuous activities are in alignment with the WRC strategy. The strategic context of the KSA and its activities respond to the WRC five-year strategy. Within this context the KSA will put greater emphasis over the next few years on the following concepts:

- **One Water** – this is based on a vision that there is no wastewater in the system and that all qualities of water are a resource for use.
- **Resource recovery** – this relates to the view that there are and will be no pollutants in the sources of water, only resources which can be recovered for beneficiation offering opportunities for direct reuse.
- **Energy resource** – the view is based on the role of water resource in the efficient use of energy, as well a net contributor of green energy.

During 2012/13 the portfolio will continue to build on the strategic changes from previous years, as well as strengthen the portfolio towards making greater impacts on the social and health aspects, environment and economy of the country. In summary, we do not foresee any major changes to the KSA strategy and portfolio of thrusts over the next few years.

3.3.2 Objectives

The primary objective of this KSA continues to be the provision of knowledge that ensures reliable, affordable and efficient water use and waste management services to enhance the quality of life, and contribute to economic growth and improved public health.

The secondary objectives are to:

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

3.3.3 Thrusts and Programmes

The research portfolio (including new initiatives and ongoing projects) has been grouped into six strategic thrusts and programmes which directly address the abovementioned objectives and are summarised as follows:

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

The efficient functioning of water service institutions and their viability is key to sustaining water services in rural and urban areas. The focus of this thrust is to address strategic research aspects related to policy issues, institutional reform, regulation, infrastructure management, water-related competencies and capacity required for the strengthening of water institutions (water service providers, water service authorities, water boards, national departments) in providing sustainable water services.

Achievements: completed research

- Asset management toolkit for municipalities and review of the state of asset management
- Investigating mechanisms and processes used in setting water services tariffs
- Regulation – towards standards for municipal water accounts
- Institutional options for water services delivery and O&M, examining centralisation versus decentralisation
- Community procurement in supporting services
- Measuring the impact of water and sanitation interventions
- Examining sanitation policy and implementation
- Impact of watsan services
- Assessing the effectiveness of handwashing

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 4: Maintenance and supply availability of our bulk water infrastructure

- Reduce unaccounted for water from approximately 30% of supply to 18%
- The establishment of the water economic regulator

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

Output 3: Rural services and sustainable livelihoods

- Scale up government services. The proportion of households with clean water rises from 74% to 90%. The proportion of households with access to improved sanitation rises from 45% to 65%.

OUTCOME 9: A responsible, efficient and effective local government

Output 2: Improve access to basic services

Output 6: Improve municipal financial and administrative capability

- Reduced municipal debt
- Reduced municipal overspending on operational expenditure (OPEX)
- Reduced municipal under spending on capital expenditure (CAPEX)
- Increased municipal spending on repairs and maintenance

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water

The following programmes are addressed:

- **Pricing and financing water services**
  The issue of pricing and financing of new, and rehabilitation of old, water infrastructure is becoming a huge problem affecting the sustainability of water services. As the gap between the infrastructure requirements and what the State can support continues to increase, radical solutions are required which take into consideration tariffs, subsidies, pricing and cost recovery. This programme intends to develop innovative solutions and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.

- **Institutional and management issues – water services**
  Relationships and partnerships between service providers, both external and internal, are a key to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.

- **Innovative management arrangements – rural water supply**
  The focus of research within this programme is to provide support to water service institutions with special reference to sustainable cost-recovery and implementation of the free basic water policy; key performance indicators for monitoring and evaluation of service delivery; guidelines for sound management of water service institutions and development of effective strategies for promoting an integrated approach to rural development.

- **Regulation of water services**
  Regulation of water services is important for the sector to achieve improved functioning and performance of the delivery of water and sanitation services, to the benefit of the population. Further, it ensures greater efficiency and improved management of the infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.

- **Water services education and awareness**
  A fully informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services.

Future research
- Institutional options for water services O&M
- Asset management
- Regulating public water services institutions
- Climate change and its impact on water services in South Africa
- Valuing water in the water services sector
- Water security and water services
- Benchmarking of water services
- Financing water services infrastructure

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 4: Maintenance and supply availability of our bulk water infrastructure
- Reduce unaccounted for water from approximately 30% of supply to 18%
- The establishment of the water economic regulator

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

Output 3: Rural services and sustainable livelihoods
- Scale up government services. The proportion of households with clean water rises from 74% to 90%. The proportion of households with access to improved sanitation rises from 45% to 65%.

OUTCOME 9: A responsible, efficient and effective local government

Output 2: Improve access to basic services
Output 6: Improve municipal financial and administrative capability
- Reduced municipal debt
- Reduced municipal overspending on operational expenditure (OPEX)
- Reduced municipal under spending on capital expenditure (CAPEX)
- Increased municipal spending on repairs and maintenance

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

The provision and supply of affordable and reliable water of quality and quantity for drinking (domestic) and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. The objective of this thrust is to develop innovative technologies and processes that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

Achievements: completed research

- Capacity of mobile, small-scale purification plants
- Determining apparent losses
- Determining non-revenue water
- Water safety plans for small systems
- Scoping studies on energy efficiency
- Wave-powered drinking water treatment
- Standards of water treatment chemicals
- Electronic water quality management system
- Energy generation from pressurized conduits

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 4: Maintenance and supply availability of our bulk water infrastructure

- Reduce unaccounted for water from approximately 30% of supply to 18%

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

Output 2: Improve access to basic services

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

New initiatives and current projects have been grouped into programmes which directly address the abovementioned objectives and are summarised as follows:

- **Drinking water treatment technology**
  The programme aims to acquire adequate understanding of potable water treatment processes and related activities and to be able to assist in treating our scarce water resources in the most efficient and cost-effective way to an acceptable quality for potable and industrial use. Expected outcomes include improved and more cost-efficient process technologies, increased operational efficiency of treatment plants and an improved manpower training level and knowledge base.

- **Water treatment for rural communities**
  This programme aims to provide, through research products, adequate quantities and quality of water to rural communities on a sustainable basis. Expected outcomes required to achieve sustainable water services include community involvement, cost-recovery, effective operation and maintenance, affordability and willingness to pay for water services.

- **Drinking water quality**
  The programme aims to protect human health by ensuring that water supplies are of acceptable quality and standards. Outcomes include improved analytical methodologies, treatment technologies and hygiene practices.

Water distribution and distribution systems

The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated, potable water to the end-users thereof. The programme has the following expected outcomes: to develop reliable processes for predicting and improving the operational efficiencies in distribution systems, with the purpose of reducing both capital and operational costs; to ensure that the quality and quantity of water is maintained in the distribution system – from the water treatment plant to the furthest end user; and to develop innovative methods, tools and processes that will improve system integrity and reliability.

Future research

- Solving the problems with membrane processes: brine disposal, membrane lifespan
- New sources of water: seawater, recycled water, water conservation
- Blue Drops for all: service delivery in small- and medium-sized communities
- New technologies for new pollutants: what can nanomaterials do to emerging contaminants?
- Minimising the carbon and energy footprint of water suppliers
- Microhydropower, energy efficiency, local synergies
- 100% water recycling
- Non-piped water supplies to reduce the number of people without a supply to zero: leapfrog technologies, e.g., self-treating rainwater tanks
- Closing the loop

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 6: An efficient, competitive and responsive economic infrastructure network

Output 4: Maintenance and supply availability of our bulk water infrastructure

- Reduce unaccounted for water from approximately 30% of supply to 18%

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

Output 2: Improve access to basic services

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

This thrust focuses on the development of technologies and systems that optimise the full wastewater and sanitation services chain in the municipal (domestic) sector. This includes the reticulation, treatment and management of the residues. The challenge is to implement fitting solutions for a particular application that will remain functional throughout the intended lifespan of the installed infrastructure. This includes the responsible management of the wastewater sludge and faecal sludge that is generated. The need for innovative technologies and solutions is recognised as we prepare for the future – achieving more stringent effluent discharge standards,

developing acceptable non-waterborne sewerage solutions, reliable treatment of ever-increasing high-strength domestic wastewater, and informing future policy.

Achievements: completed research

- Sewer planning made simple – tools and a poster for rural and small municipalities
- First plant-wide model for wastewater treatment plants (inclusive of anaerobic digestion) which will feed into IWA specialist groups
- Development of wastewater treatment technology posters for dissemination by SALGA to local municipalities
- Infrastructure refurbishment costing case studies in partnership with SALGA and WIN-SA
- O&M and IAM case studies in partnership with DWA, DBSA, Northern Cape and WIN-SA
- Completion of the piloting of the Technical Assistance Centre for Small Wastewater Treatment Works in EC and WC
- Msunduzi stormwater ingress case study showing clear correlation between illegal sewer connections and WWTW inflows during rain events supporting the need to re-institute inspections

The above projects contribute to the following Government outcomes and outputs:

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

Output 3: Rural services and sustainable livelihoods

- Scale up government services. The proportion of households with clean water rises from 74% to 90%. The proportion of households with access to improved sanitation rises from 45% to 65%.

OUTCOME 9: A responsible, efficient and effective local government

Output 2: Improve access to basic services

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

The following programmes are addressed:

- **Emerging treatment technologies: Preparing for the future**

  It is imperative to develop technologies which can achieve future policy objectives and stricter standards. It is also recognised that research generates information which could inform future policy. This programme encourages the development of technologies to address the future anticipated municipal waterborne sewage and sanitation needs as well as support Government by informing future policy. It supports development of technological solutions addressing, amongst others: reuse, recovery, non-waterborne sewerage solutions, grey-water management, peri-urban sanitation solutions, high-strength effluent treatment, industrial and domestic effluent co-treatment, etc. It also supports research aimed at informing future policy through

data interpretation, projections, risk assessments, addressing emerging pollutants, predictive models, etc.

- **Application of appropriate technologies and tools**
  This programme addresses the improvement and innovative application of existing 'fit for purpose' technology for waterborne sewage treatment and on-site sanitation. The objective is to optimise appropriate applications to consistently achieve strict standards, with added benefits such as cost saving, ensuring ease of operation and maintenance, and improving reliability and energy efficiency. The integration of social and local economic development objectives is encouraged. The programme further focuses on the technical sustainability of wastewater treatment and sanitation services by critically appraising existing policy (including effluent discharge standards) and impacts.

- **Stormwater and sewerage systems**
  The programme supports the strategic and technical aspects of managing stormwater and sewerage and impacts in urban, peri-urban and rural contexts. The development of generic stormwater and sewerage planning and technology selection, design and maintenance tools is encouraged to address current needs. In order to address anticipated needs, the programme supports research focusing on improved technology, including water-sensitive urban design (WSUD) and stormwater reuse. It will cover aspects of technical design, operational, maintenance, refurbishment and management aspects of stormwater and sewerage reticulation systems, to provide sustainable infrastructure in the extended delivery of sanitation services as a national priority.

- **Wastewater sludge and faecal sludge management**
  All wastewater treatment and on-site sanitation facilities generate a solid/sludge that needs to be managed responsibly. This programme focuses on research dedicated to improve wastewater sludge and faecal sludge management practices. Research on characterisation, emerging technologies and solutions, anaerobic processes for stabilisation, minimisation, dewatering, disinfection and beneficiation is encouraged.

- **Sanitation technology and innovations**
  The upscaling of sanitation to low-income and dense settlements is resulting in a number of technical and operational challenges. Current technologies and solutions are proving to be inadequate and new solutions are required. The programme will focus on the development of innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.

Future research

- Wastewater as a resource (building blocks to urban ecology)
- Nanotechnology-linked solutions for emerging pollutants: membranes and biosensors, EDCs
- Stimulating design innovation through the use of wetland knowledge and the biomimicry design philosophy
- Advancing pond performance by inclusion of duckweed- and algal-based systems
- Application of plant-wide models (IWA) linked to capacity building
- Provision of guidelines for the use of alternative sewerage options for different environments (informal)
- Guidelines for stormwater management using water-sensitive urban drainage principles for the design of new towns and cities to lessen pollution to rivers and supplement adaptation options
- New sanitation technologies for informal areas and low income settlements

The above projects can contribute to the following Government outcomes and outputs:

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

Output 3: Rural services and sustainable livelihoods

- Scale up government services. The proportion of households with clean water rises from 74% to 90%. The proportion of households with access to improved sanitation rises from 45% to 65%.

OUTCOME 9: A responsible, efficient and effective local government

Output 2: Improve access to basic services

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL-WATER MANAGEMENT

Water is a strategic issue to the industrial sector. While the water usage by the industrial sectors is not as great as, e.g., agriculture or domestic consumption, the impacts of the pollutants in industrial wastes and effluents on health and the environment can be significant, costly and long-lasting. The aim of this thrust is to quantify water use and waste production, predict impacts (risks) over the short-, medium- and long-term, and develop and apply methods of prevention, minimisation, reuse, recycling, recovery and beneficiation. This thrust also aims to provide appropriate, innovative and integrated solutions for water efficiency and waste management for industries. In addition, Thrust 4 establishes the governance, policy and regulatory environment that currently exists and the enabling environment that will be required to change behaviours to conserve water, grow the economy, protect society and the environment.

Achievements: completed research

- Nano-beads for remediation
- Development of an analytical sensor for detecting heavy metals
- Development of technical guidelines for determination of municipal effluent charges in support of the impending Waste Discharge Charge System (WDCS)
- Demonstrating of the pilot application of a dual-stage membrane bioreactor for pulp and paper and the textile industry wastewater
- Water efficiency and cost savings through the use of a developed zero-effluent mathematical model for the pharmaceutical industry in South Africa

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water
- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

The following programmes are addressed:

- **Emerging challenges and solutions for the 21st century**

  This programme seeks to look at major challenges that may face South Africa in the future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable future industrial complexes and their water management will allow for better planning and regulation of new industries, allowing for improved adoption of integrated resource management systems, processes and tools.

- **Integrated management**

  This programme focuses on integrated and innovative management arrangements, e.g., public-private partnerships (PPP) to support industry and government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries, to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.

- **Quantification, prediction and minimisation of water use and waste production**

  In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.

- **Governance, policy, regulatory, and economic instruments to improve industrial water management**

  The regulatory authorities are responsible for authorising and regulating the impact of industrial waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used almost exclusively to manage water quality. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new approaches are believed to be more cost-effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective, in order to improve, review and enable implementation.

- **Water efficiency, cleaner production, beneficiation and treatment of industrial effluents**

  This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will, for the foreseeable future, remain an expected consequence of industrial activities; thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycling, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary-economy opportunities within South Africa.

Future research

- Adapting water and carbon footprints in South African water industry in a water sensitive catchment – link to the GWRC and WRC collaboration
- Supporting regulation – development of a protocol for the quantitative assessment of industrial effluents for discharge permitting by municipalities
- Full-scale application of co-digestion of industrial effluent for biogas and wastewater reuse purposes
- Beneficiation of agri-industry effluents
- Hybrid membrane system for product recovery in the olive oil industry
- Valuing water for South African industries
- Industrial brine minimisation energy efficiency – evaluation of forward osmosis technology for industrial effluents
- Water reuse (on-site and non-potable)
- A tuneable immobilised lignocellulosic enzyme (TILE) system for treating industrial wastes
- Recovery and beneficiation of nutrients and reuse of water from brewery effluent through the use of integrated algal ponds, constructed wetlands and aquaculture

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water
- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

This thrust also supports local government effectiveness by developing protocols for the evaluation of industrial wastewaters for discharge permitting and technical guidelines for the determination of municipal effluent charges to encourage industries to switch to cleaner production approaches rather than end-of-pipe.

THRUST 5: MINE WATER MANAGEMENT AND TREATMENT

The usage of water in mining and mineral processing/refining produces high volumes of solid wastes and liquid effluents. Some mining activities generate acid mine drainage (AMD). This thrust aims to provide appropriate, innovative and integrated solutions to water use and waste management in the mining sector. Future operations will almost exclusively take place in water-scarce regions (e.g. Waterberg, Eastern Limb) and their development will require reallocation of already stretched resources through, e.g., improved water demand and water conservation management. Additional priorities will include brine handling, biological sulphur compound transformation and aversion of future impacts.

Achievements: completed research

- Minimising AMD through management of rocks and tailings – Nona beads
- Membranes to treat wastewaters from mining
- Cleaner production guidelines specifically for the mining industry
- New method to remove salts from a mixed solution one at a time (eutectic freeze).
- Pilot plant application of novel process (ambient temperature ferrite process) for treatment of AMD

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water
- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

New initiatives, including current projects, have been grouped into programmes which directly address the abovementioned focus areas and are summarised as follows:

- **Water use and waste production**
  This programme focuses on investigations into quantification of water used and waste currently produced by the sector, and into predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.

- **Regulatory, management and institutional arrangements**
  The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: policy development falls under KSA1.)

- **Minimising waste production**
  This programme focuses on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, or life-cycle analysis, or through applying other risk assessment methodologies. The programme incorporates novel mining methods and AMD prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.

- **Mining in the 21st century**
  The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, new waste treatment methods, etc. (especially innovative ideas and piloting/scale-up).

- **Low-volume mined products**
  Much research attention has been paid to coal and gold mining; however, other quarried or mined products, such as radionuclides and platinum group metals, also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.

Future research

- Solution for water in mining and mineral processing/refining producing high volumes of solid wastes and liquid effluents
- Strategies for the management and treatment of acid mine drainage (AMD), neutral or saline mine drainage, all of which present environmental challenges
- Innovative and integrated solutions to water use and waste management in the mining sector
- Focus on water-scarce regions (e.g. Waterberg, Eastern Limb) and their development
- Solution for brine handling, biological sulphur compound transformation and aversion of future impacts

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected

Output 1: Enhanced quality and quantity of water resources

- Reduction of water loss from distribution networks from current levels of approximately 30% to 18% by 2014 coupled with encouraging users to save water
- To improve current capacity to treat wastewater, 80% of sewage and wastewater treatment plants should be upgraded by 2015 and the percentage of wastewater treatment plants meeting water quality standards should be increased from 40% to 80% by 2014

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

- To begin reducing South Africa's footprint with regard to greenhouse gas emission, the percentage of power generation from renewable sources should increase from 2 000 GW/hours to 10 000 GW/hours by 2014

THRUST 6: WATERSMART FUND

Drinking water and commercial activities have a high cost and assurance attached to them, as well as growing competitive demands. The wise and efficient use of this water has a profound impact on our water environment, resources and investments. Thus, this fund will support research, demonstration and development of any innovative idea, technology or process which supports the efficient use, reuse and conservation of our precious water and also improves the related energy-efficiency in the domestic, industrial and mining sectors. Current innovations under the WaterSmart Fund include a low-flush latrine for public schools, a water bottle for use during emergency conditions, and a ceramic home water filtration systems, among others.

3.4 Water Utilisation in Agriculture

3.4.1 Scope

The strategic focus in this KSA, as described in previous years, is on increasing the efficient use of water for the production of food, forage, fibre and fuel crops; ensuring sustainable water resource use; reducing poverty and increasing the wealth of people dependent on water-based agriculture. The needs and requirements of present and future generations of subsistence, emergent and commercial farmers is being addressed through the creation and application of water-efficient production technologies, models and information systems within the following inter-related sub-sectors of agriculture, namely:

- Irrigated agriculture
- Dry-land agriculture
- Woodlands and forestry
- Grasslands and livestock watering
- Aquaculture and fisheries

The challenge for applied research and knowledge dissemination is to exploit opportunities and to provide solutions to practical problems which are experienced in the process of utilisation, development and protection of water resources, thereby contributing to productivity growth in agriculture.

3.4.2 Objectives

The primary objective is to increase household food security and to improve the livelihoods of people at farming, community and regional levels through efficient and sustainable utilisation and development of water resources in agriculture.

The secondary objectives are to:

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

3.4.3 Support to cornerstones of the 2012-2015 Strategic Plan for the Water Research Commission

The research output of this KSA directly addresses South Africa's main water challenges: The focus is on increasing the productivity of water use in agriculture by quantifying the beneficial and non-beneficial water use for different land use classes and thereby progressively increasing water availability. The capabilities for agricultural water management are improved by providing knowledge and technologies which empower farmers to take correct decisions and actions to improve household food security and rural livelihoods. With investment in research projects, existing and new research capacity is strengthened by involvement of new and young researchers and broadening representativeness of female and black researchers. At the same time, efforts are made to expand research partnerships with universities and available research capacity at science councils and private organisations. Research projects are directed and managed within the innovation process, thereby ensuring that new knowledge is created and technologies are developed through high-quality scientific research that is applicable and socially beneficial. In this process inputs are made to better inform private and public policy-making. The research products supplied and services rendered therefore contribute to finding sustainable solutions and supporting dynamic economic development.

3.4.4 Thrusts and Programmes

THRUST 1: WATER UTILISATION FOR FOOD AND FIBRE PRODUCTION

The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of field, horticultural and industrial crops.

Achievements: completed research

- Generally applicable methods to estimate water use of crops
- Technologies for efficient irrigation scheduling
- Scoping study on water use of bio-fuel crops/trees
- Use of grey-water for food production in peri-urban areas
- Groundwater quality risk assessment for livestock watering and human use in rural areas
- Guidelines for management of water quality in farm irrigation dams for aquaculture
- Approaches and guidelines for improved irrigation water use efficiency
- Guidelines for ryegrass pasture irrigation management

The above projects contribute to the following Government outcomes and outputs:

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

Output 1: Sustainable agrarian reform – Reduced water demand from irrigation and agriculture's use of water

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quantity and quality of water resources – Reduction of water losses from distribution networks and conservation of groundwater resources

The following programmes are addressed:

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

  Water productivity can be increased by producing more with the same quantity of water or by producing the same quantity with less water usage. This requires an understanding of water dynamics in the soil-water-plant-atmosphere continuum, the equipment which is used and the method of production which is followed. Research on all these aspects can contribute to higher water use efficiency in agriculture.

- **Fitness-for-use of water for crop production, livestock watering and aquaculture**

  Various processes and factors, which are site-specific, have an influence on the quality of water for crop, livestock and fish production. Significant shortcomings exist in the assessment of the fitness-for-use of water sources and identifying water-related production problems. The emphasis in this programme is on the efficient use of water and management of water quality for the irrigation of crops, livestock watering and aquaculture in rivers, ponds and dams.

Future research

- Water use quantification with remote sensing
- Water use of indigenous food crops and bio-fuel crops
- Water use of pasture crops and livestock management systems
- Water use and nutritional productivity of food crops
- Water quality and water treatment options for microbiological food safety
- Water footprint of selected vegetable and fruit crops

The above projects can contribute to the following Government outcomes and outputs:

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

Output 2: Improved access to affordable and diverse food – The percentage of the total population that experience hunger and the rate of under-nutrition of children falls

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quantity and quality of water resources – Improved current capacity to treat wastewater

THRUST 2: WATER UTILISATION FOR FUEL-WOOD AND TIMBER PRODUCTION

The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the processes of production of trees in woodlands, plantation forestry and trees planted in combination with food and forage crops.

Achievements: completed projects
- Water use of staple food crops and trees for fuel-wood in agro-forestry systems
- Water use of selected indigenous trees

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 3: Sustainable environmental management – The percentage of net deforestation is to be maintained with protection of indigenous forest assets.

The following programmes are addressed:

- **Water-efficient production methods and systems in agro-forestry, woodlands and forestry plantations**

  In catchment areas where trees are a prominent feature of land use, runoff and deep percolation of water can be reduced. Management of these so-called streamflow-reduction activities necessitates an understanding of the water use by trees and the competitive or complementary relationship between water use by trees and water use by staple food and forage crops. Due to research specialisation, separate attention is given in this programme to increase the efficiency of water use by trees in woodlands and plantations for fuel-wood and timber production.

Future research
- Water use, biomass production and economic value of indigenous trees in natural and plantation conditions
- Water use, restoration of degraded lands and replacement of alien invasive plants with re-establishment of indigenous trees

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 3: Sustainable environmental management – The percentage of land affected by soil degradation decreases and the percentage of deforestation is to be maintained with protection of indigenous forest assets

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

The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the management processes undertaken by people who are using water.

Achievements: completed projects

- Techniques and practices for rainwater harvesting and conservation (RWH&C) in homestead food gardens
- Nutritional value and water use of indigenous crops for rural food security
- Approaches and guidelines for revitalisation of smallholder irrigation schemes
- Good practices and training material for rainwater and irrigation water management by small-scale farmers
- Revitalisation of hatcheries and manual for profitable rural freshwater aquaculture
- Soil-water management programme for rain-fed farming
- Development of models and technology transfer for efficient irrigation water management at field and farm level
- Implementation of water management systems for reducing water losses at irrigation scheme and river catchment scale

The above projects contribute to the following Government outcomes and outputs:

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

Output 1: Sustainable agrarian reform – Reduced water demand from irrigation and agriculture's use of water

Output 2: Improved access to affordable and diverse food – The percentage of the total population that experience hunger and the rate of under-nutrition of children falls and poor households are enabled to produce some of their food and improve income

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quantity and quality of water resources – Reduction of water losses from distribution networks

The following programmes are addressed:

- **Sustainable water-based agricultural activities in rural communities**

Poverty, hunger and malnutrition amongst rural people are widely recognised as major problems. These members of rural communities, consisting mainly of women, children and the elderly, are also disadvantaged or marginalised for various social, economic and political reasons. A comprehensive programme is required to support the sustainable development of rangeland, livestock, rain-fed and irrigated crop production. Efficient use of water through a combination of

agricultural activities can contribute to improving living conditions. Empowerment of rural people can further be promoted through participatory action research which improves knowledge, farming skills and leadership capabilities.

- **Integrated water management for profitable farming systems**

Commercial farming is a major user of water resources and faces a particular challenge to ensure that this share of water is used effectively and efficiently. There is invariably a close link between efficient use and allocation of water and whole-farming profitability. Water management on farms is also time-dependent and based on incomplete knowledge of changes in the weather, prices and technology. Under these circumstances modelling is a powerful tool to provide decision-support and management advice. The focus in this programme is therefore on developing procedures, methods and models to provide advice to farmers on best management practices and the optimal combination of crop and livestock enterprises within the constraints of water, land and capital resources.

Future research

- Water use security and skills development for empowerment of women and rural poverty reduction
- Water storage assessment for inland freshwater fisheries and livelihood alternatives
- Food value chain analysis in rain-fed and irrigated agriculture for mainstreaming of emerging farmers
- Up-scaling of rainwater harvesting to communal croplands and livestock water use productivity
- Optimisation of water use and entrepreneurial development paths for rain-fed and irrigated smallholder farming
- Impact of electricity cost increases on sustainable irrigation water use
- Knowledge transfer for training of water use in homestead gardening and cropland rainwater harvesting

The above projects can contribute to the following Government outcomes and outputs:

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

Output 1: Sustainable agrarian reform – Reduced water demand from irrigation and agriculture's use of water

Output 2: Improved access to affordable and diverse food – The percentage of the total population that experience hunger and the rate of under-nutrition of children falls and poor households are enabled to produce some of their food and improve income

Output 4: Improved employment opportunities and economic livelihoods – Rising percentage of small-scale farmers producing for market sales and increased jobs in agro-processing

Output 5: Enabling institutional environment for sustainable and inclusive growth – Small-scale farmers are organised to give collective power in negotiating for inputs and marketing

THRUST 4: RESOURCE PROTECTION AND RECLAMATION IN AGRICULTURE

The direction and driving force for research activities and outputs are determined by the strategic focus to improve the knowledge of the natural processes and man-induced impacts of resource use.

Achievements: completed research

- Impact of salinity on crop production and on sustainability at farming, irrigation scheme and regional economy level
- Knowledge review and modelling for effective management of non-point source pollution
- Measuring and modelling sediment in forestry and mixed farming systems

The above projects contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quantity and quality of water resources
Output 3: Sustainable environmental management

The following programmes are addressed:

- **Sustainable water resource use on irrigation schemes and within river catchments**
  With cultivation and irrigation, larger quantities of salts present in the soil and lower strata could be mobilised. Increasing salinity levels and higher water tables threaten the sustainable use of soil and water. Knowledge and tools to manage the quantity and quality of water resources for agricultural production are therefore required. The focus of research is on developing methods and models to manage water distribution and to prevent water resource degradation.

- **Impact assessment and environmental management of agricultural production**
  Agricultural decisions, to use land and to conserve rainfall, or to withdraw water from rivers, dams and boreholes, have wide-ranging impacts on the natural environment. Intensification of crop and livestock production processes can potentially contribute to higher levels of chemical residues of fertilisers, pesticides and herbicides in surface water and groundwater. Precautions must be taken as part of the agricultural production process to protect the terrestrial and aquatic ecosystems. This requires an understanding of the negative impacts of agriculture and guidelines for an assessment and mitigation of those impacts.

Future research

- Guidelines with GIS monitoring of salinisation and standards for drainage of irrigated land
- Impact assessment of pollution by agricultural chemicals
- Vulnerability assessments and adaptation to climate change
- Crop and grassland systems for generation of renewable energy with bio-gas
- Drought impact assessment and vulnerability analysis of crop and livestock farming

The above projects can contribute to the following Government outcomes and outputs:

OUTCOME 10: Environmental assets and natural resources that are well protected and continually enhanced

Output 1: Enhanced quantity and quality of water resources
Output 2: Reduced greenhouse gas emissions, climate change impacts and improved air/atmospheric quality – Better cope with the unpredictable and severe impacts of climate change, with development of adaptation plans for key sectors of the economy including agriculture, water and forestry
Output 3: Sustainable environmental management

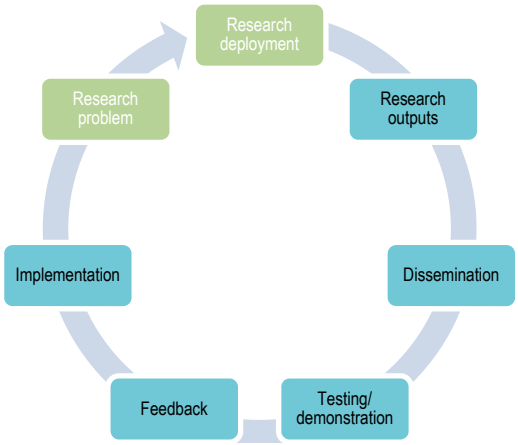
3.4.5 Strategic framework set by the 2011 National Planning Report and Vision for 2030

The National Planning Commission released the National Development Plan and Vision for 2030 on 11 November 2011. The most relevant sections which will direct the research and development (R&D) strategy of the Key Strategic Area (KSA) on Water Utilisation in Agriculture are **first**, 'Key drivers for change' of science and technology; **second**, '"Economy and employment' in relation to the National System of Innovation and Learning that permeates society and business; **third**, 'Economic infrastructure', in particular, water resources and services; **fourth**, 'Inclusive rural economy', regarding trade-offs and risks for agricultural expansion; and **fifth** 'Improving education, innovation and training', with a focus on achieving the vision for 2030. More details are provided in the R&D Strategy of this KSA in Appendix 1.

3.5 Knowledge Management

3.5.1 Scope

The role of Key Strategic Area 5 (KSA 5): **Knowledge Management** is to support and continue the knowledge cycle. The WRC research portfolio addresses the full water cycle through the four research key strategic areas and links this to the knowledge cycle with the support from KSA 5 (as shown in the light blue text boxes in the figure below).



This KSA supports the achievement of the organisational vision 'The WRC strives to be South Africa's premier water knowledge resource'. This KSA supports the following key elements of the five-year Strategic Plan:

- New partnerships
- improved political profile
- water technologies development
- stronger research and human capital development profile
- budget and resource expansion
- international leadership

KSA 5 also addresses the management of water-centred knowledge (created via the support of the WRC as well as other sources) and leads the effective dissemination thereof.

The scope of this KSA includes:

- Facilitating and where appropriate formalising new partnerships
- Supporting the continuous improvement of the political profile of the WRC by enhancing the credibility and relevance of the WRC through strategic positioning and strengthening stakeholder relations
- **Leading the up-scaling and demonstration of water technologies in partnership with the research KSAs and strategic partners**
- Providing the instruments to track, measure and report on the impact of the WRC in research and human capital development
- Providing support and in some cases leading initiatives aimed at increasing budget and resources
- Coordinating local and international dialogues led by the WRC
- Supporting knowledge creation by providing appropriate research management tools and logistic support
- Sharing and disseminating water-centred knowledge internally and externally
- Providing strategic research advice

The overall scope and objectives are further expanded in a number of thrusts.

3.5.2 Thrusts

THRUST 1: RESEARCH – WATER-CENTRED KNOWLEDGE

The aim of this thrust is to provide strategic research advice related to the water sector, R&D capacity, knowledge flow and ultimate impact. This KSA focuses on researching various elements, drivers and trends affecting the dynamics of the water-centred knowledge cycle, from issues related to research capacity and overall funding of research by the sector to the effectiveness of research and its impact on policy and technology used by the sector. The aim for this financial year is to develop the research portfolio, securing resources and to develop the first of a series of 'State of Water Research and Development' reports.

THRUST 2: TECHNOLOGY TRANSFER AND IP MANAGEMENT

The aim of this thrust is to demonstrate technologies and solutions through scale-up and demonstration facilities and to manage the intellectual property effectively according to the legislative framework and the WRC IP Policy. This is a new thrust in the WRC. The focus in the next financial year will be on establishing the feasibility and mobilising the sector and strategic partners to become involved in two initiatives, i.e. the establishment of a national water technology convergence centre as well as the establishment of a living laboratory including a model catchment, incorporating a local municipality, in which the WRC studies the 'Knowledge/practice interface'. The aim of this programme will be to actively embed WRC solutions in the sector and obtain the required feedback from the sector.

THRUST 3: STRATEGIC POSITIONING AND PARTNERSHIPS

The aim of this thrust is to enhance the credibility and relevance of the WRC locally and globally by coordinating strategic local, continental and international partnerships and to facilitate dialogues that position the WRC as a significant international player and a recognised asset to South Africa. This new thrust has been created to coordinate the national, continental and global initiatives and formalise strategic partnerships. It will provide the golden thread for key selected dialogues and partnerships in which the WRC wants to play a major leading role. Initiatives that will be begin in the 2012/13 financial year include global dialogues on selected topics such as adaptation to climate

change, and the establishment of a Water Knowledge and Capacity Advancement Programme (WaterKCAP) in partnership with the DWA. The KSA will also initiate the WRC Water Dialogue Series to enhance the profile of the WRC.

THRUST 4: PUBLIC RELATIONS AND COMMUNICATIONS

The aims of this Thrust are: (1) to effectively share and disseminate relevant knowledge in the water sector and within the WRC and to develop knowledge-sharing mechanisms/instruments to support the objectives of the WRC, (2) to build and maintain relationships with stakeholders and, (3) to market the WRC effectively. In the 2012/13 financial year, the KSA will revisit the communication strategy to align the activities with the WRC five-year plan and develop a media and marketing strategy. The KSA will also establish the feasibility of a Knowledge Commerce Centre with or without a Water Science Centre.

THRUST 5: BUSINESS SYSTEMS MANAGEMENT

The aim of this thrust is to coordinate the research funding cycle and provide effective tools, systems and procedures to support the core business of the WRC. The tracking of publications and degrees emanating from WRC-funded research, as well as enhancing the FMS to provide better management reports and allow the harvesting of metadata, will receive priority in 2012/13. This will provide the data required to report on the WRC's progress on the strategic objective to enhance the WRC's Research and Human Capital Development Profile.

THRUST 6: PRODUCTION AND KNOWLEDGE PACKAGING

The aim of this thrust is to provide an effective printing and distribution service for the WRC and to package water-centred knowledge for different users. Through this thrust, KSA 5 will continue coordinating the printing and distribution of the WRC knowledge products (WRC-funded research reports, technology transfer reports, *The Water Wheel*, *Water SA*, brochures and briefs). This thrust also includes the management of the report distribution facilities (manual and electronic). Additional activities in this thrust include the implementation of Phase II of the WRC Electronic Water Knowledge Hub.

4. FIVE-YEAR BUDGET PLAN

4.1 Financial Indicators and the Five-Year Plan

The WRC has developed a five-year budget plan (Table 1) that supports the translation of its Strategic Plan into operational actions. The plan is directly linked to the WRC budget submission (September 2011) which was approved by the Minister of Water and Environmental Affairs. This plan is guided by the organisation's strategic targets and follows a number of key financial ratios (Table 2). Table 1 presents income and expenditure trends for the current year (revised budget 2011/12), the planned budget for the next financial year (2012/13) and estimated budgets for the following three financial years up until March 2016. The WRC has assumed a conservative increase in levy income for future years which is linked to inflation.

Table 1 does not include an 'income' item specified as 'transfer of unutilised research funds' as reflected in the individual budgets of each of the KSAs (see the individual Strategic Plans for the Key Strategic Areas). Tables 3 and 5 provide for a breakdown of transfer of unutilised research funds (roll-over) for each of the KSAs. This line item is not included in the five-year overview

budget as presented in Table 1, as it does not translate to actual income or expenses during a specific financial year, but rather reflects a financial risk related to contractual commitment and cash flow. The practice of including this line item (addressing transfer of unutilised funds) at KSA level is highly beneficial as a management tool for managing financial risk related to roll-over on research projects. Although roll-over is an inherent risk due to the nature of many of the water research projects funded by the WRC, the organisation continues to drive a number of interventions (e.g. introducing specific deliverables in each of its contractual project agreements) as well as key performance indicators and targets related to the level of this roll-over. These indicators call for minimising the deviation between the budgetary amounts planned for roll-over (for each of the KSAs) and the actual roll-over figure at year-end (the target for the next financial year is 20% deviation).

TABLE 1
A summary of the five-year budget plan (excluding roll-over)

DESCRIPTION	REVISED BUDGET March 2012 (R)	BUDGET March 2013 (R)	BUDGET March 2014 (R)	BUDGET March 2015 (R)	BUDGET March 2016 (R)
Levies	149 485 793	157 442 375	166 465 082	175 263 985	184 537 570
Interest received	4 974 000	5 123 220	5 276 917	5 435 224	5 598 281
Leverage	19 571 861	20 207 258	20 511 749	20 830 463	21 164 082
Sales/Commercial	692 453	715 326	733 342	747 359	762 710
TOTAL INCOME	174 724 107	183 488 179	192 987 089	202 277 031	212 062 643
Fixed costs	3 512 974	3 677 017	3 843 645	4 018 062	4 200 638
Running costs	13 471 237	13 879 823	14 480 557	15 109 356	15 766 809
Human resource costs	32 450 210	34 541 710	36 453 798	38 455 780	40 567 717
Total corporate expenditure	2 062 729	2 164 925	2 272 187	2 384 766	2 502 925
Total capital expenditure	849 028	555 981	573 779	592 468	612 091
Research funding	122 377 929	128 668 723	135 363 124	141 716 600	148 412 464
TOTAL EXPENDITURE	174 724 107	183 488 179	192 987 089	202 277 031	212 062 643

The WRC continues to strive towards maintaining a high ratio of research funding and other research-support activities (direct support to capacity building, knowledge dissemination, protection and commercialisation) as a percentage of total income, as indicated in both Tables 1 and 2. A specific key performance indicator (under the KPA addressing **Financial Perspectives**) has been set to target a ratio of research funding and other research support activities to total income. Table 1 indicates a trend of growth in research funds (linked to the growth in levy income), where the aim is to gradually increase the available funds for research activities from R122.4 m. to R148.4 m. by the year 2016, an increase of about R26.0 m. or about 21% from the budget amount planned for 2011/12. The financial indicators given in Table 2 clearly emphasise the WRC's commitment to maintain its role as a funding agency, by managing its own internal affairs and the fund management activities in an efficient and effective manner that will allow a very high percentage of the income to serve the role of the organisation as a knowledge hub. The table also indicates that the organisation aims at maintaining this current high ratio in future years. The ratios addressing all of the other different costs as a percentage of total expenditure (Table 2) indicate a trend where the ratios are maintained at the same or a slightly reduced level.

TABLE 2
Financial indicators and targets for the period 2011/12 to 2015/16 (based on financial data presented in Table 1) (excluding roll-over)

FINANCIAL RATIOS	REVISED BUDGET March 2012	BUDGET March 2013	BUDGET March 2014	BUDGET March 2015	BUDGET March 2016
INCOME					
Growth in income		5%	5%	5%	5%
Growth in levies		5%	6%	5%	5%
EXPENDITURE					
Fixed cost as % of total expenditure	2%	2%	2%	2%	2%
Running cost as % of total expenditure	8%	8%	8%	7%	7%
HR cost as % of total expenditure	19%	19%	19%	19%	19%
*Other cost as % of total expenditure	2%	1%	1%	1%	1%
(Research funding+**research support) as % of total income	73%	73%	73%	73%	73%

**Capital + Corporate expenditure*
**Printing and publishing and patent registration

4.2 Research funding – 2012/13

The WRC plans to invest approximately R128.7 m. in research funding during the next financial year (2012/13). The investment in research amounts to about R146.1 m. if R17.4 m. (Table 3) committed for roll-over is included. The allocation of research funds to the various KSAs for 2012/13 is presented in Table 3. The project funds allocated to the central fund (R5.0 m.) include funds earmarked for WIN-SA. The distribution of research project funds to the various types of providers is, in general, similar to that of the previous year, where higher education institutions (universities) are the major recipients. For more details regarding project fund allocation, please see the individual KSA business plans for 2012/13. The allocation of research project funds (not including roll-over) between the KSAs for 2012/13 (Table 3) results in **Water Resource Management** receiving 27.7% of the funds, **Water-Linked Ecosystems** 14.1%, **Water Use and Waste Management** 29.2% and **Water Utilisation in Agriculture** 23.2%. The balance (5.8%) is allocated to Water-Centred Knowledge and the **Central Fund** and includes **WIN-SA**. The allocation of research funding to water resources (including water-linked ecosystems) is about 41.8% and for water utilisation (effluent treatment and management, including agriculture) is 52.4%. However, since most of WIN-SA activities relate to water utilisation this reflects the same trend as in previous years, where about 42% of the research project funds are given to the areas addressing the resource and 58% to those addressing utilisation of the resource. The allocation of research funds reflects the strategic Government outcomes and outputs. The individual Strategic Plans for Key Strategic Areas provides more specific investment per KSA and relates specific research thrusts to Government's outcomes and outputs.

The WRC has a Board approved materiality framework as required by the Treasury Regulation 28.1.5 (**Appendix II**).

5. KEY PERFORMANCE AREAS (KPAs)

The targets for the WRC 2012/13 to 2016/17 are congruent with the mandate, mission and vision of the organisation. In addition the KPAs directly address the strategic risk areas as identified by the Board and Management.

5.1 Knowledge Generation

The objectives and indicators presented in this KPA reflect on the core business of the WRC, i.e., supporting knowledge generation by funding relevant research. This is directly linked to Government's outcomes. Further information regarding research focus and specific research projects is given in Section 4 of this strategy and in greater detail in Appendix 1.

The WRC aims to continue to provide South Africa with knowledge that will support the national development agenda and delivery on all government's targets. The provision of such knowledge, also aims to enhance the activities of the water sector in a manner that will support economic growth and sustainable development and improve quality of life for all South Africans. Further, the research and development activities of the WRC will contribute to the protection and sustainable use of the country's water resources and natural environment and protecting South Africa's rich biodiversity.

The WRC focuses its research and development in the four key strategic areas aimed at improving knowledge for decision making and implementation as described in section 3. The table below provides an overview of targeted research and development projects and new innovations. New innovations will provide new technologies, processes, methodologies and approaches that could support the addressing of South Africa's water issues, if appropriately deployed along the impact value chain. The table includes the absolute numbers per year as well as the accumulated totals in square brackets.

Overall Objective	Overall Indicators	Target 2011/12	Target 2012/13	Target 2013/14	Target 2014/15	Target 2015/16	Target 2016/17
Knowledge generation *(Across all four KSAs)*	To increase water knowledge by initiating new research projects addressing water management	69	78	65 [143]	68 [211]	77 [288]	81 [369]
	To provide the country with supportive knowledge via completed projects	58	80	76 [156]	69 [225]	74 [299]	80 [379]
	To search for new innovative approaches to support water management	14	17	14 [31]	14 [45]	18 [63]	18 [81]
	To increase the number of students supported in WRC research projects	400	400	400 [800]	400 [1200]	400 [1600]	400 [2000]

It is envisaged that in this 5 year planning period the WRC would initiate 369 new projects. In this same time it will have completed 379 projects and introduced 81 innovations and innovative solutions in the protection and sustainable use of water. In addition we will support a total of 2000 post-graduate students through the WRC projects. The next table provides a further elaboration of these targets.

Objective	Indicators	Target 2011/ 12	Target 2012/ 13	Target 2013/ 14	Target 2014/ 15	Target 2015/ 16	Target 2016/ 17
Improve knowledge on water resource management	To increase water knowledge by initiating new research projects addressing water management	31	28 [28]	25 [53]	28 [81]	29 [110]	31 [141]
	To provide the country with supportive knowledge via completed projects	13	18 [18]	25 [43]	23 [66]	23 [89]	25 [114]
	To search for new innovative approaches to support water management	2	3 [3]	3 [6]	3 [9]	4 [13]	4 [17]
Enhance the knowledge on healthy ecosystems and preserve biodiversity	To increase water knowledge by initiating new research projects addressing ecosystem health and biodiversity	6	12 [12]	9 [21]	9 [30]	13 [43]	15 [58]
	To provide the country with supportive knowledge via completed projects	5	18 [18]	15 [33]	10 [43]	12 [55]	14 [69]
	To search for new innovative approaches to support ecosystem management	2	3 [3]	3 [6]	3 [9]	4 [13]	4 [17]
Improve the knowledge base on water use and waste management, addressing the domestic, mining and industrial use of water)	To increase water knowledge by initiating new research projects addressing water use and waste management	26	30 [30]	25 [55]	25 [80]	25 [105]	25 [130]
	To provide the country with supportive knowledge via completed projects	28	35 [35]	30 [65]	30 [95]	30 [125]	30 [155]
	To search for new innovative approaches to water use and waste management	7	7 [7]	5 [12]	5 [17]	5 [22]	5 [27]
Improve the knowledge on productive water utilisation in agriculture	To increase water knowledge by initiating new research projects addressing productive water utilisation in agriculture	6	8 [8]	6 [14]	6 [20]	10 [30]	10 [40]
	To provide the country with supportive knowledge via completed projects	12	9 [9]	6 [15]	6 [21]	9 [30]	11 [41]
	To search for new innovative approaches to support productive utilisation of water in agriculture	3	4 [4]	3 [7]	3 [10]	5 [15]	5 [20]

5.2 Knowledge Dissemination and Capacity Building

The WRC will actively contribute towards capacity building as well as to enhance the sharing and dissemination of WRC-funded research findings, i.e., knowledge sharing and dissemination functions. This KPA is linked to Government outcomes/outputs related to building skills, by addressing the building of future research capacity and improving knowledge dissemination.

- **Improvement of the WRC's contribution towards the water knowledge base** in South Africa, including capacity building by increasing the number of students supported through research projects funded by the WRC
- **Enhancing the WRC knowledge-sharing activities and positioning** through knowledge dissemination and sharing (measured against the number of knowledge-sharing events, including workshops as well as publications such as *The Water Wheel* and *Water SA*, and technical, policy and ministerial briefs)

Objective	Indicators	Target 2011/ 12	Target 2012/ 13	Target 2013/ 14	Target 2014/ 15	Target 2015/ 16	Target 2016/ 17
Improve knowledge dissemination	To enhance public understanding of water research (measured as volumes/cumulative number of issues of *The Water Wheel*)	6	6 [6]	6 [12]	6 [18]	6 [24]	6 [30]
	To cumulatively increase the numbers of briefs (technical, policy and Ministerial)	30	30 [30]	30 [60]	30 [90]	30 [120]	30 [150]
	To improve the dissemination of water research (measured as volumes/cumulative number of issues of *Water SA*)	4	4 [4]	4 [8]	4 [12]	4 [16]	4 [20]
	To engage the sector in knowledge-sharing events (number of workshops)	20	20 [20]	20 [40]	20 [60]	20 [80]	20 [100]
Human capital development for knowledge	To increase the number of students supported by research projects	400	400 [400]	400 [800]	400 [1200]	400 [1600]	400 [2000]

5.3 Financial Perspectives

The WRC will continue to improve the financial practices, management and performance of the WRC. This is translated into the listed quantitative indicators addressing growth and sustainability and effective management of funds, as presented below. The overarching objectives have been translated into a number of indicators as follows:

- **Improving financial performance**
  - Income growth (income growth is measured as meeting the budgetary target)
  - Research ratio (measured as research funding and support as a percentage of total income)
  - Cash-flow management (measured against availability of cash for effective operation)
- **Improving financial management**
  - High-quality budget planning and reporting (measured as the percentage deviation between actual and budget at year-end)
  - Audit results (measured as a percentage of the previous year's internal audit queries addressed and a clean vs. qualified audit)

- Roll-over of research funds (measured as the deviation from the budgetary figure for roll-over of research project funds)

Objectives	Indicators	Target 2011/12	Target 2012/13	Target 2013/14	Target 2014/15	Target 2015/16	Target 2016/17
Improved financial performance	Maintain income growth (income growth is measured as meeting the budgetary target of leverage income)	Meet budget target in full	Meet budget target in full	Meet budget target in full	Meet budget target in full	Meet budget target in full	Meet budget target in full
	Maintain high level of research ratio (measured as research funding and research related overheads as percentage of total expenditure)	74% (revised budget)	75% (revised budget)	75% (revised budget)	75% (revised budget)	75% (revised budget)	75% (revised budget)
	Improve cash-flow management (measured against availability of cash for effective operation)	R25m	R30m	R32m	R34m	R35m	R35m
Enhance effective financial manage-ment	Improve quality budget planning and reporting (measured as the percentage deviation between actual and budget at year-end)	10%	10%	10%	10%	10%	10%
	Improve response to audit results (measured as a percentage of the previous year's internal audit queries addressed and an unqualified vs. qualified external audit)	70% (internal audit) Unqualified audit report (external audit)	70% of operational audit findings (internal audit) Unqualified audit report (external audit)	72% of operational audit findings (internal audit) Unqualified audit report (external audit)	74 of operational audit findings (internal audit) Unqualified audit report (external audit)	75% of operational audit findings (internal audit) Unqualified audit report (external audit)	75% of operational audit findings (internal audit) Unqualified audit report (external audit)
	Decrease roll-over of research funds (measured as the deviation from the budgetary figure for roll-over of research project funds)	20%	20%	19%	18%	17%	16%

5.4 Support Systems and Processes

The WRC continues to place strong emphasis on improving its internal processes in order to improve the efficiency and effectiveness of the organisation and its core business process of research funding. This KPA is closely linked to information technology related risk as well as human resource related risks such as inadequately skilled staff.

Objective	Indicators	Target 2011/12	Target 2012/13	Target 2013/14	Target 2014/15	Target 2015/16	Target 2016/17
Improve the system for fund management	To expand Fund Management System to include short-term projects	10% of short-term projects are on the system	50% of short-term projects are on the system	75 % of short-term projects are on the system	100% of short-term projects are on the system	NA	NA
Improve stakeholder relationships	Enhance WRC relationship with the research community (number of WRC 101 courses)	2	2 [2]	2 [4]	2 [6]	2 [8]	2 [10]
Improve human resource management	Improved diversity profile through improved equity measured by the percentage new appointments being EE	90% of new appoint-ments are EE	80% of new appoint-ments are EE	80% of new appoint-ments are EE	80% of new appoint-ments are EE	80% of new appoint-ments are EE	80% of new appoint-ments are EE
	Enhance staff skills by training (measured against in-house and external training courses)	2 in-house training courses 5 external training courses	4 in-house training courses 10 external training courses	6 in-house courses 15 external courses	8 in house courses 20 external courses	8 in house courses 20 external courses	8 in house courses 20 external courses
Compliance	Alignment with King III as relevant to a public research agency	-	50 % of gaps closed	50% of gaps closed	60% of gaps closed	80% of gaps closed	100% of gaps closed

APPENDIX I

Strategic Risk Assessment Report

KPMG

cutting through complexity™

The Water Research Commission

Strategic risk assessment report

February 2012

Contents

1 Introduction

1.1 Mandate and objectives

KPMG was engaged by the Water Research Commission (WRC) to facilitate the updating of the strategic risks of the WRC. Consequently we were requested to facilitate a strategic risk assessment workshop for the WRC, with a view to best direct Executive Management's efforts towards the management of the highest risks to which the WRC is exposed. The strategic risk assessment workshop was facilitated by KPMG on 8 November 2011.

The main purpose of this workshop was to involve and assist the Board, Chief Executive Officer and Executive Management of the WRC in assessing and prioritising the risks that need to be managed in order to achieve the vision, mission, and strategic objectives of the WRC. The workshop was also designed to assist management in the establishment of a risk management process as required by the Public Finance Management Act (PFMA) and best practice corporate governance, as well as provide guidance to the internal audit function in the development of a risk based internal audit strategy and annual internal audit plan for the WRC.

The participants included amongst others:

- WRC Board Members
- Chairperson of the Audit Committee
- Chief Executive Officer
- Chief Financial Officer
- Executive Directors.

It is important to note that risk management is the responsibility of the Board, Chief Executive Officer and Executive Management. **KPMG's responsibilities were limited to the facilitation of the strategic risk assessment workshop.**

We are pleased to provide you with a summary of the results of the risk assessment. The risk assessment information incorporates the participants' perceptions, assumptions and judgments about the WRC's strategic risks and related controls. **The report does not seek to identify all risks faced by the WRC. It focuses only on those risks that were highlighted during the workshop by the participants.**

1.2 Recommendation

A firm commitment to robust enterprise risk management by Executive Management is needed to ensure that the WRC is proactive in identifying and managing the risks to which it is exposed. This would also assist management in having foresight to identify emerging risks. Executive Management might consider a 'mitigation strategy' to assist the WRC to direct resources and effort effectively and efficiently, to ensure that possible crises are averted.

1.3 Acknowledgements

We would like to thank the Chief Executive Officer and all workshop participants of the WRC for their cooperation and participation in the workshop.

1.4 Restriction on distribution of this document

This document has been prepared for the sole and exclusive use of the WRC and may not be made available to anyone, other than authorised persons within the WRC, nor relied upon by any third party, without the prior written consent of KPMG.

2 Results

The results of the risk assessment workshop reflect participants' views only. The facilitators did not attempt to influence the process or results in any way. Their role was merely to gather information in a structured manner and to record the views of the participants.

Participation and discussion during the workshop was open and constructive.

Strategic risks were identified by the workshop participants of the WRC. The risks were first rated in terms of impact and likelihood (inherent risk), and then current controls were rated in terms of perceived control effectiveness (from which the residual risk is derived). The workshop participants agreed and confirmed the strategic objectives of the WRC and linked risks identified to the strategic objectives.

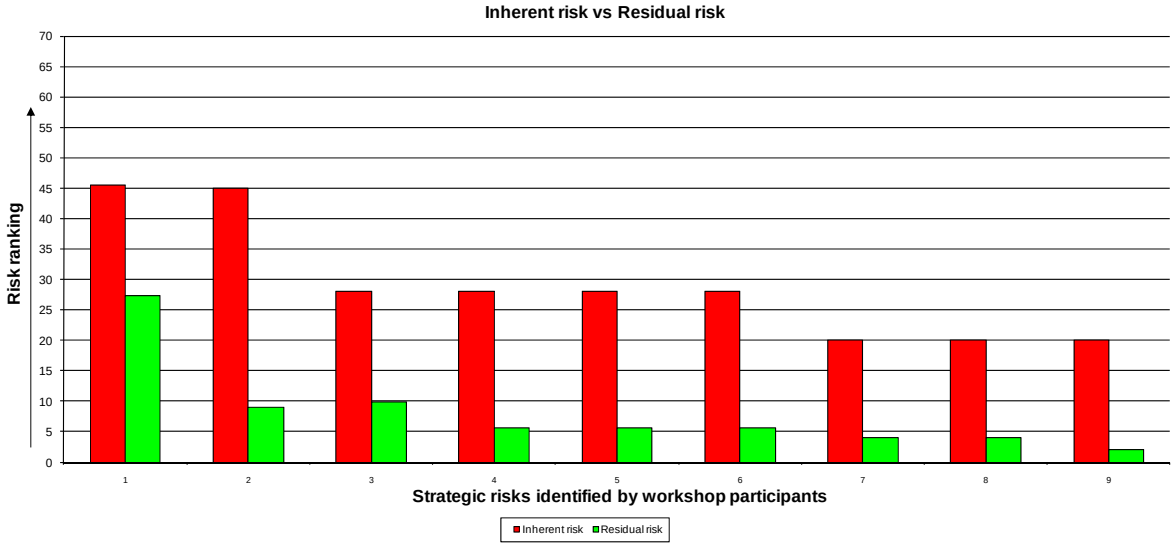
The results of the risk assessment workshop have been depicted graphically in **Paragraph 2.1** from highest to lowest **inherent risk**.

The strategic risks currently faced by the WRC, as identified by the participants during the strategic risk workshop, are presented in **Paragraph 2.2** from highest to lowest **inherent risk**.

2.1 Graphical illustration

2.1.1 Strategic risks

The identified 9 strategic risks are depicted graphically below in terms of the inherent and residual assessment of the risk. Refer to Paragraph 2.1.2 for the detailed explanation to the graph.



The risk name for each of the identified strategic risks above has been reflected in the table below.

Risk number	Risk name	Risk number	Risk name
1	Insufficient research capacity (fields, quality and quantity) in the country	6	Inability to attract, retain and develop skills within the WRC
2	Insufficient funding	7	Non adherence to government practices and regulations
3	Decreasing quality and relevance of research portfolio	8	Business interruption / disaster
4	Instability of levy funding	9	Fraud and theft
5	Negative response to research output / results		

2.1.2 Risk graphs

The relative size of the strategic risks threatening the achievements of the WRC's strategic objectives in terms of inherent as well as residual risk exposure for each of the risks, as identified by the workshop participants, is depicted graphically from the highest to the lowest inherent risk exposure in **Paragraph 2.1.1** above.

The inherent nature of the risk is the assessment of the risk without specific, focused controls in place. The residual nature of the risk is the assessment of the risk taking into account the existing controls and their perceived effectiveness.

The larger the difference between the inherent and residual risk factors the more effective the controls in place are perceived to be, and therefore reliance placed on the controls.

The smaller the difference between the inherent and residual risk factors, the more management actions and improved control effectiveness is needed to ensure that the risk is properly managed. Management should take cognisance that the higher the inherent risk factor, the greater the need for effective controls.

The items should therefore attract more management in order to:

- Maintain the quality of control where control effectiveness is considered adequate
- Improve quality of control further where residual risk is considered to be too high.

The KPMG Risk Methodology classifies and defines residual risk as the following priorities:

Priority 1:	*The risk is intolerable and requires urgent action to further mitigate the exposure*
Priority 2:	*The risk is intolerable and requires management intervention to further mitigate the exposure*
Priority 3:	*The risk exposure exceeds the current risk tolerance and should be monitored to ensure prompt intervention if and when required*
Priority 4:	*The risk exposure is tolerable*
Priority 5:	*Risk may be over controlled*

2.2 Summary of the strategic risks identified during the risk workshop

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
1	Knowledge dissemination and capacity building	Insufficient research capacity (fields, quality and quantity) in the country	Lack of discipline continuity Shortage of research capacity Inadequate succession planning Aging research capacity in traditional disciplines Increased complexity of research Lack of structured student and junior researcher development	Insufficient research output Reduced research investment to address the future development of the country Poor quality of research which may result in poor decision-making	Critical	Likely	High	Development of research training material Capacity building - as part of research contracts and research prioritisation Engagement with research partners Funding of research equipment Support publication and exposure of students and training material Leading (implementing	Weak	Priority 1	Chief Executive Officer Directors: KSA's 1 - 5

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
			programme Lack of interest in water research Importance of research infrastructure not prioritised					agents) for national capacity drive			
2	Support systems and processes	Insufficient funding	Insufficient funds to address research activities Adequacy of research funds vs. needs	Negative impact on research activities Negative impact on stakeholder trust relationships Possible litigation Limited ability to grow	Serious	Almost certain	High	Escalation provisions for funding Diversified levy agencies Regular interaction with shareholder Prioritisation of available funds Stretching of resources	Good	Priority 4	Chief Executive Officer

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
3	Knowledge generation	Decreasing quality and relevance of research portfolio	Ineffectiveness of peer review Long lead time on multi-year projects (research delays) Lack of research capacity Lack of sector wide dialogue related to the research portfolio Irrelevant research priorities due to wrong projections, might not address the needs of the country	No new relevant knowledge created Delays in delivery of knowledge Reputational damage/ credibility decline Poor quality results Possible loss of funding and closure	Critical	Possible	Moderate	Deliverable system Regular project meetings Stakeholder involvement in research portfolio Annual strategic review of research portfolio Periodic institutional review of research portfolio Engaging performance of Researchers	Satisfactory	Priority 4	Chief Executive Officer Directors: KSA's 1- 5 Research Managers

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
4	Financial perspectives	Instability of levy funding	Poor administration by levy collector Poor / inappropriate accounting systems Department of Water Affairs metered basis not verifiable Delayed payment of levy	Reduction in level of levy income Incorrect payments received Poor cash flow management Inability to execute monthly operation of the WRC	Critical	Possible	Moderate	Regular meetings with funders Diversified levy agencies Adherence to legislation (collection of income - WRA) Regular interaction with funding stakeholders	Good	Priority 5	Chief Financial Officer
5	Knowledge dissemination and capacity building	Negative response to research output / results	Insufficient early warning systems Unrealistic expectations of users of information Ineffective communication	Poor uptake on implementation of results Harm to reputation Deterioration of stakeholder	Critical	Possible	Moderate	Implemented media policy Draft code of practice relating to multi stakeholder relationship management	Good	Priority 5	Chief Executive Officer All Directors

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
			with stakeholders	relationship				Involvement of end users in research Early warning practice			
6	Support systems and processes	Inability to attract, retain and develop skills within the WRC	Technical nature of the organisation Technical and experienced people in short supply Unplanned loss of key personnel Unsatisfied / unhappy staff Unstable conditions Recruitment of inappropriate resources	Inappropriate skills Lack of capacity Shortage of skills Inefficient fund management Low performance of the WRC	Critical	Possible	Moderate	Informal succession planning Development programme for individuals Informal head hunting Competency based recruitment Salary benchmarking Attractive conditions of employment	Good	Priority 5	Chief Executive Officer Human Resources Director

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
			Uncompetitive remuneration								
7	Support systems and processes	Non adherence to government practices and regulations	Increasing compliance burden Insufficient knowledge of new applicable legislations	Non-compliance to PFMA and Water Research Act and other relevant legislations Qualified audit report Legal repercussions Loss of upfront donor funding Harm to reputation	Serious	Possible	Low	Good internal knowledge of the PFMA and other legislation Ongoing training Compliance is a KPI	Good	Priority 5	Chief Executive Officer Chief Financial Officer Human Resources Director

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
8	Support systems and processes	Business interruption / disaster	Dependence on IT platforms Centralised storage of assets and storage of information Fire, hacking, negligence, etc.	Delays and disruptions in operations Possible loss of life / injury on duty Financial loss Loss of research results (reports/ loss of knowledge base - intellectual property)	Catastrophic	Unlikely	Low	Offsite backups Disaster recovery plans Firewall Uninterrupted Power Supply Anti-virus software Insurance Dedicated First Aid Officials Logical and physical access controls	Good	Priority 5	Human Resources Director

	Link to most appropriate strategic objective	Risk name	Root cause	Consequence of the risk	Impact	Likelihood	Inherent risk exposure	Current controls / business processes to manage the risk exposure	Perceived control effectiveness	Residual risk exposure	Risk owner
9	Support systems and processes	Fraud and theft	Non adherence to procedures Lack of management oversight Opportunists	Financial loss Operational inefficiencies Harm to reputation Inability to meet set service delivery targets Increased pressure from stakeholders	Serious	Possible	Low	Financial and management (reconciliatory, supervisory, etc.) controls Segregation of duties Delegation of authority Fraud prevention plan Whistle blowing policy	Very good	Priority 5	Directors: KSA's 1- 8

3 The way forward

The risk assessment workshop provides a basis for commencing the implementation of a formal risk management framework at the WRC.

Management should now focus on ensuring it understands the risk universe within which it operates. Achieving the strategic intent within the risk universe involves identifying what has to be managed and ensuring that such management and control actually takes place timeously and effectively.

The next challenge is to develop and implement a structured plan for implementing effective and ongoing risk management at the WRC.

This should include the following key phases and steps, amongst others:

3.1 Project planning

Develop a detailed project plan to implement enterprise-wide risk management at the WRC, meeting the key requirements of:

- The Public Finance Management Act;
- the King Report on Corporate Governance; and
- the Standards of the Institute of Risk Managers of South Africa.

3.2 Risk awareness and strategy

- Develop and roll out an ongoing risk management awareness and training programme for all levels of management – to build upon the current level of understanding and knowledge.
- Establish ownership and accountability for risk management within the WRC- Incorporate risk responsibilities in key management mandates, charters, performance contracts, job descriptions, etc.
- Include risk management as a key agenda item on key meetings.
- Gradually formalise and approve a risk strategy that is aligned with and supports the achievement of the WRCs strategic direction.
- Ensure alignment with the WRC's Risk Management Strategy and Policy.

3.3 Risk management structures and culture

- Ensure an independent committee is formally charged with overseeing the risk management process – this may form part of the Audit Committee mandate or may be allocated to a separate body that reports back at Audit Committee meetings.
- Identify a Risk Champion who will work closely with the designated Chief Risk Officer who is responsible for coordinating and analysing risk management and assurance efforts on an ongoing basis.

3.4 Integrated risk assessments and risk management activities

- Maintain the WRC's strategic risk register current and up to date – including a formal risk identification and assessment process conducted at least annually.

- Incorporate the identified risks into the Strategic and Business Plans for the WRC.

- Allocate responsibility for each individual strategic risk to a senior (and accountable) member of management (risk owner) – including the implementation of management action plans to improve levels of control where required.

- Regular management / monitoring of the identified exposures through:

  - Further development of specific action plans to address individual exposures
  - Allocation of individual officials responsible for action plans
  - Setting of due dates / implementation of time frames
  - Development of key performance indicators by which the success of the improved controls can be measured
  - Facilitation of process level workshops.

Process level workshops should be conducted to reach consensus regarding:

- Related process level objectives and risks
- The alignment of the above with strategic focus areas as well as the risks identified in this report
- Controls which management relies upon to manage those risks
- Perceived and desired effectiveness of those controls
- Areas considered to be lacking in control, which would require further management action.

- Integrate the active monitoring of identified risks and related controls (including the allocation of individual "risk owners") into the ongoing activities of the Executive Management, Chief Executive Officer, Board and the Audit Committee.

- Ensure there is regular report-back by the "risk owners" on the status of the risks and related internal controls – This should be performed as part of the normal management activities, e.g. monitoring performance against "risk based" business plans and budgets.

- Develop a "Combined Assurance Plan" which coordinates the efforts of various assurance providers available to the WRC – internal audit, external audit, management, insurers, etc.

Appendix 1 Strategic overview

The WRC's mission, vision and strategic objectives is as follows:

Mission

The **mission** of the WRC is as follows:

"The WRC is a dynamic hub for water-centred knowledge, innovation and intellectual capital. We provide leadership from research and development through the support of knowledge creation, transfer and application. We engage stakeholders and partners in solving water-related problems which are crucial to South-Africa's sustainable development and economic growth, and are committed to promoting a better quality of life for all."

Vision

The **vision** of the WRC is as follows:

"To be a globally recognised leader in providing innovative solutions for sustainable water management to meet the changing needs of society and of the environment."

Strategic objectives

The strategic objectives of the WRC are as follows:

1 *"Knowledge generation*

- *Improve knowledge on water resource management*
- *Enhance the knowledge on healthy ecosystems and preserve biodiversity*
- *Improve the knowledge base on water use and waste management, addressing the domestic, mining and industrial use of water)*
- *Improve the knowledge on productive water utilisation in agriculture*

2 *Knowledge dissemination and capacity building*

- *Improve knowledge dissemination*
- *Enhance research capacity*

3 *Financial perspectives*

- *Improved financial performance*
- *Enhance effective financial management*

4 *Support systems and processes*

- *Improve the system for fund management*
- *Improve stakeholder relationships*
- *Improve human resource management."*

The risk assessments were performed taking the above strategic objectives into account by consistently asking the question:

"What are the major threats that could prevent the WRC from achieving its strategic objectives?"

Appendix 2 Risk assessment approach adopted for the WRC

An overview of the risk assessment process followed is presented below:

Methodology

In order for any business to be effective, it must focus its attention and resources on the areas of most significant risk and concern to stakeholders. The risk assessment workshop is fundamental elements of the risk management process.

The principal aims of the risk workshop were to:

- Identify the strategic risks threatening the achievement of the strategic objectives.
- Assess the risks (impact and likelihood).
- Identify the controls (mitigations) in place.
- Analyse the perceived control effectiveness of the identified controls.

During the workshop, participants were required to provide input based on their actual knowledge and experience of the WRC's operations and environment.

Risk in the Public Sector environment

The underlying premise of risk management is that every entity exists to provide value for its stakeholders. Such value is based on the quality of service delivery to the stakeholders. All entities face uncertainty, and the challenge for management is to determine how much uncertainty the WRC is prepared to accept as it strives to grow stakeholder value. Uncertainty presents both risk and opportunity, with the potential to erode or enhance value.

Risk definition for the purpose of the workshop

For purposes of the workshop and implementing an effective risk management system at the WRC, a risk / threat was defined as follows:

"Risk can be defined as uncertain future events that could influence, both in a negative and a positive manner, the achievement of the company's objectives."

The King III Code on Corporate Governance

For each risk / threat identified the following was assessed:

The impact

This is the **potential magnitude of the impact** on the WRC's operations **should the risk / threat actually occur**. No account of existing controls is taken into consideration in assessing the impact of risks. The impact was categorised into 5 different levels, namely:

Catastrophic	Critical	Serious	Significant	Minor

For a detailed explanation of the different categories please refer to **Appendix 3**.

The probability of occurrence

This is the likelihood that the identified risk / threat will occur within a specified period of time on the basis that **management have no specific / focussed controls in place to address the risk / threat**. The probability of occurrence was categorised into 5 different levels, namely:

Almost certain	Likely	Possible	Unlikely	Rare

For a detailed explanation of the different categories please refer to **Appendix 3**.

Inherent risk

Inherent risk is the **product of the impact of a risk and the probability of that risk occurring before the implementation of any direct controls**. The score for inherent risk assists management and internal audit alike to establish relativity between all the risks / threats identified. Please note that at this stage no account is taken of existing controls implemented by management.

This indicator may be used to assign / measure the level of management effort / resources required to control the relevant risks and to determine the level of internal audit focus required.

Controls

Controls are the processes / functions / departments that Executive Management and the Chief Executive Officer have put in place, and rely upon, to manage the strategic risks. At this risk assessment workshop we have limited ourselves to the ranking of the perceived effectiveness of these high level controls.

Perceived control effectiveness

The participants **assessed the control effectiveness based on their understanding of the control environment currently in place at the WRC**. This is a measure of how well management perceives the control processes to be working and effectively managing the risks. Processes / controls were categorised into 5 different levels of effectiveness, namely:

Very good	Good	Satisfactory	Weak	Unsatisfactory

For a detailed explanation of the different categories please refer to **Appendix 3**.

Residual risk

This is the score of risk that the WRC is exposed to taking into account the potential impact of the risk, the likelihood of the risk occurring and the related control processes which are in place to manage that risk. **Residual risk / exposure is therefore the product of the inherent risk and the control effectiveness factor**.

This information will assist decision makers in assessing the acceptability of the residual risk / exposure and in deciding whether further management action is required to effectively control the risk.

Management actions

Based on the relative score of the residual risk / exposure, **management will need to decide whether or not they are willing to accept the identified level of residual risk / exposure**.

If the residual risk is considered to be too high, then an action plan will then need to be developed outlining the identified action / s to reduce the risk to a level that is more acceptable to management and other stakeholders.

Management actions may include the re-examination of the control design and / or the business / quality objective identified earlier in the risk management process.

The action plans must clearly identify:

- The required action;
- The person responsible for implementing the action; and
- The expected date of implementation.

Appendix 3 Assessment tables

Below are the tables used to size the risks according to the potential impact of the risk, the likelihood that the risk will occur, as well as the perceived effectiveness of existing controls. The following three tables provide the legends for the respective decisions required during the workshop.

Qualitative assessment of impact

The table below was used to assist management in quantifying the impact of a specific risk occurring.

Impact	Continuity of Supply	Safety & Environmental	Technical Complexity	Financial
Catastrophic **100**	Risk event will result in widespread and lengthy reduction in continuity of supply to customers of greater than 48 hours	Major environmental damage Serious injury (permanent disability) or death of personnel or members of the public Major negative media coverage	Use of unproven technology for critical system / project components High level of technical interdependencies between system / project components	Significant cost overruns of **>**20% over budget Affect on revenue / asset base of **>**10%
Critical **70**	Reduction in supply or disruption for a period ranging between 24 & 48 hours over a significant area	Significant injury of personnel or public Significant environmental damage Significant negative media coverage	Use of new technology not previously utilised by the WRC for critical systems / project components	Major cost overruns of between 10 % & 20 % over budget Affect on revenue / asset base of between 5% & 10%
Serious **50**	Reduction in supply or disruption for a period between 8 & 24 hours over a regional area	Lower level environmental, safety or health impacts Negative media coverage	Use of unproven or emerging technology for critical systems / project components	Moderate impact on revenue and assets base
Significant **30**	Brief local inconvenience (work around possible) Loss of an asset with minor impact on operations	Little environmental, safety or health impacts Limited negative media coverage	Use of unproven or emerging technology for systems / project components	Minor impact on revenue and assets base
Minor **10**	No impact on business or core systems	No environmental, safety or health impacts and / or negative media coverage	Use of unproven or emerging technology for non-critical systems / project components	Insignificant financial loss

Qualitative assessment of probability of likelihood

The table below was used to assist management in quantifying the likelihood of a specific risk occurring.

Likelihood factor	Qualification criteria	Rating
Almost certain	The risk is almost certain to occur in the current circumstances. The risk is already occurring, or is likely to occur more than once within the next 12 months	**90%**
Likely	More than an even chance of occurring. The risk could easily occur, and is likely to occur at least once within the next 12 months	**65%**
Possible	Could occur quite often. There is an above average chance that the risk will occur at least once in the next 3 years	**40%**
Unlikely	Small likelihood but could happen. The risk occurs infrequently and is unlikely to occur within the next 3 years	**20%**
Rare	Not expected to happen – Event would be a surprise. The risk is conceivable but is only likely to occur in extreme circumstances	**10%**

Qualitative assessment of perceived control effectiveness

The table below was used to assist management in quantifying the perceived effectiveness of controls to mitigate or reduce the impact of specific risks.

Effectiveness factor	Qualification criteria	Rating
Very good	Risk exposure is effectively controlled and managed	**90%**
Good	Majority of risk exposure is effectively controlled and managed	**80%**
Satisfactory	There is room for some improvement	**65%**
Weak	Some of the risk exposure appears to be controlled, but there are major deficiencies	**40%**
Unsatisfactory	Control measures are ineffective	**20%**

Inherent risk exposure

The table below was used to categorise the inherent risk exposure of the identified risks into the 5 different categories.

Category	Category description	Factor
Extreme	This risk should be terminated / insured / controlled	**50 +**
High	This risk should be insured / controlled	**35 - 50**
Moderate	This risk will typically be controlled (treated)	**25 - 35**
Low	Management will make an informed decision as to whether this risk must be controlled or absorbed by the entity. The decision will be based on a "cost vs. benefit" approach	**15 - 25**
Insignificant	Impact and probability is insignificant. This risk may be tolerated, and cost of losses will be absorbed by the entity	**1 - 15**

Residual risk exposure

The table below was used to categorise the residual risk exposure into the 5 different categories.

Category	Level	Category description	Factor
Priority 1	Immediate action required	Management should take immediate action to reduce residual risk exposure to an acceptable level	**+25**
Priority 2	Action required	Management should implement more controls or increase the effectiveness of current controls to reduce the residual risk to a more acceptable level	**17.5 - 25**
Priority 3	Monitor	Management should constantly monitor the risk exposure and related control effectiveness	**12.5 – 17.5**
Priority 4	Acceptable	The residual risk exposure is acceptable to the WRC	**7.5 – 12.5**
Priority 5	Reduce control	Management may consider reducing the cost of control	**1 – 7.5**

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APPENDIX II

Water Research Commission Materiality Framework in Terms of Treasury Regulation 28.1.5

Materiality Framework in terms of Treasury Regulation 28.1.5

1 Definitions

Accounting Authority	-	Board of Directors
Executive Authority	-	Minister of Department of Water and Environment Affairs
Entity	-	Water Research Commission
PFMA	-	Public Finance Management Act (Act 1 of 1999 as amended by Act 29 of 1999)
Treasury Regulations	-	Public Finance Management Act, 1999: amendment of Treasury Regulations in Terms of Section 76 as published in Government Gazette No. 7372.

2 Introduction

In terms of Treasury Regulation 28.1.5, the accounting authority must develop and agree a framework of acceptable levels of materiality and significance with the relevant executive authority in consultation with the external auditors.

3 Framework

Fiduciary duties of the accounting authority (PFMA section 50)	**Quantitative (Amount)**	**Qualitative (Nature)**
(1) The accounting authority must - (c) On request, disclose to the executive authority responsible for that public entity or the legislature to which the public entity is accountable, all material facts, including those reasonably discoverable, which in any way influence the decisions or actions of the executive authority or that legislature.	Any fact discovered of which the amount exceeds the determined materiality figure as calculated in Annexure A.	1. Any item or event of which specific disclosure is required by law. 2. Any fact discovered of which its omission or misstatement, in the Board's opinion, could influence the decisions or actions of the executive authority or legislature.

Annual Report and Financial Statement (PFMA section 55)	Quantitative (Amount)	Qualitative (Nature)
(2) The annual report and financial statements referred to in subsection (1) (d) must – (a) Fairly present the state of affairs of the public entity, its business, its financial results, its performance against predetermined objectives and its financial position as at the end of the financial year concerned: (b) Include particulars of – i. Any material losses through criminal conduct and any irregular expenditure and fruitless and wasteful expenditure that occurred during the financial year; ii. Any criminal or disciplinary steps taken is a consequence of such losses or irregular expenditure or fruitless and wasteful expenditure; iii. Any losses recovered or written off; iv. Any financial assistance received from the state and commitments made by the state on its behalf; and v. Any other matters that may be prescribed.	1. Losses through criminal conduct – any loss identified. 2. Losses through irregular / fruitless / wasteful expenditure – if the combined total exceeds the planning materiality figure used by the external auditors for the year under review.	Any identified loss through criminal conduct
Annual Report and Financial Statement (PFMA section 54)	**Quantitative (Amount)**	**Qualitative (Nature)**
(2) Before a public entity concludes any of the following transactions, the accounting authority for the public entity must promptly and in writing inform the relevant treasury of the transaction and submit relevant particulars of the transaction to its executive authority for approval of the transaction: (b) Participation in a significant partnership, trust, unincorporated joint venture or similar arrangement; (c) Acquisition or disposal of a significant shareholding in a company; (d) Acquisition or disposal of a significant asset; (e) Commencement of cessation of a significant business activity.	Not applicable Not applicable Not applicable Not applicable	Any participation, outside of the approved strategic plan and budget. Any acquisition or disposal, outside of the approved strategic plan and budget. 1. Any asset that would increase or decrease the overall operational functions of the WRC, outside of the approved strategic plan and budget. 2. Disposal of the major part of the assets of the WRC. Any business activity that would increase or decrease the overall operational functions of the WRC, outside of the approved strategic plan and budget.

4 Authorisation

This framework was recommended for approval to the Board by the Audit Committee on 21 February 2012.

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Chairperson of the Board

Annexure A
Determination of Materiality

1. Materiality Basis

		2010/11 Actuals	
Materiality bases	**% Used**	**R**	**Materiality (R)**
Gross Income	**0.625%**	**R 160 344 353**	**R 1 002 152**
Gross Expenditure	**0.625%**	**R 168 753 685**	**R 1 054 710**
Total Assets	**1.250%**	**R 145 560 181**	**R 1 819 502**
Net Deficit for the Year	**6.250%**	**R - 8 409 332**	**R 525 583**

2. Materiality basis selected and the reasons therefore

Gross income consists mainly of levies received from DWA, Rand Water and Umgeni Water. This has shown steady growth over the past 3 years. Gross expenditure can fluctuate for a variety of reasons and did not show consistency over the past 3 years. Net profit/(loss) is derived from gross income and gross expenditure.

Assets consist mainly of investments and cash, which are not operating assets of the WRC itself. The WRC is not a capital intensive business. Therefore this would not be considered an appropriate basis for calculating materiality.

Because of the uneven pattern in gross expenditure and net profit/(loss), gross income is regarded as the most appropriate basis for the calculation of materiality.

3. Justification of percentage used

A moderate percentage was used based on planning done in prior year audits which had assessed risk as medium. The audited figures as at March 2011 have been used as this constitutes the most reliable, verifiable and objective information available to use.

4. Materiality figure

Thus the most appropriate indicator for the purposes of setting materiality is Gross income. For this reason, materiality has been selected at 0.625% of gross income which amounts to R1 002 152. In the previous financial year, materiality was set at R994 716. This is considered consistent with the previous financial year.