KSA 3: Water Use and Waste Management

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SCOPE

The Water Use and Waste Management 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 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 minimising the negative effect on human and environmental health.

The provision and supply of water of adequate quality and quantity for economic and public health purposes remain continuous challenges. Water is a finite resource and, specifically in the context of South Africa, becoming incrementally scarce. Managing water use and the waste released to the water environment is thus of paramount importance to ensure the sustainability of the resource and the activities relying on it. Water use and waste management in South Africa is consequently a key factor for social and economic growth, as well as for our environment. The entire way we think about and use water is thus an important factor in determining our future. In recent years the focus of the KSA has been on supporting the implementation of various pieces of legislation that impact on the provision of sustainable water services. The support was in the form of unpacking and understanding key elements within legislation and the impact on the water services sector. The result has been a bias towards developing guidelines and tools to assist new and emerging municipalities and politicians to understand their responsibilities, which also included repackaging information of a technical nature. In the process we have maintained a balance with dealing with cutting-edge technological advances and have been concentrating on their application and commercialisation. Developing innovative processes and technologies for water purification, and reuse and treatment of wastewater from domestic to industrial and mining activities, has been and is of even greater importance to our country, especially in the light of problems related to the deteriorating quality of our water resources and the rising costs and reliability of energy. Considering the emerging challenges, research in the KSA will continue to focus on greater innovation and development of cutting-edge technologies to respond to the issues of poor O&M, competency and capacity constraints, reuse, energy efficiency, climate change constraints, emerging contaminants and the aspect of drinking water quality.

OBJECTIVES

The primary objective of this KSA is to provide 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 to 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

The objectives of the KSA are orientated towards making a difference and impact in the areas of health, economy, environment and society. These are achieved through a portfolio of focused thrusts:

Thrust 1: Water Services – Institutional and Management Issues
Thrust 2: Water Supply and Treatment Technology
Thrust 3: Sustainable Municipal Wastewater and Sanitation
Thrust 4: Industrial and Mine-Water Management
Thrust 5: Sanitation, Health and Hygiene Education.
Thrust 6: WaterSmart Fund (new)

THRUSTS AND PROGRAMMES

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: 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, operations and maintenance, sanitation (stormwater, sewerage and on-site sanitation), 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.

Current programmes are:
- Cost-recovery in water services
- Institutional and management issues – Water services
- Innovative management arrangements – Rural water supply
- Regulation of water services
- Impact of water and sanitation interventions

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of sufficient quality and quantity for domestic and economic (industrial/commercial and mining) activities, remain continuous challenges. Research support for these activities is the focus of this thrust. Linked to water supply is the all-important aspect of the protection of human health. The objective of this thrust is to develop innovative technologies, processes and procedures that address aspects related to bulk water supply, water treatment technology, distribution and water quality.

Current programmes are:
- Drinking water treatment technology
- Water treatment for rural communities
- Drinking water quality
- Water distribution and distribution systems.

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: 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 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.

Current programmes are:
- Emerging treatment technologies
- Application of appropriate technologies and tools
- Stormwater and sewerage systems
- Wastewater sludge and faecal sludge management

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. This thrust aims to provide appropriate,

innovative and integrated solutions to water use and waste management in the industrial and mining sectors.

Current programmes are:
- Quantification of water use and waste production
- Regulatory mechanisms to improve industrial and mine-water management
- Minimising the impact of waste on the water environment
- Minimising waste production
- Improved ability to predict and quantify effects
- Beneficiation and treatment of industrial and mining effluents

THRUST 5: SANITATION AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national Government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery beyond 2010. The focus is on low-cost and affordable sanitation technologies.

Current programmes are:
- Advocacy, health and hygiene education
- Peri-urban sanitation research
- Institutional and management aspects of sanitation service delivery
- Technical sustainability of sanitation services.

THRUST 6: WATERSMART FUND

Scope: 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 related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PORTFOLIO FOR 2010/11

The KSA's continuous activities, supported by needs analysis, and needs expressed by the Minister of Water and Environmental Affairs as well as through the variety of strategic workshops and seminars with DWA and other stakeholders, ensures that the KSA's objectives and thrusts are aligned to the priorities and are well supported. The External Review 2006 highlighted that the relative weight of this KSA's thrusts seems to be well balanced regarding the needs of urban-industrial-mining and rural research needs but, given the urgency to redress past inequities, there is a need to increase the number/weight and relevance of research projects related to sustainable rural water supply and sanitation projects. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. Thus, the primary and secondary objectives of the KSA remain unchanged.

During 2010/11 the portfolio will continue to build on the strategic changes, as well as strengthen the portfolio towards making greater impacts on the social welfare, health, 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. This KSA will continue to build on and strengthen the strategic direction implemented over the recent years, which has resulted in foresight orientating the portfolio to emerging and new issues. Thus the portfolio of thrusts and programmes remains; however, we have redirected the scopes of the following thrusts and programmes to give us the flexibility to be more inclusive of emerging issues. Specifically, we have included the element of 'water footprints' into Thrust 4, and in some of the programmes we have put greater emphasis on the aspects related to policy and finance, as well as reuse and recovery. These contribute to strengthening the portfolio of the KSA and direct the KSA towards greater relevancy and emphasis. This process is continuous and will further build and strengthen the research portfolio of the KSA.

The primary objective of this KSA (as presented in KSA 3 Business Plan 2009/10) is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs' strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the new framework strategy Water for Growth and Development (Version 6).

It is now 3 years since the KSA has been directing its activities towards its new strategic portfolio of thrusts. The modus operandi used during the last few years has been to direct most of the KSA resources through solicited projects. This has greatly and successfully affected the strategic direction and the required changes in scope have been achieved. The research sector has embraced this direction to allow greater development and innovation. Strategically, this has paved the way to a changed approach where the research areas can be addressed through funds of both solicited and non-solicited projects. Thus in the portfolio we will continue to place emphasis on the following areas:

- Asset management of water services infrastructure
- Drinking water and wastewater quality
- Small water and wastewater treatment systems

- Energy efficiency and generation from water and wastewater systems
- Nanotechnology
- Water and wastewater beneficiation and reuse technologies (mine and industrial water)
- Water for growth and development
- Water conservation and demand management
- Investigating alternative energy and biofuel potential from wastewater and sludge
- Climate change
- Improving regulation of water use in the sector

The WaterSmart Fund

In South Africa, this water resource is limited, and thus can become a limiting factor to the development and growth of the country. Added to the aspects of a limited water resource and droughts, is the variability of climate and global warming which will place an additional burden on the availability of water. Water is a finite and precious natural resource. It underpins the prosperity of our communities and the health of our environment. Together as a community our challenge is how we can use our water smarter. Achieving sustainable management of South Africa's water resources is essential for current and future generations. This includes balancing the ever-increasing demand to meet the needs of industry, individuals and the environment. Use of our precious water resources is influenced by many factors, including – population growth, housing types, population densities, water consumption habits, droughts and weather patterns. These factors place pressures on our precious water resources in terms of residential, commercial, industrial and agricultural water uses. With the growth in our cities and economy, domestic and industrial water use continues to grow rapidly and put demand on our scarce water resources. This situation will also add pressure for building more infrastructure to meet this high assurance, as well as increasing the unit costs of water. Further, the downstream impacts will also increase. These sectors can play a meaningful role by improving their efficiencies in their use, postponing these large investments and reducing pressures on the scarce resources.

The objective of the fund is to bring about a paradigm shift in the use and management of water, as well as the use of energy in water, from a supply-side toward a demand-side approach. It can be generalised that the SA population is ignorant about water conservation, water efficiency and reuse. This fund and process is a small step in stimulating research and innovation in the smarter use of water and in energy-efficient water processes, and in this way can be a catalyst for bringing about awareness and behaviour change in the way the country uses its water. It also aims to bring industry, entrepreneurs and innovators into the re-search environment to support the cause of efficient water use.

The 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 related energy efficiency in the domestic, industrial and mining sectors.

BUDGET FOR 2010/11

The approved funding of the research portfolio for 2010/11 led to a committed funding budget of R 34 001 420, including R8 920 852 for new projects.

CORE STRATEGY

Strategic context

Water is an essential ingredient for economic development, the maintenance of natural life support systems and basic human existence. Urbanisation and industrialisation rates in developing countries have escalated significantly and continue to grow. Economic growth and development resulting in a greater demand for water and annual consumption continue to rise in most countries. Ensuring a reliable source of clean water and adequate treatment of wastes and wastewater for large urban populations and rural communities poses great challenges for many developing countries. South Africa is no exception to this situation and this has led the Government to embark on major water-related infrastructure development projects and to introduce water conservation measures, the focus being on optimal utilisation of existing water resources, the upgrading of existing sources and the conservation and protection of catchment areas.

Although the water requirements for domestic (rural 4% and urban 23%), industrial (3.5%), power generation (2%) and mining (2.5%) sectors are a fraction compared to total water availability and water consumed, it is the assurance (98%) and continuation of the supply that dictates the high capital and infrastructure costs. Industrial and mining processes, though a small user of water, together contribute to the bulk of the pollution affecting our water environment. The commercial use of water in the domestic urban areas accounts for 20% of the total urban water use. With the increase in population and the economy, it is projected that by 2025 water demand in the domestic sector will increase to between 30 and 35%. Any future peaks in water demand will affect the assurance levels, resulting in demand being exceeded and vulnerability increasing.

Whereas the provision of water for human needs plays a cardinal socio-economic role in the upliftment of people and in promoting a healthy population, it is the industrial and mining sectors which play a primary role in the devel-

opment of the South African economy and, hence, in the development of the country in terms of wealth creation, employment creation and export earnings. Sanitation and wastewater treatment are essential elements of service delivery that contribute to maintaining a healthy environment for our population. Environmentally, the mining and industrial sectors have common features such as an intensive demand on material and energy resources, a major impact on the landscape, a relatively low demand on the national water use and a proportionately much higher pollutant profile. This includes effluents of high concentration, contaminants that are difficult or expensive to remove, and with these the potential to degrade large volumes of water, thereby rendering them less fit for other beneficial uses. Effluents from all of these sources arise either as point sources (e.g. piped effluents from factories or sewers) or as non-point sources (e.g. runoff from un-ser¬viced high-density settlements and seepage from mine slimes dumps or mine workings).

A situation of growing dichotomy created by past practices, the current challenges for the water services sector are split into bridging the gap between the poor and unserved, in terms of access to water and sanitation services, and supporting the growth of the economy through improving infrastructure and services to industry. The rate of urbanisation is fundamentally affecting the provision of water services and is beginning to result in regular failure of existing infrastructure. The increased migration from rural areas and influx to urban areas is continually putting demands on existing systems. In the rural areas, traditional settlements present significant challenges to service delivery. While many achievements have been made by the water sector over the years in addressing these issues, the greatest and most elusive challenge is the aspect of sustainability of these achievements. The lack of investment in infrastructure operation and maintenance over the years, coupled with a skills shortage and lack of investment in replacement of infrastructure, is resulting in many systems failing to meet the requirements of good service delivery. This situation is escalating and is evidenced by the increase in reports highlighting problems.

The situation is further compounded by climate change; shortages of high-quality water sources, growing megacities, growing informal settlements, capacity and financial constraints, energy shortages and higher expectations for water, which are challenging the sustainability of the water industry in the long term. Efficient use of water for domestic, industrial and mining purposes, as well as improved sanitation, will be critical for improving public health, eradicating poverty and contributing to global competitiveness.

Taking into account all of the achievements and developments to date, it is clear that South Africa has amassed a substantial knowledge base and the competencies required to face the future challenges. However, there is a need to develop greater environmentally-sound technologies and processes that command greater integration in the solutions they provide. A more holistic and integrated approach is required towards providing sustainable solutions focusing on aspects related to the participation of society, the impact on the environment and resource base, institutional and management issues, minimisation of wastes and other emerging issues.

As water consumption continues to rise, Government will face the huge challenge of meeting increasing water supply and wastewater treatment demands. Only by developing long-term strategies to address these issues, including the introduction of water conservation measures and continued investment in water-related infrastructure, will access to clean water and treatment facilities be available to a greater proportion of the population in the future. It is clear that the cost of providing clean water to an expanding and growing population and growing economy will continue to increase.

To achieve the above, more innovative policies and improved implementation strategies for water use and waste management will be required, supported by a strong basis for appropriate technologies, changes in infrastructure approaches and broader water management policies. It is inherent that institutional processes and capacity must be in place, supported by sound technologies and methodologies. The KSA's contribution to the national strategy for growth and development is through conducting research that can yield impacts on society, economy, health and environment as defined in the strategy and the WRC's impact areas:

Water and society

In the impact area of **Water and Society**, the KSA contributions are made through understanding the effective demand for water services and the value society attaches to water. It is imperative that in dealing with challenges of water quality and availability, society is fully informed and participates in the management and use of water into the future. Initiatives delve into creating a good understanding of social scarcity and social vulnerability, people's usage of water and establishing a platform for involving society in the local regulation of water services. Some examples of projects which contribute to this impact area are: investigating the social vulnerability of people and their livelihoods and their response to water infrastructure; investigating operational and indigenous knowledge of water use and waste management; and establishing ways to integrate them into water services.

Water and economy

The costs and the price of water and water services have a significant impact on the economic growth of the country, since water is considered to be both a social and economic good. Providing affordable water services allows the sector to effectively meet the basic water supply needs of society and stimulate economic growth. Impacts in the area of **Water and Economy** are achieved by undertaking projects which create an understanding of the role of water in economic development at all levels, development of economic instruments for the management of water and stimulating water efficiency. Some examples of projects which contribute are: investigating the mechanisms and processes used in setting water services tariffs; guidelines on pricing and debt management; investigating the mechanism and processes used in setting water services tariffs; value of water to the industry.

Water and environment

All activities related to the use of water have a direct and indirect impact on the water environment. The health of our ecosystems and quality of water are key requirements for sustainable water management, and thus the understanding of linkages between the natural environmental components and their interaction with the anthropogenic components within the water cycle are crucial. The KSA contributes to the area of **Water and the Environment**, by influencing the reuse of effluents through developing cutting-edge technologies, establishing monitoring techniques to enable better regulation, introducing pollutant recovery and minimising processing techniques to minimise the impact on the environment. Some initiatives in this regard are: 'Health for Purpose' in wetlands treating waste streams; beneficiation of agri-industry effluents; development of a zero-effluent mathematical model for wastewater minimisation in a pharmaceutical facility; protocol for quantitative assessment of industrial effluents for discharge permitting; mass balance modelling for wastewater treatment plants; nanotechnology in water treatment; pilot application of a dual stage membrane bioreactor for industrial effluent treatment.

Water and health

Eradicating all forms and types of water and sanitation-related diseases, resulting in improvement in the quality of life of people and an increase in productivity, is ideally what is to be impacted through the area of **Water and Health**. Good, clean, safe drinking water and safe sanitation technologies are key ingredients, together with strong institutional support to realise this objective. The KSA achieves this through the development of innovative technologies, improved testing protocols for measuring water quality, identifying emerging pollutants and their consequences on human health, developing sound educational materials and communication techniques and undertaking risk assessments. Some examples of projects which contribute are: the development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply; the development of immersed membrane microfiltration systems for the treatment of rural waters and industrial waters; assessment of WatSan and hygiene in relation to home-/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas; development of more user-friendly structures for home-based treatment in rural areas; development of more robust and lighter VIP structures.

Needs analysis

The KSA, in its endeavour towards identifying research needs, as well as developing and improving research strategies at the thrust level, has continuously engaged at a strategic level both nationally and internationally, to identify any gaps and to strengthen the portfolio of priority research topics and areas requiring attention. We believe that the continuous process of analysing and reviewing our strategy ensures that the KSA remains on a strategic path, as well as responding to challenges of the sector. The new DWA framework Water for Growth and Development has set priority imperatives for the water sector and the KSA portfolio is aligned to respond to the challenges posed.

During the year, interaction with the Minister of Water Affairs highlighted the following areas of priority of relevance to the KSA activities:

- **Climate change:** need for interventions at provincial and local levels
- **Water conservation and demand management:** more emphasis at a domestic and industrial level
- **Water pollution:** development of technology-based solutions and changing public attitude, as well compliance and enforcement
- **Rainwater harvesting:** Raising its profile, with the need for new technologies and awareness

Similarly, a strategic session with a broad representative group of stakeholders highlighted the following areas of concern:

- Better understanding and management of the water crisis
- Skills development
- Non-compliance issues
- Water security and availability
- Carbon footprint vs. water footprint debate
- Water pollution
- Cost of water to industry

- Water footprint
- Improved knowledge dissemination and transfer

We also acknowledge that the impending changes to the institutional environment will have an impact on the KSA strategy and focus. DWA is going through a water services review process, as well as an institutional realignment process. The component of sanitation will effectively be transferred from DWA to the Department of Human Settlements from 1 April 2010. Similarly, CoGTA is also going through an institutional review process and is considering the effectiveness of the three tiers of Government process, and National Government is establishing the planning commission. We are conscious of these developments and anxiously await outcomes from these processes such that we are able to align our portfolio and projects to support the needs emerging from them.

In reviewing the wealth of information generated through the various processes, including consultation with DWA and other stakeholders, it is clear that the key challenges facing the water sector in South Africa,, remain unchanged and warrant greater emphasis and support. The orientation of the portfolio in the 2009/10 Business Plan gives the KSA the ideal platform to deal with the current and future challenges and thus we see no change in the portfolio. We believe that our strategy and focus are in line with supporting Government's long- and short-term objectives, and especially those of ASGISA (Accelerated Shared Growth Initiative for South Africa) and the recent DWA framework strategy Water for Growth and Development. These objectives are:

- In a changing and dynamic legislative and strategic environment many solutions are required for sustainable and affordable water services provision. A key focus over the next few years will be on strengthening the capacity of local government to function in this challenging environment, the introduction of successful models of service delivery which enjoy the support of all stakeholders, addressing the issue of poverty and service provision (including affordability and cost-recovery), development of appropriate strategies, tools and policies to regulate water services and give effect to the water services and related legislation. The aspects of community participation and local economic development are central to these objectives.
- The realisation of the challenges of meeting the MDG targets, and in the case of South Africa, eliminating the water and sanitation backlogs.
- The water services environment is in a continuous process of dynamic change. The newly-published related legislation, besides setting a new set of challenges and goals for the sector, has reached a point of review. It will be imperative that the success of these frameworks and legislation will realise the ultimate goal of national water policy and local Government legislation.
- The provision of sanitation is more complex and provides greater challenges as the responsibility is spread across many Government departments. The short-, medium- and long-term goals are to find effective and efficient mechanisms to accelerate sanitation delivery and hygiene education coverage. These two components are essential ingredients for sustainability and for achieving public health objectives. Focus areas over the short term are to develop appropriate technical solutions, finding cost-effective ways to provide high-impact hygiene education, finding acceptable and affordable service arrangements, models for sanitation delivery and O&M, and improving the legislation and policies that contribute to an enabling environment. The sustainability of low-cost and on-site sanitation systems is already beginning to surface. Short design life, pit emptying, relocation and access to pits are some of the key technical challenges which may jeopardise achievements made to date and the provision of sustainable sanitation.
- It is evident that new issues in water supply (water treatment, distribution, etc.) will continue to emerge as new contaminants are introduced into the water sources. Great challenges also exist in providing sustainable and affordable technical solutions for the poor and indigent sections of the population.
- The energy crisis has raised the need for more efficient use of electricity and the need for alternative energy sources. As part of the KSA's objective of efficient and affordable water services, three key variables have been the focus for many years; these being energy, chemicals and materials, which together make up an estimated 70% of the operational cost of providing water services. More emphasis is now being placed on energy issues and proactively we have initiated and promoted many approaches to support this important cause. The research on efficient water use has also been stepped up, and this has a direct bearing on the energy requirements of supplying water services. These areas will continue to grow in an endeavour to meet the needs.
- Gearing the sector towards the impetus created towards water for growth and development.
- In water supply and treatment technology, the needs over the next few years revolve around the supply of more affordable water of improved quality, especially to those people who do not yet have a reliable drinking water supply. Specific issues and research needs include the reduction in cost of water treatment and supply; the removal of organic contaminants; the removal of *Cryptosporidium, Giardia* and other pathogens; safe and efficient water fluoridation; improvement in the cost-efficiency and sustainability of small- to medium-sized water treatment plants; dependable and efficient distribution systems; cost-effective distribution systems for rural water supply and sustainable and low-cost small

water treatment systems. Medium- and long-term goals are to focus on infrastructure and asset management.

- Most of the country's industrial and mining activities are concentrated in areas where there is a lack of water resources. These sectors generate large amounts of wastes (toxic and non-toxic), which have a profound impact on the ecology of the receiving water environments. As urbanisation and industrialisation increase, increasingly complex wastewater streams are introduced. It is imperative that solutions are generated to manage these negative impacts. Furthermore, there is growing recognition for more innovative approaches such as water footprint, cleaner production and waste minimisation. These areas require greater research support for knowledge generation and application.
- The mining industry presents additional needs that emanate from its legacy of water quality-degrading waste that has been accumulating for more than a century, and which could potentially affect water quality for future generations. In the case of gold mines these needs have to be addressed with urgency, as many mines are about to close down, which may represent lost opportunities to introduce pollution-prevention measures. Key areas to be addressed include the process of acceleration of cleaner production and waste minimisation technology and the development of innovative solutions, to deal with the legacy of waste and acid mine drainage potential that has accumulated as a result of mining activities.
- There is a need for improving institutional capacity in the management of water and wastewater problems, as it has become increasingly clear that these problems cannot (in the South African context) be solved by technical solutions alone. Institutional reform and strategic management issues (such as regulation, capacity, competencies, partnerships, tariffs, community participation, etc.) all play an equivalent role in achieving an integrated solution. Great strides in information gathering and knowledge generation and application are required in this area over a short period.
- Over the past few years great strides have been made in covering water and sanitation backlogs resulting in significant achievements. This has also resulted in the expansion and growth in infrastructure in urban and rural areas. More small schemes have come into existence and from international and local experience; they pose greater challenges in their sustainable management.
- Furthermore, the infrastructure and associated resources are the assets of our country and contribute to improving the quality of life and these assets need to be managed effectively. Lack of attention over the past few years on O&M, together with the lack of training and capacity is beginning to show its weaknesses in the state of our water infrastructure. This valuable investment, if not given due attention, could prove costly for the country.
- Industry and mining is facing increasing pressure on the rising cost of water, but also increased scrutiny on the sustainable use of the resource. The concept of a 'water footprint' is an emerging and effective tool being developed to assist industry to scrutinise their activities and continuously strive to reduce their footprint on the environment.

In this regard, we will continue to build on these imperatives and will put greater emphasis in the years 2010 to 2013 in the following areas:

- Asset management of water services infrastructure
- Drinking water and wastewater quality
- Sustainability of basic sanitation
- Small water and wastewater systems
- Energy efficiency and generation from water and wastewater systems
- Nanotechnology
- Water and wastewater beneficiation and reuse technologies (mine and industrial water)
- Water for growth and development
- Water conservation and demand management, including water footprints
- Investigating alternative energy and biofuel potential from wastewater and sludge
- Climate change
- Improving regulation of water use in the sector

Overview of technological trends

At an international level there is a continuous move towards new approaches to the provision of water services and adaptation of new approaches to improve domestic water quality and improve availability of water through alternative advanced technologies. Within these objectives climate change and energy efficiency are now becoming key drivers and influences. In the quest to achieve efficient and sustainable water service delivery, it is becoming more and more important to include these two variables or factors which have a significant impact on the continuous provision of services. Against the background of South Africa's current electricity challenges, energy efficiency and wise water use are priorities.

An emerging trend in developing countries is to decentralise the management of services to a local level or to a local government level, with the national authorities moving into a stronger regulatory role. This shift provides a number of challenges of capacity and competency in the delivery of water services, especially in developing countries where there is the need to address the plight of the poor and indigent who make up a large portion of the customer base. Thus, innovative institutional arrangements and partnership models between public/private/ community are being investigated to provide optimum solutions.

Specifically in Africa, the issue of capacity and competency requirements, technology choices, institutional arrangements and costs and affordability are key areas of activity. Internationally, there is a new drive to accelerate sanitation and hygiene education delivery and radical new policies and strategies are being investigated to achieve the millennium goals. It is essential that these concepts and ideas be translated at a local level; thus requiring the need for developing improved strategies, policies and mechanisms that create a sustainable and enabling environment.

In water supply, the emphasis is on efficient use of water and on managing demand, as well as looking at the contributory elements such as energy, pipe components and materials, water supply components and behavioural aspects. In terms of treatment technology, the current international trends are toward the increased removal of more specific contaminants in the water. In addition, it is aimed at adding fewer chemicals to the treated water product (improved source quality). The removal of pesticides, heavy metals, endocrine disruptors, disinfection byproducts and other harmful organics is receiving attention. The removal of *Cryptosporidium* and *Giardia* and the use of membrane filtration in this regard are receiving much attention – especially in the USA. There is a strong trend towards improving determination techniques of these new emerging contaminants. An area receiving considerable attention is in the use of molecular biology and genetic engineering techniques. In developing countries the emphasis continues to be on breaking the transmission cycle of water and faecal-oral related diseases through understanding the practices and behaviours which contribute to the spread of diseases. Improved education and knowledge are central strategies to tackle these problems.

In the quest for improving the water quality delivered to consumers, there are growing needs for improved analytical methods to analyse for undesirable and emerging contaminants. In this regard new improved methods are continuously being investigated, keeping up with the international trends. In the developed world, there is greater attention and focus being placed on managing source quality for improved potable water quality. Secondly, as desalination technologies become cheaper, we see more use of these technologies (Singapore/Middle East are examples). This source of water is also being seriously considered by some South African coastal cities. Further to the concerns of the diminishing levels of fossil fuels, water and waste are being looked at amongst the renewable resources for energy creation. Greater attention is also being given to new promising technologies such as nanotechnologies, membranes, etc., as they may greatly benefit water treatment technology.

In both the municipal and industrial sectors, the most significant trend internationally, nationally and at local authority level has been the growing realisation of recognising effluent wastewater and wastes as a resource. The treatment of wastewaters and wastes that have been generated without the application of cleaner production and waste minimisation principles is a losing game, ultimately costing all the parties material and energy resources, i.e. money. The consequences are profound: co-regulation becomes a meaningful negotiation; value as co-product is extracted from 'wastes' before discharge, thereby further reducing the waste load requiring treatment; technologies for treatment aim at being 'cleaner', are more focused towards specific waste fractions or even constituents and include recovery and reuse where technically and economically justifiable; resource-efficient technologies are not only favoured, but even their optimum deployment ('where' in the process stream) is critically examined, etc. These trends are predicted to not only continue but, in fact, accelerate in the future.

The mining industry has yet to embrace these new realities, and wastewater and waste treatment in this sector presently continues to be material- (e.g. chemicals) and energy-intensive, although more environmentally-friendly solutions are increasingly favoured, for example, biotechnological treatment of acid mine drainage associated with potential recovery and reuse of the renovated water for a variety of purposes. The cost-effectiveness of cleaner production technology is increasingly recognised and will in itself be a strong driving force for the accelerated introduction of the technology. Another driving force is the international trade sanctions that are increasingly being applied against manufacturers that do not apply responsible environmental practices. In South Africa, it is foreseen that the introduction of waste discharge charges will be a further powerful driver towards internalising pollution costs and implementation of cleaner technology. The contribution of mining-related non-point sources to water quality degradation is increasingly appreciated and has given rise to a need for improved techniques with which to quantify their contribution and improve technologies to minimise their effect.

Key stakeholders

The Minister of Water and Environmental Affairs is the shareholder of the WRC, and DWA and DST are its key stakeholders. In addition, the following stakeholders also continue to be of key importance to the WRC in general and to this KSA in particular. They comprise both internal and external stakeholders. Over the years, our inter¬national partners and business partners have also proven valuable to us.

The internal stakeholders are the WRC personnel, Executive Management and the Board, the shareholders being the Minister of Water and Environmental Affairs and DWA.

The external stakeholders include:

- Government ministries and departments (Environmental Affairs, Cooperative Governance and Traditional Affairs, Health, Mineral Resources, Science and Technology, Human Settlements, etc.)
- Beneficiaries (i.e. the users or potential users of research, development and knowledge products produced through WRC funding)
- SALGA, local government, provincial government units
- Development Bank of Southern Africa
- Water boards, water service providers, catchment management agencies, water user associations
- Industrial sectors and industry-representative bodies (mining, forestry, water services, etc.)
- NGOs, CBOs and international aid agencies
- Private consultants
- Tertiary institutions, primary and secondary education institutions, science councils, professional bodies (Water Institute of Southern Africa (WISA), South African Institute of Civil Engineering (SAICE), Institute of Municipal Engineering of Southern Africa (IMESA), etc.), media agencies
- The public
- International coalitions such as Global Water Research Coalition (GWRC), Water Supply and Sanitation Collaborative Council (WSSCC), Water Utility Partnership (WUP), Emerging Technologies (ET), United Nations Environment Programme (UNEP), International Resource Centre (IRC), Water Research Fund of Southern Africa (WARFSA)
- The business sector

Research providers

Providers are solicited or unsolicited individuals and organisations who generate research, development and knowledge products with WRC funding. The key providers are tertiary institutions, science councils, consultants, NGOs, water boards, research units within government departments and local government, private companies and individuals.

STRATEGIC INITIATIVES

National initiatives

Contributions to national initiatives included:

- The WRC continued to play a key role in supporting DST's nanotechnology platform, whereby the Water Nanotechnology Strategy and Centre was established through a collaborative effort of MINTEK, WRC and DST. The WRC serves on the Advisory Board and the new water niche area strategic framework task.
- The WRC continued research with Anglo Platinum into treatment of mine-water currently held in indefinite storage.
- The WRC, through the WISA Small Wastewater Treatment Division, continued to support knowledge sharing and capacity building initiatives on appropriate technologies for small wastewater treatment works (SWWTW). A research manager is the chairperson of the SWWTW Division.
- The WRC continued to play a role in DST's initiative on technology-based solutions for accelerating delivery of water services.
- Launch of the National Business Initiative: A meeting was held with NBI on 8 November 2010. Both groups agreed that there were opportunities to work together on the new Water Disclosure Project that industries in South Africa are part of, as well as on further avenues to disseminate WRC research outcomes.
- A research manager is a panel member for Tshwane University of Technology's Quality Review process which will look at reviewing programme offerings, teaching and learning facilities and resources and professional practice.
- The KSA is assisting the DWA in the Water Research Institutional Review process. To this effect a national workshop was held with DST and the science fraternity on 10 March 2011 to chart out a national scenario for water research.
- The WRC, in partnership with SALGA, launched the new cycle of Benchmarking of Water Services on the 24 March 2011. The partnership will enhance municipal performance and contribute to national outcomes.

Leadership positions

KSA 3 staff members continue to undertake various national leadership positions, including the following:

- Chairperson, Water Institute of Southern Africa Small Wastewater Treatment Works Division.
- Member of UNEP and DEA National Forum Steering Committee for National Programme of Action on Protection of Marine Environments.
- Member, Steering Committee of DST/DWA initiative on Accelerating Services Delivery.
- Member, SALGA Sanitation Technical Advisory Committee.
- Member, Advisory Committee on Water Services Infrastructure Asset Management Strategy, DWA.
- Member, Advisory Committee on the DWA projects on Water Tariffs.
- Member of the National Water Conservation and Water Demand Management (WCWDM) Reference Group. The main aim of the Reference Group will be to provide strategic thinking and advice to the water sector, through the Water Sector Leadership Group, on how to promote and enhance the role of WCWDM throughout South Africa.

- Member of the Water Sector Leadership Group (WSLG).
- Advisor and member of the Steering Committee of the IWA – International Development Agency.
- Member, Water Institute of Southern Africa (WISA) Board.
- Member, Task Team on Water Boards Water Institutional Review Process.
- Member, Coaltech Surface Environment Steering Committee.
- Member, Department of Science and Technology Nanotechnology Innovation Centre Advisory Board.
- Member, Water Institute of Southern Africa Council.
- Vice-chairperson, Water Institute of Southern Africa Mine Water Division.
- Convener of WISA Mine Water Division task team on capacity building in mine water management.
- Members, DWA Task Team on Water Services to Informal Settlements.
- Member, Task Team to Review the Sanitation White Paper on Basic Household Sanitation – Department of Human Settlements.

Strategic positioning

- A research manager is a member of the Coaltech 2020 Surface Environment Committee. This Committee deals with the acid mine drainage issues that are also a major focus area of WRC research initiatives.
- A research manager is a member of the International Water Association Specialist Group management team on Nanomaterials and Water.
- A meeting was held with SABS and SANS on 6 April 2010, at the SABS offices, to discuss participation and involvement of the WRC in the processes of the SABS and SANS. Institutional changes at SABS had resulted in the breakdown of links and agreements with the WRC and the new management teams are in agreement that these processes need to be re-established.
- A meeting was held with two representatives of the National Business Initiative (NBI) on 30 July 2010 with representatives from KSA1, KSA 3 and KSA 4. It was agreed that there are several activities that the NBI is doing with its member organisations which WRC research (KSA 3) can steer and add value to.
- A Thrust 4 strategic workshop was held on 2 August 2010 with key stakeholders to help define key research priorities and potential programmes for 2011 and beyond. This process was followed by questions relating to the thrust and programmes to other stakeholders via e-mail to ensure good feedback before finalising a new or updated strategic research agenda for industrial and mine-water management.
- The WRC is a member of the Inter-Ministerial Task Team on Acid Mine Drainage for the Departments of Water Affairs and Mineral Resources.

African leadership

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

- Through an initiative hosted by WIN-SA as part of the Sanitation Knowledge Node, a meeting was held in Swakopmund, 27-28 May 2010, to discuss modalities of partnership and knowledge sharing with Namibian representatives.
- Delivered a keynote address and shared WRC research on franchising of water services, at the first IWA 'Meeting of African Utility Managers', a platform created to share knowledge between African leaders, Swaziland, 8 October 2010. WRC will support the IWA initiative with its products and tools and support other capacity building initiatives in Africa.
- Hosted the first 'Regional Seminar on Faecal Sludge Management' in March 2011, in partnership with WIN-SA, SALGA, SAKN.
- Founder Member, African Water and Sanitation Network.
- Editor: Sanitation Matters.
- Founder Member, IWA Water Safety Plan Network: Africa.
- Task Leader for South Africa and Work Package 5 Leader for African partners, Kenya, Ethiopia, Morocco and Burkino Faso, for EU CLARA Project.

International player

- Founder Member, Management Committee of the International Water Association Nanotechnology Specialist Group.
- Advisory Committee Member, IWA – GDA.
- Member, Planning Committee IWA Resilience Conference – Australia 2012.
- Member, Planning Committee IWA Development Conference – Malaysia 2011.
- The WRC continues to be an active member of the Global Water Research Coalition (GWRC). The WRC is currently collaborating with members of the GWRC in research programmes addressing algal toxins and asset management, as well a programme on Energy Efficiency in the Water Industry: A Compendium of Tools, Best Practices and Case Studies. The WRC has contributed several case studies to the GWRC project 'Energy Efficiency in the Water Industry: A Compendium of Best Practices and Case Studies'. The objective of this research study is to develop a Compendium of best practice in the energy efficient design and operation of water industry assets.
- The WRC will also be linking with the GWRC 'Water Footprinting' initiative.
- WRC is part of a new initiative coordinated by the WERF - USA, called 'Next generation of used water' which entails assessing the sustainability of current water management practices, identify those that are projected to be least sustainable over the next 20 years, and defin-

ing a new vision for conveying, treating, and reusing water that would address the shortcomings.
- The WRC is part of the new GWRC project 'Brine handling in desalination'.
- The WRC is to be a partner member in the EU-FP7 research programme CLARA: Capacity-linked water supply and sanitation improvement for Africa's peri-urban and rural areas. The WRC is one of 16 global partners involved in the project.
- Member, IWA task force on Water Quality and Health.
- Member, Scientific Programme Committee of the *IWA Nano and Water 2011 Conference*, May 15-18 2011.
- Contributed to case studies on South African experiences on water reuse for the EPA guidelines on water reuse, and invited to give a keynote address at the workshop hosted by the EPA/USAID in Jordan on March 30, 2011.

GROWING THE KNOWLEDGE BASE

Capacity building initiatives

Of the 145 students engaged in KSA3 projects in 2010/11, 106 were previously disadvantaged individuals (Table 1).

TABLE 1
Capacity building through student involvement in KSA 3 projects in 2010/11

Organisation/institution	No. of historically-disadvantaged (HD) students	Total no. of students
Africa Remediation Technology	1	1
ATL-HYDRO	3	3
Cape Peninsula University of Technology	17	20
Corporate Research Consultancy	1	1
CSIR	5	5
Counterpoint Development	0	1
Durban University of Technology	3	3
Emanti Management	1	3
Emanti Water & Environmental Engineering Services	2	2
Golder Associates Africa (Pty.) Ltd.	2	2
Hlathi Development Services	2	2
Nelson Mandela Metropolitan University	3	7
Nemai Consulting	3	3
Partners in Development	4	4
Re-Solve Consulting	0	1
Rhodes University	2	5
Sinelwati Scientific Research & Management	1	1
Sustento Development Services	0	1
Tshwane University of Technology	4	4
Umgeni Water	7	7
Umvoto Africa	1	1
University of Cape Town	3	12
University of Johannesburg	1	1
University of KwaZulu-Natal	3	3
University of Pretoria	3	4

University of Rhodes	9	12
University of Stellenbosch	4	9
University of the Western Cape	14	18
University of the Witwatersrand	5	6
Virtual Consulting	0	1
WRP Consulting Engineers (Pty.)Ltd.	2	2
TOTALS	**106**	**145**

The KSA was involved in hosting the following workshops, among others:

- The WRC co-hosted a workshop with CSIR on urine separation, to foster debate and discussions around source separation of wastewater from large complexes, new estates and office buildings, for improved functioning of wastewater treatment plants.
- The WRC co-hosted a workshop with Digby Wells and Associates on 'Cleaner production in the mining industry', April 2010.
- The WRC co-hosted a workshop with WISA Oxidation and Disinfection Division on Oxidation and Disinfection of Drinking Water, April 2010.
- The WRC co-hosted a workshop with the Southern African Young Water Professionals on 'Transdisciplinary issues in the water sector', April 2010.
- The WRC co-hosted a workshop with WIN-SA, DWA, and COGHSTA in the Northern Cape, Kimberley on 8th April 2010 on Infrastructure Asset Management and Operation and Maintenance. The workshop was well attended by 25 delegates from local and district municipalities. The NC is seen as a possible case study for the DWA IAM strategy.
- The WRC hosted a workshop on 'Franchising of water services O&M, in partnership with CSIR, during *WISA 2010*.
- KSA 2 and KSA 3 co-hosted a workshop on natural and constructed wetlands, May 2010.
- The IAM Reference Group, compromising the WRC, DBSA, DWA, Joburg Water and WIN-SA initiated a workshop in KwaZulu-Natal on 20 July 2010, which introduced infrastructure asset management (IAM), and shared the Northern Cape IAM/O&M case study with delegates with the aim of driving twinning amongst provinces and municipalities.
- The WRC hosted a TECHNEAU workshop, October 2010, on 'Water reclamation in Southern Africa: monitoring systems and risk assessment'.
- The WRC hosted a TECHNEAU workshop, October 2010, on 'Risk management of drinking water systems in Southern Africa'.
- The WRC and DWA hosted a 'Wastewater Risk Abatement Plan' workshop, December 2010.
- The WRC co-hosted an 'Anaerobic digestion' workshop with eThekwini municipality and UKZN, February 2011, to open discussions around the state of anaerobic digestion in South Africa.
- The WRC hosted the first ever regional seminar on Faecal Sludge Management in association with WIN-SA, SKN and SALGA, March 2011. The event captured five years of WRC investment and outcomes on managing dry pit latrine sludges.

Strategic capacity building interventions

- Exploratory meetings were held with Unilever, WRC, eThekwini and the Pollution Research Group on 25 May 2010 to look at future collaborative opportunities.
- An exploratory meeting was held with SAPPI Innovation Hub to re-establish links with pulp and paper stakeholders. Contact has also been made with Paper Makers Association of SA (PAMSA) Research Co-ordinator, to discuss a partnership in promoting water research.
- An initial meeting was held with DST on 28 January 2011 to explore synergies with a potential centre of competence for environmental technologies within the DST.

Conference presentations and other activities by staff members

Involvement in knowledge dissemination activities by staff members included:

- A WRC research manager chaired a session on water and was a member of the panel in a debate at the South African Institution of Civil Engineering conference, *Engineering Planet Future*, at the CSIR ICC, 16-17 March 2010.
- A paper was presented at the *WISA Small Wastewater Treatment Division*, 21 April 2010, on gaps and challenges for SWWTW and the vision and objectives of the newly formed WISA Division.
- A paper was presented on 'Biosorption and bioaccumulation of copper and lead by *Phanaerochaete chrysosporium* and *Pleurotus ostreatus*' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper was presented on 'Energy Efficiency in the water industry: a compendium of best practices and case

studies' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper was presented on 'Quality of domestic water supplies guidelines: 10 years of relevance to the sector' at the *WISA Biennial Conference and Exhibition 2010*, Durban, South Africa, 19-22 April 2010.
- A paper entitled 'Biosorptive recovery of platinum from metal refining wastewaters by immobilised Saccharomyces cerevisiae' was presented at the *IWA World Water Congress 2010* in Montreal, Canada, September 2010.
- A paper on 'Franchising principles for the operations of water services' was presented at the *IWA World Water Congress 2010* in Montreal, Canada, September 2010.
- A paper was presented on 'Web enablement of a Water Safety Plan via the South African municipal-based electronic Water Quality Management System (eWQMS)' at the *International Water Association / World Health Organization Water Safety Conference: Managing Drinking Water Quality for Public Health* and an associated meeting of the WHO International Small Community Water Supply Network in Kuching, Sarawak, Malaysia in November 2010.
- A paper was presented on 'Franchising of water services O&M' at the *IWA Water Utility Managers Conference,* Swaziland, 18 October 2010.
- A keynote address on 'Greywater - the invisible problem' was delivered at the *UNC Conference on Water Quality and Health*, Chapel Hill, USA, 23 to 26 October 2010.
- Co-authored a paper entitled 'Biosorptive recovery of platinum from platinum group metal refining wastewaters by immobilised *Saccharomyces cerevisiae*' in the journal *Water Science and Technology* (63 (1): 149-155).
- Co-authored a chapter entitled 'The Water Research Commission' in the book *Transforming Water Management in South Africa - Designing and Implementing a New Policy Framework, Global Issues in Water Policy 2 Series.*

IMPLEMENTATION PLAN

Research portfolio for 2010/11

The KSA's continuous activities, the results of the strategic needs analysis and its review, needs expressed by the Minister of Water and Environmental Affairs through the variety of workshops and seminar, engagement with DWA and other stakeholders, with regard to its objectives and thrusts have been well supported. The External Review 2006 highlighted that the relative weight of this KSA's thrusts seems to be well-balanced regarding the needs of urban-industrial-mining and rural research needs but, given the urgency to redress past inequities, there is a need to increase the number/weight and relevance of research projects related to sustainable rural water supply and sanitation projects. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. Thus, the primary and secondary objectives of the KSA remain unchanged.

During 20010/11 the portfolio will continue to build on the strategic changes, 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.

The primary objective of this KSA (as presented in KSA 3 Business Plan 2009/10) is to continue to provide knowledge that ensures reliable, affordable and efficient services to enhance the quality of life, and contribute to economic growth. These objectives are in line with the Department of Water Affairs' strategic goals in meeting the objectives set in the Water Services Act and the National Water Resource Strategy, as well as the new DWA framework strategy Water for Growth and Development (Version 6). We believe that the programmes and projects are strongly orientated to the challenges. This is receiving, and will therefore continue to receive, greater attention.

The new portfolio of projects continues to providing solutions that support these directions in the following ways:
- Developing tools, guidelines and appropriate institutional models for accelerating sustainable delivery of water and sanitation services
- Providing information that supports the development and application of water services legislation
- Improving understanding and knowledge on sanitation and hygiene education
- Extending the implementation of waste minimisation, cleaner production, cleaner consumption and clean technologies
- Investigating the potential and technologies required for recovery and reuse of water from industrial, mining and domestic wastewaters (including grey-water and stormwater)
- Furthering the knowledge and technologies for recovery and reuse of material and energy resources in water and wastewater management
- Enhancing ways to predict pollutants and their impacts
- Addressing infrastructure security and sustainability
- Optimisation of water and wastewater treatment processes
- Opportunities of energy from water and sanitation
- Supporting water for growth and development
- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology

Thirty-one (31) new projects have been approved for funding, all being non-solicited projects. The scope and expected outcomes of the thrusts and programmes are provided in Table 2.

TABLE 2
Overview and explanation of thrusts and programmes

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: 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 services providers, water services authorities, water boards, national departments) in providing sustainable water services.

Programme 1: Cost-recovery in water services	**Scope:** The issue of cost-recovery has been identified as a critical aspect affecting sustainable services. In an environment where genuine poverty affects cost-recovery, this programme intends to develop innovative strategies and processes to tackle the problem. The focus will be on generating in-depth knowledge of the problem and testing new approaches.
Programme 2: Institutional and management issues – Water services	**Scope:** Relationships and partnerships between service providers, both external and internal, are important prerequisites for 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.
Programme 3: Innovative management arrangements – Rural water supply	**Scope:** 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.
Programme 4: Regulation of water services	**Scope:** 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. Furthermore, 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.
Programme 5: Impact of water and sanitation interventions	**Scope:** The programme will address aspects related to determining and quantifying the sociological, economic, technical, health, etc. impacts and benefits of 11 years of water supply and sanitation interventions in South Africa. Over the years the Government has spent considerable sums of money to meet the backlogs and substantial progress has been made. However, very little work has been undertaken to quantify the benefits which improved water and sanitation has brought to the communities and the countries. Thus, the time is most appropriate to undertake a study of this nature.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: 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.

Programme 1: Drinking water treatment technology	**Scope:** 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.
Programme 2: Water treatment for rural communities	**Scope:** This programme aims to produce innovative and appropriate water treatment and supply technologies and processes that will ensure an adequate supply of safe and clean drinking water for rural communities.
Programme 3: Drinking water quality	**Scope:** 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.
Programme 4: Water distribution and distribution systems	**Scope:** The programme aims to optimise the quality, quantity and reliability of the distribution and supply of treated potable water to the end-users. The programme has the following expected outcomes: to develop reliable processes in 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.

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Scope: 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, informing future policy, etc.

Programme 1: Emerging treatment technologies – Preparing for the future	**Scope:** 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.
Programme 2: Application of appropriate technologies and tools	**Scope:** 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 application 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.

Programme 3: Stormwater and sewerage systems	**Scope:** 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.
Programme 4: Wastewater sludge and faecal sludge management	**Scope:** 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, stabilisation, dewatering, disinfection and beneficiation is encouraged.

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Scope: The usage of water in the mining and industrial sectors produces high concentrations of wastes and effluents. Some mining activities produce wastes that act as non-point sources of water quality degradation and acid mine drainage. The aim of this thrust is quantify waste, its impacts (footprint) and the methods of prevention, reuse, recovery and beneficiation at source. This thrust also provides appropriate, innovative and integrated solutions for water use and waste management in the industrial and mining sectors.

Programme 1: Quantification of water use and waste production	**Scope:** In order to prioritise those facets of industrial and mine-water management that need most urgent attention, it is important to quantify the water used and waste produced by different sectors. The NATSURV investigation conducted by the WRC provides the benchmark for water use and waste that are produced by the major South African industries. While the WRC has reported on water use by coal mines and COMRO on water use by gold mines, no overall assessment of the effect of mining or industrial waste on water quality is available. The available information thus needs to be updated and refined. Furthermore, new information needs to be gathered for those sectors that may present important emerging issues.
Programme 2: Regulatory, policy and financial mechanisms to improve industrial and mine-water management	**Scope:** The regulatory authorities are responsible for managing the impact of industrial and mining 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 regulatory mechanisms that are used to control and reduce the negative environmental effects associated with industrial and mining waste.
Programme 3: Minimising the impact of waste on the water environment	**Scope:** South Africa has a large legacy of mining and industrial waste products that impact negatively on the water environment. In spite of efforts to the contrary, the quantity and range of waste products are expected to increase for the foreseeable future. It is thus necessary to develop cost-effective techniques and approaches to minimise or reduce the impact that historical and new waste products have on the water environment. Approaches such as pollution prevention, rehabilitation, waste beneficiation and reuse are investigated to assess their application potential and suitability to reduce and minimise the negative impact of industrial and mining waste on water quality.

Programme 4: Minimising waste production	Scope: A direct link exists between the quantity of waste produced and its impact on the water environment. The type of waste that is produced may, however, often be of even greater importance than quantity. In order to reduce the negative impact of waste production, it is important to reduce both the quantity and toxicity of waste. The international trend towards waste management is therefore to minimise the production of waste by adopting cleaner production processes. 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. This programme investigates and promotes the implementation of approaches that minimise waste production.
Programme 5: Improved ability to predict and quantify effects	**Scope:** The environmental consequences of waste products are almost always long-term in nature, with impacts that may potentially last for hundreds of years. These long-lasting effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impact of their operations and to indicate how these will be remedied. This programme is primarily aimed at establishing and improving pollution prediction capabilities appropriate to the South African situation.
Programme 6: Reuse, recovery, beneficiation and treatment of industrial and mining effluents	**Scope:** 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 and mining activities. This programme aims to support the development of a range of processes for effective treatment, beneficiation, recovery, reuse and disposal of industrial and mining effluents, with an aim to minimise negative consequences associated with the effluents and derive potential benefits associated with them. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse and fundamental scientific/engineering support for process development.

THRUST 5: SANITATION, HEALTH AND HYGIENE EDUCATION

Scope: This thrust addresses the research required to assist the national Government to achieve its goal of clearing the sanitation service backlog by 2010. It also identifies research that is essential to support planning for basic sanitation service delivery (O&M, sustainability, etc.) beyond 2010. The focus is on low-cost and affordable sanitation technologies.

Programme 1: Advocacy, health and hygiene education	**Scope:** The main objective of this programme is to support the integration of health and hygiene into the delivery of water and sanitation in order to ensure that these services lead to maximum health benefits for the beneficiary communities.
Programme 2: Peri-urban sanitation research	**Scope:** The aim of this programme is to provide research support to sanitation in informal and developing urban areas. Until recently the focus of sanitation has been on rural areas, but the situation in urban areas is much more critical and volatile in terms of public health. Urban sanitation differs from rural sanitation issues related to institutional arrangements, community dynamics and management of interventions. Due to the high densities, technical choices are more complex where an affordable and sustainable service is to be provided. Outcomes from this programme will support local authorities in implementing sustainable solutions, which cater for both the user and the institutions' needs.
Programme 3: Institutional and management aspects of sanitation service delivery	**Scope:** The main objective of this research programme is to develop institutional models, tools and guidelines that will support the improvement of delivery (O&M, sustainability, etc.) of sanitation services.

Programme 4: Technical sustainability of sanitation services	**Scope:** To develop tools, procedures and guidelines that will guide those responsible for implementing projects in their selection of appropriate sanitation technologies that are socially, environmentally and financially sustainable.

THRUST 6: WATERSMART FUND

Scope: 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 related energy efficiency in the domestic, industrial and mining sectors.

RESEARCH PROJECTS FOR 2008/09

COMPLETED PROJECTS

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Situational analysis of water services provision in South Africa – establishing future strategies for consideration by municipalities
PD Naidoo & Associates (Pty.) Ltd.
No. 1812

Currently South African water services authorities (WSAs), i.e. those municipalities tasked with governance of water and sanitation provision, and water services providers (WSPs), i.e. those organisations or individuals tasked with the actual provision of water and sanitation on behalf of the WSA, face numerous challenges in providing sustainable services. This is because of reasons including enormous services backlogs; scarcity of technical and other skills; aging and deteriorating infrastructure asset base; non-alignment of political will with technical priorities; and an inability to always maximise cost efficiencies through benefits of scale and scope.
This difficult and complex situation is exacerbated by the fact that WSA decisions to set up institutional arrangements are guided by legislation that is onerous, and that articulates a decision making process, but does not provide sufficient guidance on content and configuration of institutional arrangements, or a rationale for choosing one arrangement over another. Furthermore, institutional arrangements are viewed in terms of whether they are 'centralised' or 'decentralised'. However, these terms are used loosely and, since all water services provision takes place within a decentralised governance framework, they are sometimes misleading in their application. This study has found that it is important that the South African water services sector explores issues of 'centralisation' and 'decentralisation' in a much more nuanced way, and within the decentralised institutional framework for water services provision. Institutional arrangements for water services provision in South Africa may be described as 'more consolidated' or 'less consolidated' in terms of how functional areas within the institutional arrangement are configured. They will generally be a mix of consolidated and non-consolidated functional areas, supported, as appropriate, by consolidated auxiliary services. All institutional arrangements should be viewed as context-specific, guided by the needs of the functional areas and challenges as presented at the time of the section 78 assessment, and by opportunities for benefits of scale and scope. Politicians have a responsibility to understand the water services business, and to enable sustainable water services provision through whatever institutional arrangement they have chosen for their WSA. The link between integrated catchment management and water services provision needs to be further explored and developed in terms of the institutional realignment and reform process.

Cost: R600 000
Term: 2008 - 2010

Programme 4: Regulation of water services

Investigating the mechanism and processes used in setting water services tariffs
Nelson Mandela Metropolitan University
No. 1871

Prosperity in South Africa depends, among other things, on the sound management of water, but with expanded aspirations and political commitments, municipalities and central government in South Africa have found themselves in a challenging situation with respect to the provision of water services for the last decade. The municipalities depend heavily upon central government assistance to meet their mandate to provide water services to the local communities they serve. To address the above-mentioned challenges, the South African Local Government Association (SALGA) and the Department of Water Affairs and Forestry

(DWAF) established a need for a framework to be developed for municipal water service tariff setting. In response, this study has found that the primary current influence on municipal tariff design is compliance with water and municipal governance law and policy, and that for many of South Africa's municipalities meeting the compliance goals is challenging, to the point of being almost overwhelming. Further, many municipalities use limited (if any) accounting information to determine the availability tariff and thus there is uncertainty within South African municipalities as to the underlying economic rationale of the water service tariff (price) structure.

Estimated cost: R600 000
Expected term: 2009 -2010

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 2: Water treatment for rural communities

A management information tool for the efficient operation and maintenance of small water treatment plants
Chris Swartz Water Utilisation Engineers
No. 1718

The performance of some small and medium-sized water treatment plants in terms of the provision of a potable standard of drinking water to the end consumer is suspect, mostly due to inadequate management. South African studies have shown that in non-metropolitan communities with adequate water supply services the drinking-water quality is often poor. While effective water treatment is accepted as necessary, the need for monitoring and management of water quality from raw water supply to point-of-use is less recognised and often superficially performed. Although ensuring water treatment is already the focus of various initiatives, further attention is urgently required. One of the reasons for this is the lack of an adequate and efficient management information system. Water services providers either have their own system or do not use a system at all. This project developed a simple and user-friendly system of a set of standardised, active sheets (analogous to log-sheets) to be filled in by operations and management staff. The sheets are in electronic format, but also available in hard copies for plants without computers. It is possible to enter all categories of information that require immediate action or storage for later manipulation and use, such as flows, levels, qualities, chemicals, assets, human resources, finances, stock, maintenance schedules, etc. The operational information tool also links up with the WRC manual and training aids for sustainable operation and maintenance of small water treatment plants (WRC Project K5/1599). The tool fits into present municipal systems, and the information tool is integrated with the DWAF information systems, such as the Drinking Water Quality Framework and Management Tool. The information tool is also integrated with the eWQMS. Training aids comprising interactive media and wall-posters indicating step-by-step processes for using the tool are available on CD as well as on the Technical Assistance Centre (TAC) website.

Cost: R800 000
Term: 2007 - 2009

Programme 3: Drinking water quality

Investigation of the distribution and diversity of South African toxic freshwater cyanobacteria with special reference to analysis of the neurotoxin BMAA and molecular genetic methods for microcystin screening
Nelson Mandela Metropolitan University
No. 1719

Beta-N-methylamino-L-alanine (BMAA) is produced by free-living cyanobacteria, with one of these being marine. BMAA has also been identified as a potential risk to human health as it is implicated in Alzheimer's disease, Parkinsonism and Amyotrophic Lateral Sclerosis (ALS). The possibility of sustained exposure to BMAA via drinking water supplies prompted the establishment of local analytical capacity for the neurotoxin, urgent verification of the production of BMAA by free-living cyanobacteria, the evaluation of the distribution of BMAA producing free-living cyanobacteria in South Africa and the extent of BMAA contamination of surface waters. In the case of freshwater cyanobacteria BMAA would be released into raw water which may be used as a potable water source. The efficacy of current treatment systems for BMAA removal is unknown. The potential risk to consumers was therefore also unknown but could be determined by addressing the extent of raw water contamination and treatment efficacy. Since biotoxins are often present in low concentrations, large volumes of water needed to be concentrated to be able to quantify BMAA. In order to assess the extent of free BMAA contamination of water, a concentration method needed to be developed. A culture collection of South African cyanobacterial isolates was established, expanded and maintained as part of this project. BMAA analysis was optimized using a commercial chloroformate derivitization kit (EZ:faast) with gas chromatography - mass spectrometry (GC/MS) and high performance liquid chromatography - mass spectrometry (LC-MS) analysis of derivatized amino acids. The GC-MS BMAA detection developed for this project was 15 times more sensitive than previously published fluorescent 6-aminoquinolyl-N-hydroxysuccinimidyl carbamate-derivatized BMAA detection methods and the LC-MS BMAA detection method is 50-fold more sensitive. The lower limit of sensitivity for detection was below 100 pg per injection, and quantification was possible at 148 pg. BMAA was detected in 97% of all culture collection

strains examined. A concentration protocol based on a strong cation exchanger with hydrophobic interaction was developed for extraction and concentration of BMAA from raw water samples.

Cost: R1 000 000
Term: 2007 - 2010

Situation and gap analysis of water quality testing in South Africa
Jeffares & Green
No. 1720

There are a limited number of laboratories that undertake water quality testing in South Africa. More significantly, many of these laboratories have capacity limitations. These laboratories are a critical link in the value chain that ensures safe drinking water for consumers and unpolluted water in our water resources. Until recently there has been little focus on the quality control of the laboratories utilised in the testing of water. This has resulted in municipalities and the Department of Water Affairs (DWA) using both centres of excellence and those with little evidence of being able to produce reliable results. However, the most startling issue is that although the problem was acknowledged within the sector, it could not be quantified. This WRC project has begun the process of quantifying these gaps in the sector. A database was developed of existing laboratories that undertake water quality testing and, through a survey, obtained information on their capability and credibility. Nearly 200 laboratories were identified and 50% of these completed the survey. The geographic spread of the laboratories correlated to their testing capability has provided a useful tool in establishing if there are sufficient laboratories across the country, and where additional credible laboratories need to be established. The survey submitted to all water quality testing laboratories was based on staff capacity, laboratory capability, equipment, accreditation methodology, quality assurance methodology, area served and general remarks. By critically analysing these categories, a holistic gap analysis has been portrayed, providing a base for improvement in the water quality testing sector and thus improving water service delivery. The DWA will be the custodians of the database, using it to build a list of recommended/approved laboratories for use by municipalities in their water quality monitoring programmes, and also maintaining the information so that it remains current.

Cost: R800 000
Term: 2007 - 2011

EDC bio-assay toolbox
Biostream; University of Pretoria; A Burger (independent consultant); North-West University, CSIR (Natural Resources and the Environment)
No. 1816

The presence of estrogenic compounds in drinking waters, source waters and wastewater is of international concern because of potential adverse health effects on wildlife and humans. Chemical analysis in environmental matrices has been problematic due to both the large numbers of compounds with endocrine-disrupting capabilities that may be present in the environment and the ultra-low concentrations that have been reported in the literature to cause estrogenic effects. Biological methods are becoming increasingly popular as screening tools because the specific chemical nature of an environmental sample is not always known. As the effects of chemical mixtures cannot always be inferred from their concentrations, bioassays are an important component of examining the presence of and integrating the effects of complex mixtures of endocrine-disrupting chemicals. The project investigated a suite of bioassays suitable for laboratory screening in one or more of the matrices outlined above. Initial method selection was based on parameters such as local and global applicability, sensitivity or limits of detection, reproducibility, robustness, ease of use, application to more than one matrix, appropriate sample preparation and isolation procedures, environmental relevance, cost, repeatability and others as determined during the study. Receptor binding, reporter gene, cell proliferation and in vivo bioassays should be representative of potential adverse effects that could impact aquatic ecosystems and/or animal health and be applicable for future evaluation of water and wastewater treatment technologies. After completion of the initial evaluation of the bioassay suitability, YES Assay, T47D-Kbluc, E-screen and VTG ELISA were identified for inclusion in the manual. The complete standard operating procedures (SOPs) have been developed. The availability of such tools will allow the regulator / health authorities to make decisions based on sound scientific data when faced with a new water quality problem or the presence of new chemicals with unknown properties and to base decisions on the precautionary principle.

Cost: R870 000
Term: 2008 - 2010

Programme 4: Water distribution and distribution systems

Investigating private on-site water use and its impacts
University of Stellenbosch
No. 1819

The development of appropriate technology to oxidise sulphides to elemental sulphur, in order to close the loop in the biological removal of sulphates from acid mine drainage (AMD) and industrial water, remains an obstacle in the commercialisation of the biological removal processes where South Africa has developed a leading edge.

Advanced techniques were used to study floating sulphur biofilm structures that developed in a Linear Flow Channel Reactor (LFCR), and to develop a descriptive model integrating the various processes occurring in the floating sulphur biofilm. The LFCR showed potential as a basic unit operation for sulphide removal from AMD. An average sulphide removal of 88%, and sulphur recovery of 66%, was obtained for an eight-channel LFCR. Further studies led to the development of the Floating Sulphur Biofilm Reactor, which provided for a sump for biofilm accumulation and also investigated surface skimming as a possible improvement over biofilm settling as the sulphur recovery harvesting mechanism. A 400-day operating study achieved an average sulphide removal of 65% and a sulphur recovery of 56%. Substantial performance improvement could be achieved with further optimisation studies.

Cost: R300 000
Term: 2008 - 2009

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies

Evaluation of a South African clinoptilolite for ammonia-nitrogen removal from secondary sewage effluent for pollution control
University of Pretoria (Department of Chemical Engineering)
No. 1658

The current discharge requirement of ammonia-nitrogen in secondary sewage effluent is 10 mg/ℓ. This discharge requirement may be reduced to 6 mg/ℓ in future. Municipal biological treatment plants have experienced that it is sometimes difficult to produce treated effluent containing less than 10 mg/ℓ ammonia-nitrogen. This project investigated the potential of reducing ammonia-nitrogen via inclusion of a selective ion-exchange system to the existing treatment train. Ammonia-nitrogen can be removed from wastewaters by selective ion-exchange using clinoptilolite, biological nitrification and denitrification, liming to pH 11 followed by air (or steam) stripping, breakpoint chlorination followed by treatment with activated carbon and treatment in algal ponds. Biological nitrification and algal ponds may not be suitable where low temperatures are encountered. Stripping and breakpoint chlorination are considered to be too expensive for the high ammonia-nitrogen concentration levels encountered in secondary effluent. Selective ion-exchange of ammonia-nitrogen using the natural zeolite, clinoptilolite, in the sodium form, which is not very sensitive to temperature fluctuations, and which is a locally occurring mineral, should be suitable for ammonia-nitrogen removal from secondary sewage effluent. Knowledge that is lacking in South Africa is the performance of the local clinoptilolites for the removal of ammonia-nitrogen from secondary effluent. This technology could be an effective low-cost technology for the final polishing of secondary sewage effluent to reduce the ammonia-nitrogen concentration to acceptable levels.

Cost: R317 000
Term: 2006 - 2010

Programme 2: Application of appropriate technologies and tools

A status quo assessment of the effectiveness of wastewater pond systems for containment and treatment of wastewaters, and the development of practical operating guidelines
Emanti Management (Pty.) Ltd.
No. 1657

The aim of this study was to highlight the status quo of waste stabilisation ponds in South Africa, using the Eastern Cape and Free State as case studies. The information obtained was used to create a simpler and more user-friendly guide to operations and maintenance of waste stabilisation ponds. In addition, a key gap highlighted was the poor management of the plants which resulted in the compilation of a management guide for waste stabilisation systems. The study also led to the production of a waste stabilisation pond assessment tool which resides on the electronic Water Quality Management System (eWQMS). The tool will be useful for water service authorities (WSAs) in terms of identifying key areas of risks for waste stabilisation ponds so that they can plan and implement remedial measures accordingly.

Cost: R700 000
Term: 2006 - 2010

Programme 3: Stormwater and sewerage systems

Stormwater ingress in South African sewer systems: Understanding the problem and dealing with it
Duzi-uMngeni Conservation Trust (DUCT)
No. 1731

Stormwater ingress into sewer networks is a worldwide problem, but is particularly bad in South Africa. The Msunduzi Municipality is acutely affected, with peak sewer flows tripling or even quadrupling during times of heavy rain, and with average daily flows doubling and remaining elevated for a substantial period after rain. This study, therefore, used Msunduzi Municipality as a case study to evaluate the extent of the problem, the inventions required, the bylaws applicable, the inspection programmes that can be managed by municipalities without significant cost and the enforcement methods applied. The study showed

clearly that rainfall events which lead to sewers overflowing can be linked to illegal connections, and that sewers and wastewater treatment plants are severely impacted during rainfall events even if only 10% of the houses have illegal connections. It is important to note that people connected illegally to sewers in order to prevent their properties from being flooded; thus there was a need for municipalities to evaluate stormwater management options, especially in previously disadvantaged areas. Finally, the study demonstrated that a simple inspection programme could be created and successfully implemented by training and using local unemployed people. Public awareness and community education campaigns can serve to reduce the stormwater load at source, and provide an alternative to upgrading infrastructure which is capital intensive and time consuming. The study provided information on stormwater ingress in a pamphlet and distributed it to a sample of residents – this was found to increase awareness of stormwater ingress by up to 20% in the targeted areas relative to nearby areas which were not targeted. This was significant given the limited duration and scope of the intervention. For an awareness and education campaign to be really effective, however, it would need to be part of a co-ordinated city wide campaign followed up by extensive inspections and backed up by the political will to deal with transgressors.

Cost: R334 250
Term: 2007 - 2011

Development of a South African guide for the design and operation of waterborne sewerage systems
University of Pretoria
No. 1744

A number of sanitation options are available. The choice of the optimal/best option is inter-related to appropriate technologies, environmental impact and the health hazards to users, but is also strongly influenced by the operational and management inputs that are required for a sustainable service. Different standards for the various sanitation options are available, but no collated and comprehensive documentation is available in South Africa to educate the end user and to highlight the technologies in such a way that managers can select the optimal technology for a specific application. This is the first such consolidated and comprehensive guide in South Africa on the subject of water sanitation. The guidelines will also be a great educational tool which can be distributed throughout the country cost effectively (as a DVD), and which would open managers' and decision makers' eyes to the alternative options available.

Cost: R585 000
Term: 2007 - 2011

Sewer master planning tools and guidelines
Stellenbosch University; GLS Consulting Engineers
No. 1828

The aim of the project was to present a simplified approach to sewer system planning with accompanying tools that could be used directly as a low-technology (non-computer based) method for sewer system planning, and to better understand the planning process. A key problem identified in small local authorities was that staff members at ground level, responsible for service delivery, were often limited in terms of basic knowledge regarding the sewer system, its operation and planning. The understanding of sewer planning as a simple tool was developed through a series of workshops, an extensive knowledge review and feedback from the reference group. The knowledge review covered sewer system planning, local practice, key issues pertaining to small local authorities, design philosophies, the dynamic planning process, sewer flow and flow components, as well as an extensive review of completed South African sewer system (master) plans. The knowledge review set the scene for development of low-technology tools that could aid staff in small local authorities while the workshops allowed for the tools to be developed and adjusted during the process. Three outputs were produced from the study:

- A technical report explaining the process of development of the tools and the key components which are important for sewer planning
- A poster incorporating a simplified sewer planning process tool and sewer infrastructure estimates
- A low-technology toolkit comprising six stand-alone booklets termed 'tools'

Cost: R600 000
Term: 2008 - 2011

Programme 4: Wastewater sludge and faecal sludge management

Influence of sludge conditioners on the soil-conditioning properties of sewage sludge
University of Pretoria
No. 1540

This project studied the effect that organic and inorganic conditioning agents used in sludge treatment could have on the soil conditioning properties of sewage sludge. Overall, it was found that the polyelectrolytes investigated do not adversely affect the soil conditioning properties of sewage sludge. With the exception of ferric chloride, polyelectrolyte sludge conditioners were superior to inorganic sludge conditioners to dewater sludge. Water uptake was similar for both conditioned and unconditioned polyelectrolyte treated sludge, and higher than for sludge treated

with inorganic salts. Unconditioned and conditioned sludge displayed a similar hardness and BOD/COD ratios. Mineralisation of polyelectrolyte-treated sludge was not inhibited by high dosages of polyelectrolyte, while polyelectrolytes actually contribute towards slightly higher nutrient concentrations in the soil. It was recommended that the current practice of applying organic sludge conditioners to sewage sludge should be maintained

Cost: R101 000
Term: 2004 - 2011

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 1: Quantification of water use and waste production

An assessment of how water quality and quantity will be affected by mining method and mining of the Waterberg coal reserves
University of the Free State
No. 1830

The Lephalale region of the Waterberg contains the third largest coal reserves in South Africa and can become a new powerhouse for coal-fuelled electricity production in the country. Due to the planned expansion of the mining enterprises in the area and the accompanying developments, it is important to determine the extent of the impacts these developments will have in the area. This study looked specifically at the impacts these developments will have on the groundwater quality and quantity in the area. The project was conducted in several stages, beginning with two hydrocensus to locate as many boreholes in the area as possible. Water levels, borehole depths, location and EC and pH were measured and groundwater samples collected. Other data were gathered from Exxaro, Sasol and Eskom and compiled into a database used for contour maps, the determination of recharge, etc. Tests in the field determined the aquifer parameters of the different aquifers present in the study area. To account for influx of water to the study area, the recharge for the study area was calculated by means of the chloride mass balance method and the E.A.R.T.H. model. These calculations indicated a low recharge for the area. To determine the acid potential, acid-base accounting (ABA) was performed on the collected samples; the tests indicated that most of the samples collected would become acidic upon oxidation. To form a more complete conclusion of the potential impact of mining of the coal field samples were collected from the beneficiation plants at the Grootegeluk Mine. These samples were also analysed for acid potential, the results of which indicated that the samples will become acidic upon oxidation. Numerical modelling was used in order to determine the impact the mines would have on the groundwater and the flow directions of the groundwater. The dewatering models indicated that there very little water was available in the study area with small volumes predicted to flow into the mines. The decant models indicated that there was no possibility of the pits ever reaching decant levels with the highest recorded rise being seven metres, 50 years after mining had stopped. It was concluded that the most effective way to preserve the water quality and protect the groundwater quality from further deterioration was to keep all acid generating material dry as it would not be possible to flood this material once the mine closes, due to the small volumes of water in the area. The volumes of water that will enter the mines from groundwater and surface runoff will be small, hence it is recommended that the water be pumped out and used for run of mine operations such as dust suppression or washing of the ore. Steps should be taken to minimise the risk of encountering a fault during mining. If the mines encounter large faults and start to dewater the faults, many farmers with boreholes along the length of the fault might see significant decline in the water levels of their boreholes. It is recommended that preventative measures be taken rather than containment for the new mines planned for the area.

Cost: R700 000
Term: 2008 - 2010

Programme 2: Regulatory, policy and financial mechanisms to improve industrial and mine-water management

Geochemical sampling and analyses for environmental risk assessments using the Wits Basin as a case study
Pulles, Howard & de Lange
No. 1624

Limited work has been done on the development of methodologies for sample sizing and quantifying uncertainties in geochemical sampling and analyses. This project addressed this deficiency in geochemical sampling and analyses and proposes two methodologies (i) for quantifying uncertainties in geochemical sampling and analysis as a function of sample size and analysis and (ii) for determining the optimum sample size to ensure data quality. The two methods were applied to acid-base accounting (ABA) data derived from geochemical assessment for environmental risk assessment of the West Wits and Vaal River tailings dams. The study was aimed at assessing and evaluating the potential of tailings dams in the two mining areas to impact on water quality and the implications of this in terms of mine closure and rehabilitation. Findings showed that the number of samples needed is influenced by the purpose of the study, size of the target area, nature and type of material, budget, tolerable error and the confidence level required, among other factors. Acceptable error has an inverse relationship with sample size, and confidence level and standard deviation have a positive

correlation with sample size; hence one can minimise error by increasing sample size. While a low value of acceptable error and high confidence are always desirable, a trade-off among these competing factors must be found. The findings also demonstrated that uncertainties in geochemical sampling and analysis are unavoidable. They arise from the fact that only a small portion of the population rather than a census is used to derive conclusions about certain characteristics of the target population. Effects such as poor sampling design, inadequate sample size, sample heterogeneity and other factors highly affect data quality and representivity hence measurement uncertainty. Among these factors, factors associated with sampling, and, mainly, heterogeneity, were found to be the strongest contributing factors toward overall uncertainty. This implies an increased proportion of expenditure should be channelled toward sampling to minimise uncertainty. Uncertainties can be reduced by adopting good sampling practices and increasing sample size.

Cost: R562 000
Term: 2005 - 2010

Programme 3: Minimising the impact of waste on the water environment

Arsenate resistance in microbial communities developing in maturing FA-AMD solids
University of the Western Cape (Department of Microbiology)
No. 1655

Fly ash has been investigated as a method to neutralise acid drainage from mines. The solids generated during the neutralisation process are generally rich in insoluble metals and metalloids (some of which are toxic or otherwise environmentally undesirable). The solids are being considered, inter alia, for backfilling of mines and use in soil remediation. This project thus established that the insoluble metals and metalloids, which form part of the solid neutralisation product, can be remobilised as a result of microbial activity which (eventually) develops in the solids during the process of maturation and when they are exposed to the environment.

Cost: R220 000
Term: 2006 - 2010

Refinement of the decision support system for metalliferous tailing disposal facilities
Golder Associates Africa
No. 1735

This project represents the second phase of a three-phase research programme to develop a comprehensive decision support system (DSS) for the sustainable design, operation and closure of mine residue disposal facilities. As part of the refinement of the DSS developed during the first phase, this project developed a performance demonstration protocol (i.e. a procedure or guidance that can be used to demonstrate the acceptability of a particular technique, technology or approach), assessed the alignment of the DSS to current legislation, undertook specialist studies of specific knowledge gaps and identified and assessed new and promising technologies and approaches. Four specialist studies related to water and geochemistry were conducted, namely depth of the oxidised zone, tailings water balances, pore-water quality evolution and protocols to handle uncertainty in model predictions. Surface stability specialist studies focused on erosion rate, effectiveness of cover technologies and the development of protocols to monitor and check surface stability during the post-closure phase.

Cost: R2 200 000
Term: 2007 - 2010

A systematic approach to sulphidic waste rock and tailings management to minimise AMD formation
University of Cape Town
No. 1831

One of the major environmental issues in the mining industry is that of acid rock drainage (ARD), caused by the disposal of sulphide-bearing wastes. Re-examination of the manner in which waste materials are disposed from the mineral processing and extraction stages of metal recovery is required to relieve the environmental burden created and reduce the time frame of risk. In this study, the approaches to the removal of risk through removal of sulphur species were considered through a review of key work and a set of case studies addressing specific mineral wastes. Aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides (especially pyrite) have been addressed, with the focus of reducing capacity to form ARD through removal of the sulphidic component of the waste. The understanding of the factors governing ARD generation from dump rock and tailings (similar to those governing mineral bioleaching) has been used to improve categorisation, separation and planned disposal of its components to mitigate ARD generation. While flotation and accelerated bioleaching have been used in the case studies to demonstrate sulphide removal by separation and reaction, a review of suitable unit operations is provided. Further, use of acid-base accounting and net acid generation methods as static chemical methods for evaluating ARD potential is supported by the development of a biokinetic test for assessing ARD potential under an environment more cognisant with the ARD-generating environment, as well as providing kinetic data over a shortened time frame to conventional kinetic tests. The biokinetic test also delivers solutions through which to

analyse metal deportment through ARD. A case study using flotation for the physical separation of sulphide from tailings allowed the demonstration of the concept of risk removal. In a second case study using reaction to remove the sulphide fraction, the relative impacts of removal of acid neutralising and acid forming capacity were apparent, with the rate of the former exceeding that of the latter and being largely complete within 50 days. A third, preliminary, case study on coal desulphurisation by flotation was unable to demonstrate significant separation of total sulphur from coal ultra-fines, both visual observation and net acid generation (NAG) prediction tests demonstrated a significant separation of sulphidic sulphur, with the majority of the acid-generating sulphidic sulphur reporting to the concentrate fraction, resulting in an acid-forming concentrate while the residual tailings showed an increased NAG pH and reduced acid-forming ability over the feed material. Physical separation of sulphidic materials from tailings has been demonstrated to provide the major tailings fraction as non-acid forming while the reactive gangue may be contained in a small fraction of the tailings for additional recovery of values, utilisation of the sulphide or contained disposal.

Cost: R598 320
Term: 2008 - 2010

Programme 4: Minimising waste production

The introduction of cleaner production technologies in the mining industry
Digby Wells & Associates
No. 1553

This project introduced cleaner production (CP) technologies to the mining industry by using a number of CP tools. A scoping study identified distinct differences in how big and small companies improve their practices and consider environmental impacts. Company policy and the practices of their competitors drive awareness within larger companies, while legislation drives awareness in smaller companies. The fact that several existing water-related threats by and to the mining industry can be alleviated by CP technologies presents opportunities to facilitate the introduction of CP approaches. Cleaner Production Forums were formed where coal and gold miners could share ideas, fight common battles and share success stories. Life cycle analysis studies were carried out to determine priority areas and acquaint industry with the technique. Throughout the project term a campaign was maintained to raise awareness of the benefits of and need for adopting CP approaches. A CP guide was developed to assist mining companies with implementing CP programmes.

Cost: R3 000 000
Term: 2004 - 2009

Programme 5: Improved ability to predict and quantify effects

Evaluation and validation of geochemical prediction techniques for underground coal-mines in the Witbank/Highveld region
Pulles, Howard & de Lange
No. 1249

This project was undertaken to reduce uncertainty regarding the applicability of different techniques that are available for the geochemical prediction of long-term water quality from mines and to address confusion about how the available tools should be applied in practice. Static tests (acid-base accounting and mineralogy), kinetic laboratory tests (humidity cell and column leach tests) and equilibrium and kinetic modelling techniques were evaluated at two underground collieries to establish what predictions could be made with each tool and what the limitations and uncertainties are with each. As far as possible, different specialists assessed the different tools in reasonable isolation from each other in order to determine what conclusions could be drawn without cross-referencing the results from other more sophisticated tools. A decision tree was developed to show how to apply the different tools. The use of a full suite of tools is capable of providing extensive information on potential future water quality impacts from mines.

Cost: R1 416 100
Term: 2001 - 2010

Development of water balances for operational and post-closure situations for gold-mine residue deposits to be used as input to pollution prediction studies for such facilities
Pulles, Howard & de Lange
No. 1460

This project was undertaken to develop a procedure and methodology that mines, researchers and consultants can use to develop water balances for gold mine waste residue deposits. A wide range of measurements were made to characterise the water balance on two tailings dams and a gold waste rock dump. The water balance of tailings dams is complex since these facilities consist of variably unsaturated porous media with saturated and unsaturated zones. All of these components were studied and the report presents detailed recommendations on how water balance studies should be undertaken for cases where a screening-level water balance is required and for cases where a detailed and accurate water balance is required. For a detailed water balance, some form of numerical modelling will be required and the report provides guidance on what models could be used, what parameters need to be determined and how the required data should be collected.

Cost: R913 500
Term: 2003 - 2011

Prediction of how different management options will affect drainage water quality and quantity in the Mpumalanga coal mines up to 2040
Golder Associates Africa
No. 1628

Available information (mainly) was used to predict how a number of management interventions may change the quantity and quality of water draining from Mpumalanga coal mines by 2080. The ACRU-Salinity model indicated that the increased recharge associated with mining can significantly increase the available water in the area. The Water Resource Planning Model indicated that mine water can contribute 65 to 100 Mℓ/d to meet growing future water demands of local municipalities. Water treatment was found to be the only management option that will be able to improve water quality within Witbank and Middelburg Dams to RWQO levels. Soil covers can significantly reduce recharge and thus the volume of water that needs treatment. The associated reduction in recharge, furthermore, delayed the onset of decant and the need for treatment. Relatively small sums of money have to be set aside now to cover the closure costs in 40 or 50 years' time.

Cost: R1 500 000
Term: 2005 - 2011

Programme 6: Reuse, recovery, beneficiation and treatment of industrial and mining effluents

Novel technology for the recovery of water and solid salts from hypersaline brines: Eutectic freeze crystallisation
University of Cape Town
No. 1727

Increasing use of water recycling has resulted in an increased generation of inorganic brines and concentrates. Eutectic freeze crystallization (EFC) offers a novel, sustainable method for treating brines and concentrates that were previously regarded as recalcitrant, due to their complex nature, and which were consequently discharged to evaporation ponds. With EFC, pure water and pure individual salts can be recovered, thereby making a significant leap towards achieving zero-effluent discharge. Eutectic freeze crystallization has been shown to be effective in separating a single salt and water, but has yet to be applied to complex hypersaline brines that are typical of reverse osmosis retentates in South Africa. Thus, the aim of this research was to investigate the applicability of EFC to the hypersaline brines and inorganic effluents produced by industries. The experimental work aimed at investigating the effect of complex aqueous chemistry and impurities on the EFC process. The presence of impurities, even in small concentrations, had a significant depressing impact on the eutectic temperature of the binary system. Maintaining a critical solid mass content, i.e. the amount of ice and salt crystals in the reactor, was found to be of significant importance as it directly affected the purity and yield of the crystalline products. Thermodynamic modelling of the effects of salts on eutectic temperatures was carried out and it was demonstrated that, at these relatively low concentrations, the ice always crystallizes first, followed by the higher hydrated salts. No significant shifts in salt freezing points were observed due to the relatively low concentration of salts in the retentate. Experimental studies were carried out on synthetic brines to establish the eutectic temperatures and compositions. A preliminary economic evaluation was conducted to provide an approximation of the expected operating and capital costs associated with using EFC. These were compared to triple-effect evaporative crystallization (EC) using two brines broadly representative of typical South African industrial brines, i.e. consisting of Na2SO4 and NaCl. A basis of 100 m3/day of brine was used. The operating cost savings of using EFC over EC were found to be 79% and 76% for Brine 1 and Brine 2 respectively. Future studies will focus on further refining the understanding of the scientific fundamentals together with investigating key operating parameters that will enable the process to be tested at pilot scale.

Cost: R793 305
Term: 2007 - 2010

Laboratory and pilot scale development of the Ambient Temperature Ferrite Process (ATFP)
Phatamanzi Water Treatment
No. 1891

This project was commissioned in response to an opportunity to implement the ambient temperature ferrite process (ATFP) as part of the CSIR ABC Desalination Process that was to be installed at the ERPM site in Germiston, Gauteng, treating 100 Mℓ/d of acid mine drainage (AMD). The laboratory results indicated a relationship between the operating pH, retention time, ferrite seed concentration and feed ferrous iron concentration in removing the ferrous iron from solution and forming ferrite intermediate on the ferrite seed present. The contact stabilisation reactor was fed Harmony Gold AMD, which contained Fe(II) concentrations of 280-890 mg Fe/ℓ. The contact stabilisation reactor was capable of removing all of the aqueous ferrous iron from the AMD if the system was operated at a pH of at least 9. For the systems, the feed ferrous iron was removed from concentrations as high as 890 mg Fe/ℓ, with seed concentrations of 3gFe/ℓ and retention times as low as 10 minutes, although 15 minutes was required for a system operating with a pH of 9. For solids removal, a clarifier operating with an up-flow velocity of 5 m/h was required,

resulting in a 14-times thickening of the ferrite solids (seed plus intermediate). However, when the ATFP pilot plant was operated under these conditions, the system failed within a few days, indicated by a build-up of brown-coloured material in the process. Numerous changes to the operating procedure were made, but it was shown that it was difficult to maintain high seed concentrations in the system using the existing infrastructure, since the freshly-produced ferrite seed had different settling properties to the mine ferrite. This led to a steady deterioration in the solids quality and ultimately process failure. Therefore, it was not possible to operate a successful ATFP treating AMD using lime. The process should first be proven at laboratory scale using AMD and lime before another pilot plant is built and operated.

Cost: R1 776 957
Term: 2009 - 2010

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 4: Technical sustainability of sanitation services

Sustainable options for community level management of grey-water in settlements without on-site water-borne sanitation
University of Cape Town (Department of Civil Engineering)
No. 1654

One of the main objectives of this study was to deliver low-cost, environmentally-friendly grey-water technologies, and to ensure that in so doing there was collaboration and genuine co-operation at all phases, including reflexive learning and modification of these options. The process and results were disappointing, attributed to the fact that the devices installed became dysfunctional in a matter of weeks, and because 'on the ground' social structures in both the primary research sites were weak. It appears that a PAR methodology is not going to deliver solutions without adequate commitment from the local authorities and also that intense attention and effort is needed for developing the capacity of the users of grey-water and sanitation technologies to manage both their use of those technologies and their relationships with local authority officials. Local authorities remain critical agents of local level social change, and should increasingly be positioned and resourced so that they can build their own capacity alongside that which inheres in well-functioning, truly representative local social structures such as street and block committees. At present it appears that neither the scope fo alternative service approaches nor the opportunities for community-based participation in technical options for grey-water management currently exist in informal settlements.

Cost: R750 000
Term: 2006 - 2010

Develop more robust and lighter VIP structures
University of Pretoria
No. 1781

In South Africa there are various systems available for the construction of the superstructure of toilets. These systems can be divided into two main groups, namely, the lightweight systems that can be moved (as a whole or dismantled) when the pit of a VIP is full and systems that cannot be moved, as such, but where the material may be re-useable in the construction of a new superstructure. The major problem with the provision of VIP superstructures is that there is no standard requirement and each supplier determines what the quality of the product is that they wish to deliver. It is recommended that a National Standard should be developed with minimum requirements that all VIP superstructures should adhere to. These requirements can include aspects such as minimum dimensions, load capacities, requirements for doors and fittings. Having minimum functional requirements for suppliers will prevent clients from opting for inferior products that may seem to be cheaper. During this project a moveable lightweight superstructure system made from high-strength fibre-reinforced concrete was developed. This system consists of a base slab, wall panels, a roof and a door and the system can be provided to communities in package form or can be manufactured by the communities themselves in controlled environments. A system that consists of bricks or blocks cannot compete with a pre-cast system as far as cost or quality is concerned.

Cost: R986 900
Term: 2007 - 2011

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Guidelines on pricing and debt management for municipalities
Arcus Gibb (Pty.) Ltd.
No. 1811

Poor debt management and pricing continue to be some of the elements which are resulting in municipalities not performing in a financially viable manner and the customers not receiving an affordable service. DWAF produced a document entitled Model Credit Control and Debt Collection By-Laws (DWAF, 2005), which sets a framework and rules around this subject. It was aimed at water services

authorities who did not have any legal framework to introduce effective debt collections and credit control. Thus the by-laws were seen as model by-laws. Though the bylaws (DWAF, 2005) provided the necessary legal framework, not much has however been done with regards to the provision of guidelines, tools and strategies to assist water services institutions to give effect to the bylaws and its contents. In the complex environment of water services delivery and the growing gap of poor revenue collection, it is becoming apparent that very radical and innovative approaches are required with regard to debt control and credit control.

Estimated cost: R600 000
Expected term: 2008 - 2010

Critical assessment of raising basic level of water services
Nemai Consulting
No. 1892

The Government has indicated that its short-term goal is to meet the basic water and sanitation requirements of the nation, as well as to attain full water-supply coverage by 2008 and sanitation coverage by 2010. Government has also indicated that the long-term goal is to improve on the basic level of service, often termed 'climbing the ladder'. It is most obvious that climbing the ladder, which is possible, will nevertheless provide numerous challenges and require greater resources. Asking relevant questions and gaining an indication of specific challenges will assist the sector in starting a debate on how best to tackle the 'ladder-climbing' issue and to formulate new strategies and the necessary mind-shift. Essentially, moving to higher levels of service (i.e. above RDP levels) could have only limited health benefits but very significant economic benefits (jobs, income, etc.). The question is rather whether there should be a distinction between moving up the ladder in those areas where this can be afforded (through local finance) and those areas in which basic needs coverage has not yet been achieved and on which national finance should be concentrated. The question concerning what the priority should be ought to be posed. As the number of people without basic access to water declines, there are reduced demands in terms of attending to requirements of these groups and potentially greater benefits in refocusing attention increasingly on moving people up the ladder. The study will investigate where the break-point should be and whether the sector has already reached this stage. This desk-study, supported by analysis, will assist the sector in achieving preparedness for the future.

Estimated cost: R600 000
Expected term: 2009 - 2011

Programme 2: Institutional and management issues - Water services

Development of strategies and guidelines for integrated water meter management
University of Johannesburg; Rand Water
No. 1814

Water metering plays an indispensable role in proper management of water distribution systems. Measured consumption forms the basis for most Water Services Authority and Water Services Provider accounts, and thus affects revenue directly. Bulk water meters are used to measure water entering the system, whether from raw water sources, water treatment plants or bulk water suppliers and is used to manage the system, including water balances, water loss calculations, consumption patterns and trends, pumping requirements and future planning. It is thus very important for all parties involved in the supply or consumption of potable water that water meters are used appropriately, managed optimally and maintained at regular intervals to ensure that water accounts, loss estimates and management decisions are based on accurate information. There is currently a lack of proper water meter management in South Africa, with many bulk water suppliers and municipalities without optimal and integrated meter calibration, replacement, reading, and information management systems. In addition, water meters of 80 mm and smaller are regulated by the Trade and Metrology Act, while larger meters are not.

Estimated cost: R660 000
Expected term: 2008 - 2010

Guidelines on determining the vulnerability and risks of water services infrastructure
Emanti Management
No. 1893

Any infringements to our water infrastructure could disrupt the direct functioning of key business and government activities, facilities, and systems, as well as have cascading effects throughout a nation's economy and society. Enhanced security features should drive all new designs and retrofits for water utility systems. Vulnerability and risk assessments can help guide and prioritise enhancements. There is a need for methodology and guidelines for application of risk management to strategic asset management (AM). Much has been done in the area of risk assessment for different sectors but no specific tools or guidelines have been developed or applied as an agreed national guideline for water utilities. The tools and guidelines may be used at a strategic level but may also be applied to specific individual assets to determine what measures may be taken to mitigate unacceptable risk. The tools and guidelines will enable design, operational and maintenance measures to

be reviewed in order to mitigate risk.

Estimated cost: R996 800
Expected term: 2009 - 2011

Development of protocols and guidelines for municipalities to undertake studies to determine the impact or influence of climate change on water service delivery
University of the Witwatersrand
No. 1953

The recent damages to water and municipal infrastructure due to weather-related/natural disasters raise many concerns for municipalities as to how to respond and plan for such occurrences brought about by climate change and its influences on nature. While the delivery of basic water services, (6 kℓ per household per month free), is driven by a national development goal, the responsibility of ensuring this right is ascribed to local government. For this, the local municipality needs to ensure that water supplies meet the consumption demand, present and future. Technical and financial planning is therefore required to ensure that an undisrupted service is provided. The impact of climate change needs to be included in this planning. All municipalities need to consider how climate change will affect their water services and to show how the departments most need to act or react. They must understand what climate change means for their work and future investments. In addition, a review of changes in weather and extreme weather events over the past few decades can help identify who and what is most vulnerable to some aspects of climate change. Various departments within the municipal government also must become aware of the need to consider climate change in their plans – for instance for water supply. Poor response to dealing with the outcomes of these climate changes will only escalate and increase the problems for municipalities. Municipal officials are unlikely to act if they have little idea of what climate change means for their city. To address this, the study will review and develop an understanding of the regional climate change knowledge and its relevance to municipalities in South Africa.

Estimated cost: R700 000
Expected term: 2009 - 2011

Programme 3: Innovative management arrangements - Rural water supply

Development of people-centred programmes
Mvula Trust
No. 1815

The challenges in developing good operations and maintenance (O&M) practice are perhaps greatest in remote rural areas with stand-alone schemes. There are no economies of scale for this kind of infrastructure provision as there are vast distances between the location of WSA/WSP and where human settlements are scattered. Given this geographical reality, innovative solutions are required to ensure the sustainability of infrastructure in these areas. International and South African experience has shown that community-based approaches yield sustainable results in the field of service delivery. Several factors, however, have contributed to the decline of community-based (or people-centred) approaches in South Africa. The main reason seems to be that water services authorities (WSAs), have neither the experience nor the tools to apply people-centred approaches. From the viewpoint of service delivery sustainability and the rights of communities, this research will try to close this gap.

Estimated cost: R800 000
Expected term: 2008 - 2009

Social scarcity of water and water use
African Centre for Water Research
No. 1940

There are several ways of defining water scarcity. One view is that it is the point at which the aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements, to the extent that the demand by all sectors, including the environment, cannot be satisfied fully. Water scarcity is a relative concept and can occur at any level of supply or demand. Scarcity may be a social construct (a product of affluence, expectations and customary behaviour) or the consequence of altered supply patterns stemming from climate change. Scarcity has various causes, most of which are capable of being remedied or alleviated. A society facing water scarcity usually has options. Water is essential for all socio-economic development and for maintaining healthy ecosystems. Water has traditionally been considered a physically scarce resource. Thus, growing scarcity and competition for water stand as a major threat to future advances in poverty alleviation, especially in rural areas. This study will explore the dimensions and relationship between social scarcity and water services or use. It will unpack the causes, understand how water can be used to break the cycle of poverty and establish how the recommendations from this study be incorporated into the macro-planning process.

Estimated cost: R500 000
Expected term: 2009 - 2011

Investigating the social vulnerability of people and their livelihoods and their response to water infrastructure
Umvoto Africa
No. 1888

Socio-economic vulnerability is seen as the integration across a range of stresses (not just biophysical, but also including exposure to uncertainties from interactions with markets, political and social exclusion and so on) and across the range of human capacities (i.e., not just food security, income or health). In relation to the livelihoods of the poor, one aspect of poverty is that poor people are often less able to cope with, adapt to or recover from these stresses. Even small variations in climatic conditions, market prices, etc., that less-poor people are able to cope with, can jeopardise the prospects of poor families lifting themselves out of their poverty and, in the worst cases, can even threaten their very existence. The result is often a risk-minimising approach to livelihoods, where the poor are more concerned with securing the minimum they need to survive than with taking advantage of development opportunities that could entail some risk. The study aims to establish the dynamic interaction between expectations, standards and actual service delivery. The central questions to be answered will be: How do people respond to different systems of water delivery, management and technologies? How is water used? What is the role of women?

Estimated cost: R500 000
Expected term: 2009 - 2011

Investigating operational and indigenous knowledge of water use and waste management, and establishing ways to integrate them into water service management
Nemai Consulting
No. 1941

Indigenous (or indigenized – practices and water use that have been introduced into the country and have been adopted and adapted by society) water management knowledge has played a significant part in the lives of many communities, to sustain their water needs against the harsh forces of nature, as well as the forces of segregation and apartheid. In the late 90's, the Department of Science and Technology initiated a number of projects aimed at capturing indigenous knowledge and practices in South Africa. One of the areas dealt with water management. The introduction of modern technology and systems has meant that this knowledge and its application have dwindled, and more crucial is that there is a lack of transfer of this knowledge to the new generation. Though Government has taken many measures to secure the provision of water to all persons in South Africa, many communities remain vulnerable due to a number of reasons. One of these crucial reasons is that of climate change and the challenges it will bring. Added to this, many of our initiatives in the water sector have actually marginalised or eroded this indigenous knowledge base to extinction. Thus, it becomes imperative and important to record these practices and establish how these practices could be beneficial to the management of water services in the future.

Estimated cost: R600 000
Expected term: 2009 - 2011

Programme 5: Impact of water and sanitation intervention

Toolkit to measure sociological, economic, technical and health impacts and benefits of 10 years of water supply and sanitation interventions in South Africa
Tshwane University of Technology
No. 1700

Over the years, the government has spent billions of rand to meet the backlogs in water supply and sanitation services in South Africa, and substantial progress has been made. However, very little work has been undertaken to quantify the benefits that improved water and sanitation has brought to the communities and the countries. Over the years the WHO has undertaken a number of case studies at an international level to quantify the benefits of improved water services and has recently completed a new initiative. The methodologies used are based on a wide range of assumptions, which have not been tested. There is a need at a national level to build on these processes towards development of a standard methodology to quantify the benefits (social, technical, health, economic and environmental).

Estimated cost: R1 200 000
Expected term: 2006 - 2009

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Biological filtration of iron and manganese from groundwater
Umgeni Water
No. 1526

The project aims to develop criteria for the design of biological filtration systems that will remove iron and manganese from groundwater in rural areas in an economical and sustainable fashion. The effectiveness of such systems will further be demonstrated by the operation of a small water treatment system in a rural area in KwaZulu-Natal.

Estimated cost: R750 000
Expected term: 2004 - 2009

Development of enhanced floating media separation for drinking water production and pre-treatment in rural water supply
University of Stellenbosch
No. 1527

The project proposes to further develop a filter with floating plastic media for the supply of water for rural communities. Performance of the filter both on its own, and as a pre-treatment system for ultrafiltration membranes, will be evaluated and the operability of the system will be compared to that of a conventional coagulation, sedimentation and sand filtration plant. This system should be a more efficient and cost-effective alternative to sand filters if the research is successfully executed. It is also simple to operate and requires less head for back-washing than conventional sand filters. A successful project can ensure that more small communities will have the benefit of membrane-treated potable water supply.

Estimated cost: R914 000
Expected term: 2004 - 2009

The defouling of membranes by moving magnetic dipole polymer beads, containing nano-magnetic particles, in a scouring motion across the membrane using external magnetic fields
University of Stellenbosch
No. 1592

Fouling of membranes remains the main problem preventing the large-scale and economic use of membranes in more applications internationally. Various chemical, hydraulic and ultrasonic membrane-defouling methods have been investigated, with varying success. This project aims to investigate nanotechnology for the in situ defouling of membranes. Nano-magnets will be incorporated into small polymer beads and the magnetic fields in all of the nano-magnets inside the beads will be aligned. Movement of the polymer beads on the surface of the membrane will then be induced in order to scour the surface, which will hopefully clean and prevent fouling on the membrane surface. The resulting system will be evaluated on a typical coloured surface water purification application.

Estimated cost: R794 000
Expected term: 2005 - 2009

Development of a durable and reliable wave-energy reverse osmosis system
The Impact Free Water Group
No. 1716

Small, rural communities living at or close to the sea along the coastline of the country rarely have a good and reliable supply of potable water – nor do they generally have electricity. The project aims to further develop an innovative reverse osmosis system which utilises ocean wave power in order to produce the elevated pressures required in the desalination of seawater to potable standards. A few prototypes will be constructed to evaluate the effect of various wave parameters on the system performance and improve the system into a practical, working technology.

Estimated cost: R650 000
Expected term: 2007 - 2010

Assessment of the prevalence of organic compounds in raw and treated water for potable purposes, their fate in current treatment plants, and compilation of a guideline on best available technology for the removal thereof
University of Johannesburg
No. 1883

The number of organic chemicals discharged into the environment is escalating at a frightening pace. The United States EPA has drinking water regulations for more than 90 contaminants. The lack of knowledge about local natural organic matter (NOM) composition and interaction with the treatment steps hampers the understanding of removal mechanisms and the development of reliable qualitative and quantitative models. A large number of organic chemicals have not been adequately investigated with regard to the efficiency of their removal by local water treatment processes currently in use. Further, small and rural water treatment plants are often at a disadvantage regarding both their design and operation. Except for a few exploratory and regional studies on the occurrence of NOM, pesticides, algal toxins and endocrine-disrupting chemicals (EDCs), little has been done to determine the prevalence of organic contaminants in South African water sources being used for potable water supply – or the efficiency of SA plants in removing these contaminants. This project will investigate the prevalence of both natural and anthropogenic organic contaminant chemicals in SA water sources used for drinking water, determine the efficiencies of removal – especially by small treatment systems – and their effects in the distribution system, and suggest improvements to the treatment processes and operational procedures in order to safeguard the people against these contaminants.

Estimated cost: R1 800 000
Expected term: 2009 - 2012

Wastewater reclamation for potable reuse
Umgeni Water
No. 1894

Water is a scarce resource, especially in South Africa where runoff exceeds rainfall and is unevenly distributed. South Africa has been classified as water stressed and water should therefore be conserved. The pressure exerted on surface and groundwater supplies should be reduced or at best maintained, rather than increased as the country's human population and industrial development increase. Wastewater reuse offers such a possibility, and reclaiming

domestic wastewater from Darvill Wastewater Works for potable reuse using membrane bioreactor technology is therefore being investigated. This project is intended to pave the way for technology enabling South African water suppliers to produce consistent, acceptable drinking water quality through used-water reclamation. Initial feasibility work will be followed by a demonstration plant designed and operated over a long-term trial to establish operating guidelines that ensure reliable product water will be generated at all times.

Estimated cost: R650 000
Expected term: 2009 - 20112

The establishment and piloting of the Technical Assistance Centre for small water and wastewater treatment plants
Chris Swartz Water Utilisation Engineers
No. 1896

There currently exists a serious and acute need in South Africa to provide assistance to small water and wastewater treatment plants for proper and efficient operation and maintenance of these systems, to ensure compliance and sustainability in this important water sector. In order to address the serious challenges that are currently experienced with the compliance and sustainability of the small water and wastewater treatment systems in the country, it is proposed that a Technical Assistance Centre be established. This should be a collaborative effort between the DWA, WISA (implementing agent of DWA), the WRC, the DBSA and SALGA. Direct benefits of the Centre will be a significant improvement in compliance of treatment plants, improved leadership and facilitation of planning and development activities in the water sector, enhanced service delivery, positive economic impact through reduction in break-downs and downtime, and, overall, more sustainable development and improving quality of life in rural South Africa. This will be in line with DWAs strategy on Water for Growth and Development. The Eastern Cape and Western Cape have been chosen as the pilot provinces for the launch of this project.

Estimated cost: R275 000
Expected term: 2009 - 2010

Programme 2: Water treatment for rural communities

Application and performance of slow sand filtration
Cape Peninsula University of Technology
No. 1836

Slow sand filtration is generally highly recommended in small and rural community water treatment because of its simplicity in design, operation and maintenance. However, little awareness of the application of slow sand filters exists in South Africa. Very little is further known about the slow sand filters in operation in South Africa and how they are performing. The project, therefore, aims to investigate the extent of slow sand filtration applications in the country and practical performance of these filters, covering both successful and failed examples. It will also investigate and document the types, application and performance of the various pre-treatment processes prior to slow sand filtration. A database of all sand filtration plants in the country will further be compiled.

Estimated cost: R760 000
Expected term: 2008 - 2011

Compilation of guidelines for the selection and use of home water treatment systems and devices
Tshwane University of Technology
No. 1884

At least 5.7 million people in South Africa still have no access to treated, potable water within reasonable distances from their dwellings and many thousands more take water from water sources and use it untreated because of problems experienced with adequate and reliable potable water supply. Surface waters have steadily become more polluted – especially with regard to microbiological quality, which exacerbates the situation of the immuno-compromised when drinking inadequately treated or poor-quality water. A number of home treatment systems and devices are being used internationally by small, rural communities without potable water services (decentralised systems). These units vary from the most simple – such as using material as filter – to the most sophisticated systems treating grey-water to potable standards. Although various systems and devices have been extensively reported on in the literature, and some exploratory work has been performed in South Africa, little is known locally about the existing options – and little has been done to assist local communities or their advisers in making informed choices on whether such a system or unit will be appropriate to their situation, or which unit should be selected. This project will meet the need to source and investigate appropriate units, to determine their efficiencies of contaminant removal under local conditions as well as their sustainability potential, and to provide guidance on the selection and use of these units under local conditions.

Estimated cost: R1 200 000
Expected term: 2009 - 2012

Programme 3: Drinking water quality

New detection methods for EDCs
University of Stellenbosch
No. 1534

The project will aim to produce and test an endocrine-disrupting compound (EDC) indicator system. This will be achieved by execution of the following objectives:

- Clone cDNA for the human oestrogen receptor ligand-binding domain (LBDER) into a suitable yeast (Pichia pastorus) expression vector for large-scale expression
- Production of antibodies against LBDER-EDC complexes
- Prepare LBDER by large-scale fermentation expression and protein purification
- Biotinylation of LBDER and preparation of biotinylated pluronic acid needed for non-covalent attachment of LBDER to polysulphone membranes or hydrophobic contactors
- Development of specialised polysulphone contactors for the non-covalent immobilisation of the LBDER via pluronic biotin/avidin technology
- Development of the ELISA indicator system for EDC detection

Estimated cost: R647 500
Expected term: 2004 - 2009

β-N-methylamino-L-alanine bioaccumulation and bio-magnification: Health risks and water treatment possibilities
Nelson Mandela Metropolitan University
No. 1885

β-N-methylamino-L-alanine (BMAA) is a neurotoxic, non-proteinogenic amino acid produced by the majority of cyanobacterial isolates. Free-living freshwater cyanobacteria from all five taxonomic sections were found to contain BMAA, in a study conducted by the team, which concluded that most if not all cyanobacteria produce BMAA. Cyanobacteria frequently found in drinking water sources have been found to produce BMAA. In addition to potential risk from free or cyanobacteria-associated BMAA, the potential for exposure to significant doses due to consumption of bioaccumulated BMAA from sources higher up the food chain is much greater. However, no information on bioaccumulation or bio-magnification in aquatic ecosystems exists. The scope of the study is to investigate the potential risk by evaluating bioaccumulation, bio-magnification and toxicological effects of these in aquatic ecosystems. The aim is to investigate the potential for health risk to consumers via indirect exposure to cyanobacterial BMAA and to evaluate treatment processes for BMAA removal from water.

Estimated cost: R1 800 000
Expected term: 2009 - 2011

Rapid enzymatic detection of organochlorine pesticides in water
Rhodes University
No. 1902

Endocrine-disrupting substances in the environment have become a concern over the past few years. The organochlorine pesticides (OCPs) (one of the groups of insecticides) are known to be EDCs and among the most persistent organic pollutants present in the environment, and tend to accumulate in organisms. A study done by the team has shown that the detection of various OCPs in isolation and in combination using a rapid alkaline phosphatase assay is indeed feasible in the South African context. The aim of this proposal is to optimise this alkaline phosphatase bioassay using the latest substrate technology for increased sensitivity, to determine the potential for interference by metals and organophosphate pesticides, and to investigate the feasibility of application into an affordable (cost-effective) biosensor system.

Estimated cost: R600 000
Expected term: 2009 - 2011

Programme 4: Water distribution and distribution systems

Grouted lining systems for the renovation of old steel pipelines and the design of new pipelines
Rand Water
No. 1448

Steel pipes are used extensively in South Africa and need to be protected against corrosion, hence the need for internal linings and external coatings. In pressure pipes there are many problems associated with the use of grouted-viscous-elastic linings at joints, bends and fittings, etc. This study aims, through laboratory trials and investigations, to provide solutions to this unresolved problem experienced by water suppliers, which costs them large sums of money due to failures.

Estimated cost: R736 300
Expected term: 2003 - 2009

Inverse transients to determine deficiencies in pipelines
University of Pretoria
No. 1721

A major shortcoming in the optimal utilisation of water distribution systems is the uncertainty about the physical status and the identification of operational deficiencies. In a WRC study (Report No. 1177/1/04) the influence of localised air pockets on the hydraulic capacity of pipelines was shown. Another major problem that negates the optimal distribution of water is the presence of unidentified leakages in the systems. Inverse transients can be used to determine the location and magnitude of leaks and air pockets. The technique was already tested in laboratory conditions, indicating the advantage of this technique. The procedure could be applied without isolating the section

to be investigated (no interruption of the service). The objective now is to test and develop this further and provide assistance in the implementation of this procedure. The value of the development of this technique is that a non-destructive, non-intrusive and non-intermittent procedure will be available to investigate the status of water distribution systems.

Expected cost: R530 000
Estimated term: 2007 - 2010

Guidelines on how to determine and reduce apparent losses
Conward Consulting
No. 1722

Non-revenue demand is one of the key performance criteria of water services providers (WSP) in South Africa. The current level of non-revenue demand is estimated at more than 30% of the total water supplied. Non-revenue demand can be divided into 2 main categories: real losses and apparent losses. Before WSP can begin to address non-revenue demand, they need to understand the extent of real losses versus apparent losses. Currently, there is no common approach or guidelines on how to estimate apparent losses and this is widely considered as one of the main constraints in dealing with the overall issue of non-revenue demand. The development of guidelines on how to accurately determine apparent losses will provide a key breakthrough for WSP to deal with non-revenue demand and for the regulator in setting benchmarks and targets.

Estimated cost: R400 000
Expected term: 2007 - 2009

Durability of FC tanks
Partners in Development
No. 1818

Ferro-cement is a cement-rich reinforced modified mortar which is easily adaptable to rural construction projects and well suited to smaller sizes of reservoir. Ferro-cement reservoirs are constructed using very simple sets of shuttering and consequently can be built predominantly by utilising local labour with the assistance of a foreman and team leader. They are also considerably cheaper than reinforced concrete reservoirs. However, although the construction cost of ferro-cement reservoirs is significantly cheaper than for reinforced concrete reservoirs, they are not particularly well known and thus are often regarded with a fair amount of scepticism. As they are also a relatively recent technology, very little is known about their long-term durability. This study hopes to address this problem by investigating the status of numerous reservoirs built over the previous 15 years in KwaZulu-Natal and the Eastern Cape in order to ascertain a better estimate of their design life.

Estimated cost: R220 000
Expected term: 2008 - 2009

Determining the change in hydraulic capacity of pipelines
University of Pretoria; Rand Water
No. 1820

It is generally accepted that the operational life of pipelines could well be longer than the 30 years which are used in the economic analyses of pipeline systems. Networks of Rand Water and other water utilities prove this, although there are a number of reported cases where pipelines fell short of the expected operational lifespan. Funding of new water projects in the near future will have to compete with the capital that is required for the renovation, replacement and upgrade of existing infrastructure. An informed status assessment of a pipeline can only be made if the operational performance history of the pipeline is known. Optimal capital expenditure and operational cost is based on the performance and the expected hydraulic performance decay rate of pipeline systems. Long-term performance data are essential for this assessment and an effort should now be made to gather information on a regular basis for a number of different pipelines in South Africa.

Estimated cost: R785 000
Expected term: 2008 - 2011

Dual grey-water and drinking water reticulation for high density urban residential dwellings
University of the Witwatersrand; University of Johannesburg; University of Cape Town
No. 1821

South Africa views water as one of its most fundamental and indispensable natural resources. Although renewable, water is also a finite resource, distributed unevenly in time and space. Increased development of South African communities has led to an overall increase in water demand. This water demand has traditionally been met with water from the best available sources. However, over the years, it has become evident that high quality water sources in many provinces are inadequate to meet demands and, that not all uses require the same water quality. Some water uses can be supplied with water of an inferior quality, which frees the high quality sources for higher quality uses, e.g. drinking water production. Dual grey and drinking water reticulation systems (henceforth called dual systems) are particularly promising for application in high-density (especially multi-storey, access-controlled and centrally managed) urban residential dwellings (HDURDs) (e.g. university halls of residence) located in arid South African environments. This project is aimed at investigating the potential for implementing dual systems in HDURDs, primarily for toilet flushing and if possible, limited private

irrigation using a pilot study in a university.

Estimated cost: R1 055 500
Expected term: 2008 - 2011

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Mass balance modelling over wastewater treatment plants III
University of Cape Town; University of KwaZulu-Natal
No. 1822

The series of projects aims to develop a plant-wide wastewater treatment plant (WWTP) model used to accurately predict the outcome of the various biological, physical and chemical processes taking place in a WWTP. These tools can result in more economical wastewater plant design and operation and improved effluent quality. Significant advances have been made towards developing steady state mass balance-based integrated WWTP models which link primary sedimentation, nitrification-denitrification activated sludge and aerobic or anaerobic digestion of primary and waste activated sludges (K5/1338 and K5/1620). This project aims to determine the kinetics of P release from biological P-removal systems and determine the extent to which mineral precipitation takes place. The P release in anaerobic digestion will be compared to that observed in aerobic digestion. Certain aspects such as the mineral precipitation in aerobic digestion, the un-biodegradable fraction of primary sludge and the un-biodegradable fraction of the waste activated sludge from nitrification-denitrification systems will be confirmed. The research will determine whether the presence of primary sludge will assist in the hydrolysis of waste activated in anaerobic digestion.

Estimated cost: R998 950
Expected term: 2008 - 2010

FISHing for indigenous anammox bacteria
Stellenbosch University; CSIR (Natural Resources and the Environment)
No. 1823

Nitrogen is conventionally removed from wastewater via nitrification followed by denitrification. Nitrogen removal via anaerobic ammonium oxidation (anammox) requires only 24% of the total primary energy as compared to conventional nitrification. Anammox bacteria were first discovered in the Netherlands during the 1990s and have since then revolutionized the wastewater industry. Different configurations of anammox reactors are now appearing all over the world. In this project the researchers aim to locate and identify indigenous anammox bacteria from anaerobic habitats. Once these have been found and enriched, they aim to compare the kinetics and stoichiometry between known organisms (from literature) and the organisms located in local habitats. Parameters defining the key physiology of the local bacteria, including their optimum growth conditions under varying temperature, pH, ammonium-nitrite concentration, and dissolved oxygen concentration would be the first pointers towards implementation of this process on a larger scale in South Africa.

Estimated cost: R612 750
Expected term: 2008 - 2010

Effects of urine separation and treatment on wastewater effluent quality
CSIR (Stellenbosch); AFRICON; University of Stellenbosch
No. 1824

The project deals with alternative sewage collection and treatment for both low and high income communities in urban settings. The concept includes the separate treatment of urine and the rest of the black/grey sewage to achieve better effluent quality. This project aims to demonstrate at pilot scale that the DWA Special Standards can be achieved through (partial) separate collection of urine. In addition, this increases the capacity of the receiving wastewater treatment plant which could delay extensions. The research will be reconfiguring toilets and urinals to allow (partial) urine separation on pilot scale. It will determine the composition of urine and demonstrate the effectiveness of treating wastewater with less urine than normal in varying quantities to achieve very low nutrient effluent concentrations (DWA special authorisation), as well as relatively low salt effluent concentrations. The study will assess the operational issues, such as struvite and other forms of scaling in urine drains, odours, etc. This project will assist in creating awareness for the potential positive impacts of urine separation and the feasibility thereof.

Estimated cost: R1 200 000
Expected term: 2008 - 2011

Programme 2: Application of appropriate technologies and tools

Practical implementation of external nitrification in biological nutrient removal activated sludge systems
University of Cape Town (Division of Water Quality Engineering)
No. 1262

In this project, full-scale trials are being run on external nitrification in biological nutrient removal activated sludge (BNRAS) systems to test the fundamental, laboratory-scale

and economic studies done to date by this research group, which have shown that external nitrification in BNRAS systems can be a more efficient and cheaper (20 to 25% lower) alternative compared to other BNRAS systems covering both green-fields and retro-fitting situations. In this collaborative exercise between UCT, the Cape Metropolitan Council, and Water & Sanitation Services SA (Pty.) Ltd. (the local agent for CIRSEE/Suez Lyonnaise-des-Eaux), the cash contributions by others (excluding contributions in kind) amount to about 40% of the total budget.

Estimated cost: R1 280 000
Expected term: 2001 - 2009

Support to EU - EUROMBRA project: Development of an anaerobic membrane bioreactor
University of KwaZulu-Natal (Pollution Research Group)
No. 1661

The highest development priority in the South African water sector at present is the provision of affordable but safe community wastewater treatment (MDGs, etc.) and particularly also to provide a barrier against the transmission of water-borne diseases in the context of a population which is immunologically-challenged and under-nourished. Aerobic treatment systems, other than algal ponding systems (which however have a land footprint not suitable for urban or peri-urban situations) require a significant and probably unsustainable energy and/or chemical input to be effective in terms of the treated water quality achieved. Anaerobic systems have a significantly lower resource requirement, but to date have not been able to produce the microbiological water quality required for community health safety and concomitant quality-of-life. This project targets this problem, using an innovative approach based on established anaerobic treatment technology enhanced by the use of membranes (which over the past few years have become sustainably affordable and increasingly robust in their performance, with the major and strategic benefit of providing a physical barrier to microbial passage). The research issues addressed are the basic system performance and the requirement to limit membrane fouling and/or to develop a membrane-cleaning regime that does not require external energy inputs. If successful, the system would have an immediate and major impact on the provision of low-cost and safe sanitation to a range of communities in South Africa. This project supports an EU programme, and the potential for roll-out to a wider base, e.g. SADC/Africa/the developing world, is thus strong.

Estimated cost: R693 280
Expected term: 2006 - 2009

Denitrification in trickling filters
CSIR (Stellenbosch); Virtual Buro; Tshwane University of Technology
No. 1825

Many wastewater treatment plants in South Africa are equipped with trickling filters which could be obsolete if they cannot achieve denitrification. The researchers aim to demonstrate (at full scale) that trickling filters can denitrify by changing the effluent recycle over trickling filters and/or limiting the rotation speed of distribution arms. They will then model the processes of aerobic COD removal, nitrification and denitrification in a biofilm system and calibrate the model with results from 2 trickling filters in order to gain a better mechanistic understanding of the combined processes. This will result in a set of practical operating guidelines to achieve denitrification in trickling filters.

Estimated cost: R930 500
Expected term: 2008 - 2010

Programme 3: Stormwater and sewerage systems

Alternative technology for stormwater management
University of Cape Town; SRK; City of Cape Town; eThekwini Municipality; Johannesburg Municipality; City of Tshwane; IDS
No. 1826

Currently, stormwater planning and design in the urban areas of South Africa focuses on collecting runoff and channelling it to the closest watercourse, frequently having a significant impact on the environment through the resulting erosion and siltation. Whilst some local authorities reduce runoff peaks through the use of retention and detention ponds, few examples exist of quality improvement apart from pumping the base flow of the most polluted streams to sewerage, and the installation of litter traps. Internationally, numerous alternatives to the traditional stormwater management approach have been developed to manage the quantity and quality impacts associated with urban runoff, generally by dealing with stormwater as close to its source as possible. This solicited project aims to identify and develop new and appropriate, practical and affordable alternative stormwater management technology/technologies for South Africa in line with water-sensitive urban design (WSUD) principles. The researchers will also evaluate the technology options in terms of the ability to improve stormwater management in urban areas, i.e. reduce impacts on receiving watercourses resulting from increased velocities and volumes of runoff and deterioration of runoff quality. Four large local authorities (CCT, eThekwini, JHB and Tshwane) have expressed interest in participating in pilot studies.

Estimated cost: R1 800 000
Expected term: 2008 - 2012

Improving sewerage for South Africa
University of Cape Town; City of Cape Town; eThekwini Municipality
No. 1827

With ever-increasing development and expansion of municipal sewerage networks it is important to ensure that the current rationale applied to the selection of new sewerage is sustainable over the longer term. The integrity of the existing systems also needs to be maintained through systematic replacement of sewers that have exceeded their design. It is therefore necessary to evaluate whether there is a better way of sewering areas which would offer long-term benefits over current conventional practices. The primary objective of this solicited project is to establish whether there is a viable alternative to conventional reticulated sewer systems, which offers tangible improvements over current conventional reticulated systems. The focus will be on application in new development and unserviced areas as well as the potential as a solution for the replacement of conventional sewers which have exceeded their design life. The research will critically evaluate impending technologies and provide practical guidance to implementers on where suitable circumstances exist where these technologies will prosper. The project is supported by some major local authorities committed to assist with a pilot project to assess the operation of the new or proposed technologies.

Estimated cost: R1 500 000
Expected term: 2008 - 2012

Programme 4: Wastewater sludge and faecal sludge management

Scale-up development of the Rhodes BioSURE™ process for sewage sludge solubilisation and disposal
Rhodes University (Department of Biochemistry, Microbiology and Biotechnology)
No. 1336

The overall aim is to derive process design criteria for full-scale implementation of the Rhodes BioSURE™ process for sewage sludge solubilisation. To achieve this, the demonstration-scale BioSURE™ plant established at Ancor Sewage Works (Springs) will be operated, monitored and optimised, and the facility will be extended to include sulphide bio-oxidation and sulphur recovery. A smaller pilot plant at Makana Sewage Works (Grahamstown) will be operated and monitored to study process variables in finer detail, to identify and investigate areas of sulphidogenic sewage sludge solubilisation that require further development for scale-up.

Cost: R1 510 900
Term: 2002 – 2009

Materials mass balances modelling of wastewater treatment systems
University of Cape Town (Department of Civil Engineering)
No. 1620

This project follows on WRC Project No. K5/1338 in which the novel and far-reaching integrated chemical/physical/biological process modelling approach for biological waste treatment processes was developed and confirmed. In the new project, the overall aims are:

- To develop a mass-balance-based steady state model for wastewater treatment plants (WWTP) for preliminary design and operations overview
- To develop a kinetic simulation model that integrates the mixed weak-acid/base chemical, physical and biological processes for detailed design, dynamic simulation, process operation and optimization

These two aims represent high-end long-term objectives that require closing of several important knowledge gaps with experimental research at laboratory and full-scale supported by theoretical modelling. The project has far-reaching implications with significant spin-off benefits for other WRC research projects, as already demonstrated in the previous Project No. 1338 which is delivering modelling of activated sludge, algal ponding, and methanogenic and sulphidogenic anaerobic digestion processes.

Estimated cost: R720 000
Expected term: 2005 - 2009

Guidelines for the utilisation and disposal of water treatment residues
Golder Associates Africa
No. 1723

WRC Project No. 1148 found that the disposal of water treatment residues (WTR) to land could have positive effects. No local guidelines for land disposal exist at present. In order to determine what information is still required to develop such guidelines, a follow-on project (No. 1601) produced a scoping report on the development of guidelines for the land disposal of WTR. Although a number of knowledge gaps remain, this new study will develop guidelines based on the best current local and international information. The objective is to revisit these guidelines after 5 to 10 years of application and include actual field data and experience gained during this period. A national survey will determine the variation in the characteristics of different WTRs. The previous research and survey data will be used to develop guidelines that describe the requirements for the land disposal and agricultural use of WTR. A stakeholder consultation and scientific peer review process is planned to gain broad acceptance for the guidelines.

Estimated cost: R746 820
Expected term: 2007 - 2009

Sustainable and beneficial use of biosolids land application strategies: Quantifying nitrogen and phosphorus plant-soil mass balances
University of Pretoria
No. 1724

The recently-published Guidelines for the Utilisation and Disposal of Wastewater Sludge promotes the sustainable use of sewage sludge as a soil ameliorant and source of nutrients for crop production. However, limited research on the topic has been conducted under local conditions. This study will investigate aspects of the use of wastewater sludge on land, including high application rates. This will focus on N and P release from sludges and on soil-plant-water interactions with the released nutrients, in order to promote responsible sludge use and minimise groundwater pollution. Use will be made of laboratory, lysimeter and field experiments. Findings will be incorporated into a mechanistic daily time-step nutrient and water balance model to improve the management of sludges and effluents.

Estimated cost: R1 150 000
Expected term: 2007 - 2010

Investigating the potential of deep row entrenchment of pit latrine and wastewater treatment works sludge for forestry and land rehabilitation purposes
Partners in Development (Pty.) Ltd.; University of KwaZulu-Natal
No. 1829

A substantial amount of existing basic sanitation infrastructure (conventional pit latrines and VIPs) has reached or is reaching the end of its design life. Urgent interventions are required to deal with the escalating accumulation of sludge in these basic units. The options for disposal of this sludge are limited. This project aims to investigate how the sludge entrenchment technique may be applied under South African conditions and what safe working procedures (handling and transport, maximum application rates, etc.) should be developed to protect the health of workers, local communities and the environment. Research will be conducted at different sites that vary in such features as soil characteristics, slope, aspect, microclimate and end-use potential. The study will specifically focus on:

- Monitoring changes in the sludge contents of the covered trench and movement of solutes and any changes taking place in the surrounding soil and groundwater
- Investigating the management, logistics, health and politico-legal aspects of transporting sludge, excavating trenches and planting trees/ vegetation

Assessing the commercial and any other opportunities created (agroforestry, biofuel-producing tree species and environmental rehabilitation).

Estimated cost: R1 600 000
Expected term: 2008 - 2011

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 2: Regulatory, policy and financial mechanisms to improve industrial and mine-water management

Valuing water for South African industries: A production function approach
CSIR (Natural Resources and the Environment)
No. 1366

The industrial sector in South Africa is one of the fastest-growing sectors and relies to varying degrees (ranging from wet to essentially dry industries) on water resources as an input to many production processes. Industrial water use currently comprises about 10% of the total water use in South Africa (WSAM, 2000) and is therefore a significant water-using (and effluent-generating) sector. Very little is, however, currently known about the responsiveness to water pricing within the industrial sector in South Africa, probably because of historically low pricing structures and the perception that industrial water use is better suited to engineering rather than economic analysis. International literature offers mixed results, with industrial price elasticities ranging from very inelastic to more elastic. In the context of the National Water Act and its emphasis on economic pricing, and the significance of industrial water use in South Africa, it is necessary to provide econometric tools to decision-makers. The project aims to quantify and characterise the role that water plays in various local industries and their responsiveness to price changes; and to develop a set of indicators and judgement criteria for policy-makers, decision-takers and other stakeholders to use economic analysis for appropriate water resource management. The project's overall aim is to determine the marginal value of industrial water in South Africa, in keeping with the National Water Act's objectives to price water correctly. The specific sub-goals are listed below:

- To assess the role that industries play in the overall water demand for South Africa, and to determine which industries are the most water-intensive industries and which industries are relatively 'dry'
- To determine price elasticities of demand for water for the respective industrial sectors within South Africa, and develop a set of indicators that can be used in existing models or to assist existing techniques to ensure sustain-

able and equitable conservation of water resources
- To demonstrate through practical application how economics can be used to value water resources, and to document this application so that it may be applied across sectors
- To provide a value judgement for water resource management and policy based on the results and an extended analysis of the data
- To build capacity in all stakeholders and parties participating in the research project, through the transfer of knowledge

Estimated cost: R549 600
Expected term: 2002 - 2009

Protocol for quantitative assessment of industrial effluents for discharge permitting
University of KwaZulu-Natal
No. 1734

Local authorities manage industrial wastewater by:

- Using its wastewater treatment plants for remediation
- Issuing discharge permits with limits on discharge
- Charging a discharge tariff for financing the treatment and for providing incentives and penalties to influence users of the system

An optimal management strategy will use all these elements in the proper relation to one another. However, the relationships are complex and poorly understood because of the complex and variable nature of both the multitude of effluents discharged from industries, and the response of the biological processes to them. The study aims to provide a means of determining the link between what a particular industry is permitted to discharge and the capacity of the WWTP that received the wastewater to serve all its clients while meeting the quality standard for its treated effluent. This information will inform the process of setting the conditions for the industry's discharge permit.

Estimated cost: R1 500 000
Expected term: 2007 - 2011

Programme 3: Minimising the impact of waste on the water environment

Reclamation of water from flooded Witwatersrand gold mines by selective dewatering of key underground compartments
Pulles, Howard & de Lange
No. 1659

Defunct gold mines on the East and West Rand are rapidly filling up with contaminated water that will decant into the Vaal River system. Previous studies focused on either reducing inflow to the underground or on diverting decant water to preferred locations for treatment. This project will identify locations within the flooded basin where water quality is relatively good and which are also major recharge points (and therefore decant drivers). It is proposed to dewater the basins from these points. If found feasible, the extraction of water from such points, would serve as a source of water for Gauteng and at the same time reduce the magnitude of decant.

Estimated cost: R501 300
Expected term: 2006 - 2009

Consideration of the impact of classification and landfilling of hazardous waste
CSIR
No. 1736

The minimum requirements for general and hazardous waste have been in place for over a decade. A systematic assess¬ment is needed to determine whether the desired groundwater protection has been achieved, particularly at sites that have received delisted wastes. The assumptions made in the delisting process (i.e. whether they are conservative or not) are tested against field data from operational landfills. Further, the impact of the disposal of hazardous waste on leachate quality and landfill processes is required. This study aims to begin the process by considering the impact of selected delisted hazar¬dous or industrial waste on a selection of landfill sites. The study includes an assessment of leachate quality from a selection of general waste landfill sites that receive hazardous wastes compared to those that do not, to validate the assumptions made in the delisting process and to determine to what extent a selected hazardous waste type impacts on leachate quality.

Estimated cost: R800 000
Expected term: 2007 - 2009

Programme 4: Minimising waste production

Development of a complete process integration framework for wastewater minimisation in multi-purpose batch plants
University of Pretoria
No. 1625

The approach followed was to employ mathematical programming principles, where the overall chemical plant is mathematically modelled. The objective is to maximise profit while minimising effluent. The development of the model was conducted while taking into account the current gaps in research and limitations of current methodologies so as to ensure that the overall methodology addressed the problems at hand. The mathematical

model is based on mathematical programming principles using optimisation as an underlying framework. The main contribution of the project was to treat both scheduling and wastewater minimisation as optimisation problems within a unified framework, which indeed proved more appropriate and optimal than published methods. The final stage was the application of the developed mathematical technique to a pharmaceutical production facility. This was done in 3 steps. The 1st step involved the application of a single contaminant methodology to the operation. The 1st step gave insight into the operation and the data that was required. From the 1st step it was observed that product and wastewater compatibilities needed to be taken into account. Based on this the multiple contaminant wastewater minimisation methodology with a single storage vessel was applied to the industrial site. This formed the 2nd step of the application. During the application of the multiple contaminant model an important change came about in the sanitising method used. The chemical sanitising step was changed to a heat sanitising step. Based on this a final model was derived in the final step of the application of the methodologies. The final model schedules the production in such a manner as to maximise the amount of water that is reused, thus producing less effluent. The amount of water saved for each washout is dependent on the amount of water used for the sanitising step. The amount of water saved varies between 22% and 55%. The derived model finds practical application as it takes the current water usage into consideration. The output from the model was a production schedule, which shows the allocation of mixers to various products under the actual production requirements. Since water from the sanitising step goes to a central storage vessel, independent of the mixer, no extra pipe connections are needed to achieve water savings.

Estimated cost: R198 000
Expected term: 2005 - 2009

Cleaner production evaluation system and optimisation for metal finishing
Durban Institute of Technology
No. 1626

The metal-finishing industry is notorious for its polluting activities. Cleaner production audits to benchmark a company's operations and identify room for improvement, require a level of detailed information that is normally not recorded by smaller companies. This project aims to develop a tool that can be used to readily conduct a systematic environmental evaluation of electroplating plants and which will provide a comprehensive audit, with limited data, in a consistent way.

Estimated cost: R492 000
Expected term: 2005 - 2009

Technical guidelines for the implemen¬tation of cleaner production initiatives (for point sources of pollution) in support of determining an incentive charge for municipal effluent charges
Process Optimisation and Resource Management (PRO&RM)
No. 1832

This project surmises that the only realistic way to calculate an incentive charge to promote the implementation of cleaner production technologies by industries disposing of their effluent into municipal sewers is to determine the equivalent implementation cost of cleaner production initiatives. The imminent implementation of the Waste Discharge Charges System adds impetus to the need for such a study. The objective is to develop Technical Guidelines through which the insights gained in the study can be transferred to other applications.

Estimated cost: R570 619
Expected term: 2008 - 2010

Development of a zero-effluent mathematical model for wastewater minimization in a pharmaceutical facility
University of Pretoria
No. 1898

This new investigation is intended to be a spin-off project from WRC Project No. K5/1625, which was successfully completed in September 2007, whose aim was to develop a complete process integration framework for wastewater minimisation in multipurpose batch plants using a rigorous mathematical optimisation framework. During the course of project K5/1625 another opportunity, which is particular to industries that utilise water as a major ingredient in their final product, became apparent. The pharmaceuticals industry features very high in this category. Using careful analysis with proper understanding of these processes, a mathematical technique can be derived that could lead to almost zero-effluent operation. Preliminary results, using data from Johnson and Johnson (Pty.) Ltd., suggest that it is very possible to achieve this goal. This project aims to develop the model further and optimise it at a full-scale plant. In addition to the environmental benefit of water conservation, this research will result in significant savings in revenue. This is mainly due to the fact that the operations of interest generally produce wastewater containing product that can be recovered. Currently more than 500 t/a of product is dispensed with as effluent, which translates to more than R7 m. in lost revenue. This project thus aims to set up optimal water requirements and effluent generation in batch chemical plants, as well as designs to achieve the targets. Users of this product will also be able to assess the financial benefit of the application, without interfering with the existing plant operations.

It is anticipated that a novel mathematical technique for zero-effluent in multipurpose batch plants will be developed and that this tool can be used by the chemical industry, regulators and DWA in assessing and improving the efficiency and environmental performance of batch chemical plants. There is also a possibility for a patent to be applied for, as this is promising to be a revolutionary idea that might rekindle global interest in this area.

Estimated cost: R466 480
Expected term: 2009 - 2011

Programme 5: Improved ability to predict and quantify effects

Origin of sodium and its applications to water quality prediction in the South African coal mine environment
University of Fort Hare (Department of Geology)
No. 1663

In addition to experiencing an AMD problem, the Mpumalanga coalfields also experience an increase in the sodium concentration of mine drainage from north to south. This phenomenon adds to the unacceptability of mine drainage. This project aims at finding an explanation for the phenomenon and, to a lesser degree, to propose treatment, prevention and management strategies to address the problem.

Estimated cost: R337 600
Expected term: 2006 - 2009

Environmental sustainability of inland industrial complexes
CSIR, Eco Innovation, University of KwaZulu-Natal, University of Stellenbosch, University of Cape Town
No. 1833

Significant economic activity and prosperity of South Africa is associated with a few large industrial complexes. Since these areas are important nodes of economic growth, it is in the interests of the country that they continue to generate wealth, but do so in a sustainable way. This project will examine several inland industrial complexes as case studies with a view to establishing factors/solutions that can enhance their long-term environmental sustainability, promote high percentages of reuse of industrially generated waste streams, and lay foundational blocks in raising awareness on the significance of symbiotic industrial ecology for future economic sustainability through optimal utilisation of resources. More than one industrial complex will be selected since certain factors may be unique to a given complex.

Estimated cost: R3 000 000
Expected term: 2008 - 2011

Field-testing methods to determine the evaporation rates on brine solutions produced from mine water treatment
Golder Associates Africa (Pty.) Ltd.
No. 1895

Several coal mining groups in Mpumalanga have found that they will have excess water which needs to be treated, either currently or in the near future. Strict water quality targets must be met for either potable use or discharge to the environment. The most cost-effective technology currently available to achieve the targets is usually reverse osmosis, which produces a concentrated brine requiring an environmentally sound and stable disposal method. In Mpumalanga, evaporation ponds are the preferred brine disposal method. A good estimate of the evaporation rate is required to size a brine disposal pond. The salinity of the water results in a reduction in the evaporation rate. It is suggested that the evaporation rate for water at the disposal area is multiplied by a factor of 0.7 to determine the evaporation rate of brine. However, the evaporation rate varies from location to location and depends on the composition of the solution being evaporated. Very little literature is available on the evaporation rate of brine solutions, and this study will benefit the water engineering community of South Africa and result in more reliable information for use in the design of the brine disposal facilities by filling this knowledge gap.

Estimated cost: R452 100
Expected term: 2009 - 2010

Programme 6: Reuse, recovery, beneficiation and treatment of industrial and mining effluents

'Health-for-purpose' in wetlands treating waste streams
University of Cape Town
No. 1725

Wetlands used for the treatment of high COD and BOD effluents need to be managed to avoid imbalance and overload. The presence of key degrading organisms in a specific biodegradative community offers the potential to develop a 'fingerprinting' technology for identifying the presence and monitoring the 'health' of such a community. The study hypothesises that the impact of pollutant addition on natural microbial populations can be demonstrated by molecular methods to monitor the survival and, more importantly, the health of the microbial population responsible for the biodegradation of the impacting pollutant. The study aims to: develop molecular fingerprints of microbial communities and key degradative enzymes involved in the degradation of specific pollutants; develop methods to demonstrate microbial population changes resulting from the impact of polluting wastewater; and investigate the

effects of specific interventions on the 'health-for-purpose' of the wetland microbial population.

Estimated cost: R1 465 000
Expected term: 2007 - 2011

Beneficiation of agri-industry effluents
University of Cape Town
No. 1726

This study focuses on extractive treatment of agro-industrial effluents (specifically effluents produced by the fruit and wine industries and the simultaneous recovery of high-value by-products. The study builds on research which focused on the characterisation of specific wastes with respect to potential economic value and separation and bioconversion technologies. The study aims to characterise the wastes from the fruit and wine industries; develop and customise new extraction processes to obtain antioxidants; investigate and optimise fermentation of residuals after extraction; and investigate and determine the economic and commercial aspects. The outcome of this research potentially lends itself to a broad range of applications not yet developed in South Africa.

Estimated cost: R825 000
Expected term: 2007 - 2010

Towards passive treatment solutions for the oxidation of sulphide and subsequent sulphur removal from acid mine drainage
Rhodes University
No. 1834

The treatment of acid mine drainage typically consists of a series of unit processes which include the pre-treatment (neutralisation and metal removal) followed by the removal of salinity and residual pollutants. Several passive and semi-passive unit processes have been developed locally for the neutralisation of acid mine drainage water as well as the subsequent sulphate reduction. Biological sulphate reduction is now well understood and several innovative technologies have been developed and are currently still being developed including the IMP and the Rhodes BioSureTM process. The subsequent sulphide oxidation step is also well researched and applied in active treatment systems. However, limited passive biological sulphide oxidation and subsequent sulphur removal solutions exist. This solicited project aims to further develop the tubular fixed biofilm reactor developed by Rhodes University to remove sulphur in a passive system. This study will focus on the design, development and operational configurations for the tubular sulphur biofilm reactor. The technology will be demonstrated on laboratory and pilot scale.

Estimated cost: R1 500 000
Expected term: 2008 - 2011

Nanotechnology in water treatment
University of the Western Cape
No. 1897

The National Nanotechnology Strategy has identified water treatment as a prime area of focus. Nanotechnology could lead to advanced water treatment technologies. Promising techniques include photo- and electrocatalytic materials, leading to the destruction of contaminants, and new nanostructured materials such as filtering membranes or adsorbents that could purify even the worst wastewater. This project aims to develop a suite of nanotechnology-based water treatment technologies through stages of fundamental research, process engineering and pilot plant evaluation. The investigations will include nanostructured ion-exchangers and adsorbents, development of in situ generated ozone to sterilise water, nanospray desalination and electrospun nanofibres for application as filters. Fundamental research will be conducted to understand the molecular mechanisms by which the technologies proceed and the processes will then be optimised for industrial application using first laboratory-scale rigs and then on-site pilot plants.

Estimated cost: R1 483 000
Expected term: 2009 - 2012

Pilot application of a dual stage membrane bioreactor for industrial effluent treatment
Alt Hydro cc
No. 1900

Over the past decade solutions are increasingly sought using membrane bioreactor technology. This is mainly due to recent refinements and lowering of costs associated with this technology. Significant improvement in process efficiency associated with the treatment of industrial effluent using a novel dual-stage side-stream membrane bioreactor has been previously reported. This dual-stage approach to wastewater treatment using this membrane bioreactor configuration greatly enhanced performance and increased the long-term adaptability and stability of the developed and retained microbial populations within the system by facilitating a continuous microbial ecology management strategy. Compared to conventional suspended culture wastewater treatment processes, this system facilitated a 75% improvement in acclimation efficiency of the resident microbial consortia, which translated directly to considerable improvements in the resultant effluent quality and consistent operation of the treatment process. However, variations in wastewater streams make it imperative to assess the performance of the system on-site and at the pilot-scale level, in order to accurately gauge the impact of real wastewater challenges on the robustness of

the process technology. This pilot project therefore aims to develop on-site wastewater treatment solutions for industries typically targeted by DWA as it increases its monitoring and legislative framework capacity. As legislative enforcement is addressed, increasingly, industrial offenders responsible for further burdening already overloaded municipal WWTP infrastructure are now being forced to seek on-site wastewater solutions prior to discharge. This technology aims to address these increasingly prevalent needs by providing a mobile, adaptable solution to specific industry needs.

Estimated cost: R950 000
Expected term: 2009 - 2011

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 1: Advocacy, health and hygiene education

Assessment of the effect of drinking water quality on the health of people living with HIV/AIDS
University of Venda (Department of Microbiology)
No. 1653

The spread of the human immunodeficiency virus (HIV), which causes Acquired Immunodeficiency Syndrome (AIDS), is taking place at an alarming rate. The situation for HIV/AIDS-infected individuals is exacerbated by the fact that a large proportion has no access to safe water or adequate sanitation. The lack of safe water compounds health risks to HIV/AIDS individuals leading to increased vulnerability, decline in productivity and income and consequently a general decline in their socio-economic status. HIV/AIDS is not a water-borne disease therefore there appears to be little relation to each other but a poor microbiological quality of their drinking water could have detrimental impacts on the health of HIV/AIDS-infected individuals. This project aims to do a health impact assessment study based on the microbiological quality of drinking water used by rural households that have at least one HIV/AIDS-infected individual. The presence of selected pathogenic and opportunistic bacteria and viruses in drinking water with those present in stool samples of both people living with HIV/AIDS and healthy individuals will be correlated to identify the relationship between point-of use drinking water quality and health indicators (such as diarrhoeal morbidity and mortality) .

Estimated cost: R800 360
Expected term: 2006 - 2009

Develop the guideline: Management of Microbial Water-Borne Diseases Vol 5: What We and Our Children Ought to Know
University of Venda
No. 1672

This volume will include home hygiene and a link to sanitation, different water sources and handling of water from the sources. Disinfection and its side effects, the boiling of water and when not to boil, danger of burn wounds, etc. The origin and transmission of diarrhoeal diseases, prevention and care, will be included, as well as emergency treatment of diarrhoeal cases and special care of the immuno-compromised. Handling of containers in households, storage, contamination, etc. will also be included. All of these need to be described in a simple, demonstrative way taking into account the posters, pamphlets and reports already available at the WRC, Department of Health and DWA, as well as other such documents developed by water suppliers, NGOs, Department of Education (school curricula), etc., to get the most suitable and effective method of transferring the message to the community. Cultural differences and preferences have to be taken into consideration.

Estimated cost: R400 000
Expected term: 2006 - 2009

A guideline document for emergency disinfection of drinking water
Tshwane Institute of Technology
No. 1737

Untreated or inadequately treated water is still drawn directly from rivers, ponds, streams and boreholes in some South African rural communities for domestic use. Various water-related infectious diseases including diarrhoea are often contracted, in some cases causing the death of the immuno-compromised individuals. In some instances, following natural disasters, a local authority may urge consumers at risk of contracting water-borne diseases to follow emergency disinfection measures. Messages and recommendations regarding the 'emerging' disinfection of untreated water do not take into account the variation in the quality of the source water. General guidance and recommendations on the use of a disinfectant or boiling of the water is usually given. In some instances this could add to the detrimental health effects of the water. The aim of this study is to consolidate available literature and information and develop a user-friendly guideline for emergency disinfection of untreated water.

Estimated cost: R600 000
Expected term: 2007 - 2009

Assessment of water, sanitation and hygiene services in relation to home/community-based care services for HIV/AIDS-infected individuals in rural and peri-urban areas of South Africa
University of Venda
No. 1738

This project will be done in collaboration with the Department of Health (DoH) and will provide an extension of the project funded by DoH. The HIV/AIDS epidemic has a devastating effect on the health and well-being of the South African nation, but it also presents grave consequences for the socio-economic development of South Africa. Safe water and sanitation are basic needs and a human right, especially for people affected by HIV/AIDS, as it will help them to live longer in good health and with increased dignity. This project will highlight the issues underlying the broad context for water supply, sanitation, and hygiene behaviour, and the need for systematic attention to these. This will be done in collaboration with DoH and the Medical Research Council. The aim of this study is to provide insight into the extent to which water, sanitation and hygiene issues/practices are important and relevant for service providers and people living with HIV/AIDS, especially with regard to home/community-based care.

Estimated cost: R500 000
Expected term: 2007 - 2009

How does the HIV and AIDS epidemic in South Africa impact on the water, sanitation and hygiene sectors?
University of the Western Cape
No. 1813

In South Africa HIV/AIDS tends to be treated predominantly as a health issue with intervention efforts narrowly focused on prevention and treatment. Issues like accessibility to clean water for people living with HIV and AIDS (PLWHA) in both urban and rural areas, and related issues like sanitation and hygiene have not received a lot of policy debate, support and attention in South Africa. Safe water and sanitation constitute the most basic needs and human right issues, especially for PLWHA as it will help them to live longer in good health and increase their dignity. Therefore, information on water, sanitation and hygiene is important for making the right decisions. Access to basic sanitation and effective solid waste management is essential in reducing morbidity and mortality, particularly for those with a reduced immune function such as PLWHA. Access to clean water is essential in promoting effective health and hygiene practices amongst PLWHA. Effective health and hygiene requires an enabling environment that includes not just safe water supply, but effective wastewater disposal and solid waste management. The raising of health and hygiene awareness amongst affected households will be of little value unless safe water supplies are available to these households, so that they can practise good hygiene. Hygienic behaviour in turn reduces opportunistic infections and lengthens the time period between HIV infection and full-blown AIDS, thereby extending the period in which HIV sufferers can be both domestically and economically active. A complicated web of relationships exists between water and HIV and AIDS and cannot be underestimated. An investigation of the linkages and perspectives between PLWHA, water, hygiene practices and sanitation will enhance the development of integrated approaches. The central objective of this research study is to provide insight into the extent to which water, sanitation and hygiene sectors must strategise for services provided to people living with HIV and AIDS. Further the study intends to look at 3 distinct cross-sections; urban, peri-urban and rural areas across 3/4 selected provinces. The rationale being that the impact of intervention measures ought to differ across the 3 segments and across provinces.

Estimated cost: R700 000
Expected term: 2008 - 2010

Survey of hand-washing hygiene behaviour
Sustento Development Services
No. 1886

Hand-washing is universally accepted and promoted for health interventions, but an assessment has not been completed in South Africa to benchmark or measure the impact of programmes designed to improve hand hygiene behaviour. The unique nature of the South African environment must be better understood in order to develop more appropriate and effective hand-washing messages and programmes. It is imperative to develop a methodology to measure the effectiveness of the efforts being made and to determine what activities are most successful in changing behaviour. Hand-washing must be indicated by a community's willingness to actually do it - even though they might seem to admit that they think it is important. These results will be used to guide the development of future hand hygiene and public health programmes to deliver improved performance more efficiently. The study will measure whether a hygiene education intervention is having effect on both the quality and the frequency of hand-washing behaviour and which hygiene and hand-washing promotion activities appear more effective at stimulating and sustaining behavioural change.

Estimated cost: R520 670
Expected term: 2009 - 2011

Programme 2: Peri-urban sanitation research

Establishment of sanitation technology demonstration centre
CSIR
No. 1890

Knowledge and dissemination of sanitation technologies have been found to not be effectively transferred through guidelines. In fact, guidelines and reports have more meaning for technical practitioners; however, the key decision makers rarely have a good understanding

of the reality of the technology and its benefits. In South East Asia, the concept of sanitation technology centres and sanitation marts have proved successful in promoting technology and its acceptability. A sanitation demonstration concept consists of a site where full-scale models of technology are available for viewing (a sort of a museum), which enables one to learn and understand, as well as appreciate, the function and benefits of the technologies available. In South Africa, there is a lack of such a facility or facilities which communities, councillors and emerging professionals can access to appreciate technologies. Thus there is a need for a sanitation technology demonstration centre which can house and accommodate all existing and new sanitation technology products in existence. This will assist and facilitate decision makers and communities to have direct access to view and learn about the technology options. The study will establish a sanitation technology centre, where to-scale models of different types of sanitation technologies will be constructed for training and display. The sanitation technology platform will form part of a wider housing-services technology demonstration centre.

Estimated cost: R596 600
Expected term: 2009 - 2011

Programme 3: Institutional and management aspects of sanitation service delivery

An approach to reduce risks and hazards from human waste generated by informal settlements
Cape Peninsula University of Technology
No. 1901

Human settlement strategies continue to seek alternative approaches to confronting the growth of informal settlements while rapid urbanisation of poverty poses serious challenges to municipalities. Housing delivery has failed to address downstream water pollution. This study will identify realistic opportunities for informal settlements' residents to contribute to on-site improvements of basic waste disposal systems, in partnership with municipalities. The capacity of informal residents to contribute to protecting their immediate environment will be explored.

Estimated cost: R587 800
Expected term: 2009 - 2011

Programme 4: Technical sustainability of sanitation services

Understanding the sludge accumulation in VIPs and other on-site sanitation systems and strategies to manage desludging in the future when pits are full
Partners in Development
No. 1745

Current emphasis in sanitation rollout and the millions invested therein have a bias towards putting in sanitation facilities in the form of dry VIP toilets. Though this is one of the essential components of sanitation delivery and the easier component, less emphasis is afforded to aspects such as ownership, participation, hygiene education and ongoing maintenance which are basically the more challenging and also essential elements for sustainability in sanitation. It can be estimated that more than 1 million VIP systems will be built to meet backlogs. This is a huge investment by the Government; however, very little foresight and strategies have been developed as to how to manage these systems into the future. The research aims to tackle these questions of sustainability and, through the knowledge which is generated, make the sector better prepared to deal with the challenges. This study will develop an understanding of the sludge accumulation in VIPs and strategies to manage desludging in the future when pits are full.

Estimated cost: R1 600 000
Expected term: 2007 - 2010

Piloting and testing the pour flush latrine technology for its applicability in South Africa
Partners in Development
No. 1887

Recent research studies concluded by the WRC have raised many concerns about the long-term sustainability of dry sanitation technologies. The studies have found that the technology has led to unintended consequences due to misuse by users, as well as the lack of understanding of the science of dry sanitation systems. A combination of these factors and the stringent design requirements are proving it difficult to access pits for pit emptying. This is further compounded by user behaviour which is resulting in the intrusion of solid waste, plastics and other undesirables into the pits, resulting in difficulties around pit emptying and the rapid filling of pits. This coupled with the fact that there is no easy mechanical or physical modus operandi for servicing full pits. All of these issues are raising many new challenges which jeopardise the sustainability and the target set by government for coverage of sanitation. Amongst the suite of technologies, pour-flush latrines, which are used widely as a basic sanitation norm in South East Asian countries, have the potential to resolve many of these issues. However, very little promotion and application has been done in South Africa. This research study aims to create an understanding of the technical, social and environmental challenges associated with its application.

Estimated cost: R1 000 000
Expected term: 2009 - 2011

NEW PROJECTS

THRUST 1: WATER SERVICES - INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost recovery in water services

Strengthening the sustainability and effectiveness of Free Basic Water
Counterpoint Development
No. 1989

There is growing recognition across South Africa of the pivotal importance of sustainability in water services provision: sustainable funding and revenue to support ongoing service delivery, sustainable water resources management to meet current and future demand, and sound operation and maintenance of all associated infrastructure to sustain continuous provision of potable water to citizens and key sectors of the economy. But does provision of Free Basic Water support or undermine sustainable provision of water services? The need to provide support to households living in poverty to enable them to access at least basic water services affordably is not in question. But how sustainable is the provision of Free Basic Water, as currently implemented, if it sends out mixed messages about the real value of water in a context of growing scarcity, and if it is contributing to operating shortfalls in municipal revenue arising from unbilled water? What are the trade-offs in the current approach? Are there more effective ways of achieving the desired outcome of ensuring that even the poorest citizens can afford at least basic services? There is growing evidence that the administrative and financial requirements for providing Free Basic Water and Sanitation sustainably to those who need it have been underestimated. Free Basic Water is at risk of becoming increasingly anti-poor, because many municipalities lack the capacity to implement it effectively or sustainably, are not able to manage their available funds optimally, and are funding service provision through under-spending on operation and maintenance. Inevitably these weaknesses compromise the quality of service provision, and it is the most impoverished households who are impacted most. In a context of chronic poverty, limited administrative capacity in many municipalities, and growing water scarcity, is the provision of Free Basic Water the most effective and sustainable way of giving force to the Constitutional right of access to adequate water? This study aims to review international good practice around financing water services and designing water tariffs for sustainable water servicing and to review approaches and funding mechanisms adopted by relevant middle-income developing countries with substantial poor populations to providing affordable water services to needy and vulnerable citizens.

Estimated cost: R1 400 000
Expected term: 2010 - 2012

Programme 2: Institutional and management issues - Water services

The provision of FBW to backyard dwellers and/or more than one household per stand
Nemai Consulting
No. 1987

Backyard dwelling, prevalent since the 1950s, is not a new phenomenon, nor is it a phenomenon which is likely to dissipate. With the provision of RDP housing and an influx of rural people to urban areas to find employment, there has been an increase in backyard dwellers. It is more prevalent in larger cities where there are more opportunities for work. The WRC commissioned a study in 2008 entitled 'The impact of large consumer unit size on water and sanitation services in lower income urban areas in South Africa'. This study illustrated the access to and affordability of water and sanitation services of backyard dwellers in lower income formal urban areas. It found that affordability was an issue for large consumer dwellings. The study suggested that a policy statement was necessary to alleviate these challenges. This research project aims to answer the questions raised in the 2008 study and to address the gaps identified. The 'Provision of FBW to backyard dwellers and/or more than one household per stand' research study would thus build on the existing research in terms of conducting a policy analysis and determining the legislative implications around not providing water to backyard dwellers/more than one household per stand, suggesting the relevant policy and strategic revision and developing a user-friendly guideline for the provision of water to backyard dwellers/more than one household per stand for municipalities. This would clearly address both policy issues and technical options for water provision as recommended in the 2008 WRC report.

Estimated cost: R601 800
Expected term: 2010 - 2012

Programme 3: Innovative management arrangements - Rural water supply

Bridging the policy divide: Women in rural villages and the Water for Growth and Development Framework
Mvula Trust
No. 1988

While national policy has increasingly clear intentions for pro-poor policies and integrated and sustainable rural development, these intentions do not readily translate to improved living conditions on the ground. A range of explanations for this mismatch between intention and impact are possible, but detailed, on-the-ground research

that reaches from community to local government and to national decision making can hope to unpack these dynamics. Water provision is a core to pro-poor development. In the 2009 ANC manifesto, a new focus on rural development is put forward, including a much stronger link between land and agrarian reform programmes and water resource allocation and ensuring that the best quality water resources reach all our people, especially the poor. The Water for Growth and Development Framework clearly recognises the leading role that rural women play in the management of water, often in difficult conditions: Women should be thought of as strategic users of water. They manage the use of water for preparing food, for drinking, bathing and washing, for irrigating home gardens and watering livestock. Women know the location, reliability and quality of local water resources. They collect water, store it, and control its use and sanitation. They recycle water, using grey-water for washing and irrigation. Their participation in all development programmes should be given priority. This research will explore the multiple water use strategies of rural women in two different rural villages. The research will test the adequacy of current policies and practices against the reality and aspirations of women and their families in two villages: The research will take an explicit gender-oriented, pro-poor, bottom-up approach to policy formulation, within a framework of evidence-based policy and will produce qualitative knowledge and understanding of poverty and household dynamics, as well as the dynamics of the local government setting that determines whether and how water-related resources needed by women in rural villages are available or could be made available to them.

Estimated cost: R596 000
Expected term: 2010 - 2012

Innovative water and sanitation management arrangements at family and neighbourhood level
Sarah Slabbert Associates
No. 1990

Outcomes sought in public communication campaigns are, typically, awareness, attitude change, or behavioural change. Although large amounts of money are spent on public communication campaigns, 'many mass media campaigns proceed in the absence of a research foundation'. There is often no pre-campaign research that investigates the issues and solutions that already exist in target populations. Nor is evidence sought of how many members of the target public read the publications or listened to the radio messages, understood them, believed them, or changed their attitude or behaviour as a result of them. This will only become known through evaluation research. This research project will apply the methodologies of qualitative ethnographic research with the objective to shed new light on the user culture of water and sanitation management at family and neighbourhood level in rural South Africa. This information will assist government municipalities and other organisations to make strategic and informed decisions on sanitation delivery.

Estimated cost: R412 000
Expected term: 2010 - 2012

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Development of a costing model to determine the cost-efficiency and energy-efficiency of water treatment technologies and supply options
Chris Swartz Water Utilisation Engineers
No. 1992

While considerable information is available on technical aspects (design; operation; maintenance) of water treatment technologies, there is still a serious lack of information on costs of water treatment systems and technologies, in particular life-cycle costs, which are used in the comparison and selection of these technologies. This includes both capital costs and operating costs (operation; maintenance; management). In this regard, the escalating cost of energy is a major factor necessitating increasing attention. Water service authorities (WSAs), water services providers (WSPs) and consultants alike all have scant comparative costing information for water treatment system options on which to base their decisions for a new water treatment scheme(s). This results in incomplete planning and inadequate budgeting for these systems. This project will undertake a detailed analysis of available information and provide guidelines to assess under which circumstances decentralised, small water treatment systems are economically preferable to larger, centralised treatment schemes with their associated distribution systems. The guidelines will further encompass costing of different energy sources for potable water production. The guidelines will include a listing and description of all the different energy sources (existing; new; emerging) that can be used for driving water treatment technologies and treatment systems to produce drinking water, both on small-scale and large-scale. A user-friendly costing model for establishing and predicting the cost-efficiency of a range of small-scale water treatment technologies that are normally used in water supply schemes, thereby allowing economic comparison between different water treatment options being considered for a water supply scheme(s), will be developed.

Estimated cost: R763 000
Expected term: 2010 - 2012

An independent investigation into the purification capacity of small-scale water purification units manufactured and supplied in South Africa
University of Johannesburg
No. 1994

Recent outbreaks of cholera and other waterborne diseases in southern Africa have resulted in a public perception that tap water is not safe for drinking purposes. As a result, the use of small scale water purification systems in the domestic and occupational setting is increasing rapidly. Most of these units are sold over the counter and consumers buy the products in good faith on the basis of claims of their efficiency made during marketing and advertising campaigns, and with the expectation that the units will remove 90-100% of all harmful microorganisms. Very few independent studies have been published on the capacity of these units to remove microorganisms and the majority are only tested for a single organism or compound and/or a single product. Only two studies have been published where the units were tested for more than one compound simultaneously. The overall objective of the study is to assess small scale water purification units manufactured and sold in South Africa for their capacity to provide safe drinking water for domestic, public and occupational use and to provide guidelines to enable consumers to make informed decisions when purchasing these units.

Estimated cost: R809 000
Expected term: 2010 - 2012

Programme 3: Drinking water quality

Nanotechnology solutions for drinking water
Rhodes University
No. 1991

The South African Nanotechnology Strategy amongst its objectives states the need to: a) support long-term nano-science research that will lead to the fundamental understanding of the design, synthesis, characterisation, modelling and fabrication of nano-materials and (b) support the creation of new and novel devices for application in various areas. The Strategy also lists six focus areas which include: Water, Health as well as Advanced Material and Manufacturing. Harnessing nanotechnology ushers in opportunities that can find application in many areas including initiatives that can ensure the supply of clean drinking water. The availability of clean drinking water means that there is a positive impact on the less advantaged communities and a reduction in health-related costs. This project will develop nanotechnology solutions for drinking water. The first phase of the project will involve fabrication of electrospun nano-fibre membranes which are functionalised with a variety of moieties to enable them to serve as solid phase sample clean-up devices for complex water samples. The second phase will involve fabrication and functionalisation of electrospun nanofibre membranes for the uptake of endocrine disruptors from water samples. The third phase will involve immobilisation of enzymes/enzyme substrates on electrospun nano-fibres for point-of-use devices by encapsulation or surface attachment and optimising hydrolytic characteristics for selected endocrine disruptors. The fourth phase will involve functionalisation of electrospun nano-fibres with imidazoles and silver to impact antimicrobial activity. The project will conclude by fabricating point-of-use devices that incorporate the developed technologies.

Estimated cost: R1 800 000
Expected term: 2010 - 2012

Programme 4: Water distribution and distribution systems

Integration of water safety plan requirements into the existing WRC water supply system assessment tool
eManti Management
No. 1993

Previous WRC projects have resulted in a generic Water Safety Plan and the creation of the electronic water quality management system (eWQMS), an award-winning online tool to enable water service authorities (WSAs) to better manage their service provision and water supplies. This project will integrate the WSP with the existing eWQMS, providing an updated tool available to all WSAs in South Africa. As such, all WSAs have access to the eWQMS and tools that reside on the eWQMS. By incorporating this tool onto the eWQMS (via both a downloadable file and web enablement of the application), the developed project products would be easily available to a wide audience. In addition, the various DWA/IMESA/SALGA eWQMS teams regularly engage with WSAs and attend both National and Provincial Water Sector Forums. During these meetings, tools available for WSAs to use are demonstrated and discussed. In this way, the water sector is easily made aware of new developments and tools available to improve current practices.

Estimated cost: R190 000
Expected term: 2010 - 2012

Practical application of residential water demand and wastewater flow end-use model in South Africa
University of Stellenbosch
No. 1995

Modelling water demand on small spatial scales (e.g. individual water use events at single homes) and short time scales (as brief as one second) has various advantages above the more conventional approaches based on modelling demand at lower resolutions. There is growing

interest both internationally and locally in end-use modelling of water demand. One of the first advances was the residential end-use model (REUM) that enables the analyst to estimate the indoor- and outdoor water demand, hot water demand, wastewater flow, and concentration of total dissolved solids in the wastewater flow for an individual residential property and a given set of input parameters. This combination of components makes REUM unique. An added advantage of end-use modelling is the power provided in describing the interface between water demand and wastewater generation. End-use models have been found to accurately estimate water demand of typical suburban homes internationally. There are no local studies based on measured water use at a suitably high resolution. In addition, none of the studies reported locally or internationally have correlated end-use estimates for water demand and wastewater flow to measured results of both these parameters. This is simply because, to date, no data have been recorded at the required resolution in any African country and made available for testing the application of end-use models. This study aims to set up two such pilot application sites. Addressing this research would be the first pilot project of its kind in Africa and one of only a few in the world. It would most certainly provide for unique, high-quality research outputs during the project and for many years to come.

Estimated cost: R659 500
Expected term: 2010 - 2012

Assessment of non-revenue water in South Africa
WRP Consulting Engineers
No. 1996

In 2004 and 2005, WRP was commissioned by the WRC to undertake an assessment of the levels of non-revenue water (NRW) throughout South Africa. In the course of this work, over 100 water audits were undertaken for selected water supply areas. In some cases, the areas investigated were complete municipalities and in other cases the areas were split into smaller components for which appropriate data could be established. From the initial 100 areas investigated, it was only possible to derive a realistic water balance for approximately 60 of the areas which represented approximately 70% of South Africa's municipal water demand. The figures received were extrapolated to provide an estimate of non-revenue water for the whole country and as such represented the first such estimate based on realistic data. Although there were some gaps in the data obtained from the various municipalities, the final data sets and extrapolated estimates of the non-revenue water for SA remain the best estimates currently available and to date no one has provided a more reliable estimate. In view of the fact that the issue of non-revenue water has become the highest priority issue within the Department of Water Affairs, it is essential that the benchmarking process is not stopped and it should become an annual assessment. It is only in this manner that the results and data can be improved and the key problem areas identified. The project will complete an update of the 2005 water audits and to set up a system that can be updated on an annual basis and to extrapolate the available information to provide an indication of non-revenue water for the whole of South Africa.

Estimated cost: R994 500
Expected term: 2010 - 2012

Compendium of case studies relating to water loss and water demand interventions at the municipal level in South Africa
Resolve Consulting
No. 1997

Within this context water demand management and water loss management (WDM/WLM) have already emerged as the most desirable alternative to the augmentation of water. Indeed many studies prove that investment in demand interventions represents only a fraction of the cost of investment in infrastructure to augment supply. There have been a number of different, highly successful and even partially successful WDM/WLM initiatives in the urban water sector over the past decade. However, there is a need to disseminate this knowledge gained through the implementation of these initiatives by demonstrating the successes and shortcomings of these initiatives as case studies. Although there is, in some cases, literature on these success stories, they have not been captured, documented and disseminated as case studies in a single, easily-readable publication with the focus of the documentation of comparative WDM/WLM interventions. This study will compile a Compendium of approximately 50 case studies relating to water loss and water demand interventions that have been implemented throughout South Africa at the municipal level.

Estimated cost: R600 000
Expected term: 2010 - 2012

Apparent losses in selected areas in South Africa
University of Cape Town
No. 1998

Water is an essential but limited natural resource which is indispensable for life and economic development. Water for human, commercial and industrial consumption is abstracted from natural water bodies, purified and distributed through water supply systems to users. There is renewed international awareness that water distribution systems world-wide are aging and deteriorating, while the demands on these systems, and thus on our natural water resources, are ever increasing. Water losses from

water distribution systems are reaching alarming levels in many towns and cities throughout the world. 'Real losses' consist of physical leaks from the distribution system up to consumer connections. 'Apparent losses', on the other hand, consist of water that is delivered to users, but look like losses to the water service authority. Apparent losses consist of two main components, namely, water meter under-registration and unauthorised consumption (theft and illegal use). New municipal water meters are sized to be accurate at the normal flow rates estimated for different consumers. While the metering error at these flow rates will typically be small (less than 2%), the meter accuracy can be substantially lower at low flow rates. In addition meter accuracy reduces with time, and thus the under-registration error increases if flow meters are not replaced at regular intervals. Under-registration of consumption is worst at very low consumption rates, for example when slowly filling a toilet cistern. On-site leakage is a particular problem, since a small leak or dripping tap on a property will produce a constant, low flow rate that is likely to be under-registered by the flow meter (or may not even be picked up at all). Since the leak flow is constant, significant volumes of water can be lost by the municipality in this way. A recent WRC research project showed that significant on-site losses may be occurring in different areas in South Africa. For instance, of 182 randomly selected properties in suburbs in Johannesburg, 64% had measurable on-site leakage. The average on-site water losses were found to be in the order of 25% of total consumption. The purpose of this study will thus be to estimate the extent of apparent losses in selected suburbs in South Africa to provide insight into the extent of this problem.

Estimated cost: R400 000
Expected term: 2010 - 2012

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER MANAGEMENT AND SANITATION

Programme 1: Emerging technologies and solutions

Biotech in sanitation: biopolymer production with Natronococcus occultus, a haloalkaliphile using municipal wastewater and other waste resources
University of Cape Town
No. 2000

Natronococcus occultus is a haloalkaliphile isolated from East African soda lakes, which are characterised by low Ca and Mg levels, with high Na, Cl and CO3 concentrations and a pH of 10-11. Natronococcus occultus, produces a glutamic acid-rich polymer, poly-glutamic acid (PGA). This polymer has a wide range of uses including hydrogels, flocculants and soil conditioners and may be used for medical applications. Preliminary work in CeBER (UCT) laboratories has shown more consistent growth in the high salt environment under non-sterile conditions. This project aims to study this organism using wastewater as a feed substrate to produce a biopolymer or environmentally friendly flocculants. It can also be cross-linked and blended with the treated sludge for a high-value soil conditioner. This project investigates the potential of municipal wastewater treatment plants to produce materials required by the plant for operation, from its own waste resources.

Estimated cost: R356 000
Expected term: 2010 - 2012

Co-digestion of sewage sludge and industrial concentrates
University of KwaZulu-Natal
No. 2001

The WRC has supported several laboratory-scale and feasibility projects on co-digestion of industrial effluent as a treatment strategy for toxic industrial wastes. eThekwini municipality has agreed to pilot full-scale anaerobic co-digesters at Amanzimtoti WWTW. The digesters are expected to be refurbished in 2010. As a support to this initiative, this project will look at using WEST software to assist in building and transferring knowledge on operation and training needs. The investigation will be undertaken in six phases that will overlap with one another. The project will look to develop an in-line model of the laboratory-scale AD which will be followed by the development of an unsteady state model for the anaerobic digesters at Amanzimtoti WWTW. This will be used to predict performance of the full-scale digester. The WEST model will also be developed to analyze tests undertaken with selected industrial effluents in order to determine the parameters necessary for describing the kinetic effects of co-digestion of different feeding rates of the effluent. The model will be assessed for its ability to predict and test the performance of several industrial concentrates at once. The project will also investigate scenarios to maximise methane production or toxic effluent treatment and to demonstrate recovery from process upsets. Finally, the West model will be used to train the operational staff on how to react to different hypothetical upset conditions. If during the period of the project, upset conditions occur, data will be recorded so that a portfolio of case studies can be developed and procedures will be developed to determine the root cause of the upsets. Overall, this project will assist in developing a model to assist in the process control and training of support staff for the implementation of co-digestion at a full-scale AD.

Estimated cost: R1 050 000
Expected term: 2010 - 2012

Urban effluent treatment in a rhizofiltration system
Durban University of Technology/University of Stellenbosch/University of Cape Town
No. 2004

Urban effluent includes stormwater, drainage from informal settlements and townships, sewer overflows, illegal industrial effluent connections to stormwater systems, and so on. Stormwater should ideally be treated at the source and this is the rationale behind permeable asphalt roads, swales and buffers. Whereas in the past the objective of urban drainage was to remove rainwater from settlements as quickly as possible, the philosophy has changed towards retention and drainage as slowly as possible. Where stormwater transport is inevitable, the aim is also to remove and contain pollutants where the flow originates, at source, through vegetated and sand filters. This project proposes that passive treatment systems would be able to remove (or trap) pathogens from urban effluent, together with other pollutants such as nutrients, hydrocarbons, dissolved metals and toxic substances. The objective of this research is removal of dissolved substances and pathogens from stormwater outlets, and is complementary to initiatives such as litter traps, or source control measures. Natural wetlands remove pollutants and improve surface water quality greatly while constructed wetlands have long been used as polishing processes downstream of municipal wastewater treatment. Three generations of constructed wetlands consist of the surface flow wetland, subsurface flow wetland, and vertically integrated wetland that shares characteristics with trickling filters and slow sand filtration. An important difference between the constructed wetlands as used downstream of wastewater treatment works and downstream of urban effluent discharges is the variability of flow: treated effluent runs at a steady flow rate with recurring daily peaks, while an urban effluent discharge would see highly variable flow rates and composition, followed by periods of low or no flow. This study will include design of an experimental rhizofiltration system, where the wetland plant root zone provides oxygen and a biofilm habitat for treatment, where the filter material are selected to accommodate high flow rates, and which is hydraulically flexible to operate as different kinds of wetlands according to the above classification. The research work would be the performance evaluation of such a system under different conditions.

Estimated cost: R2 400 000
Expected term: 2010 - 2012

The optimisation of waste stabilisation ponds by combining duckweed-based and algal-based systems, together with rock filters
ARTechnologies
No. 2005

Waste stabilisation pond technology is the most cost-effective wastewater treatment technology for the removal of pathogenic micro-organisms. The treatment is achieved through natural disinfection mechanisms. It is particularly well suited for tropical and subtropical countries because the intensity of the sunlight and temperature are key factors for the efficiency of the removal processes. Poor performance of WSP in developing countries can be attributed to both poor process design and poor physical design. This project investigates the combination of rock filters, duckweed and algal ponds for improved performance of current systems. There is a worldwide trend to include a rock filtration system, often with aeration, as a polishing step to remove the suspended algal cells. Duckweed-based WSP systems have a distinctive floating mat of duckweed covering the surface of the pond; it has been shown that these systems are able to remove COD and nutrients effectively. Since they inhibit algal growth, the effluent is free from suspended material and therefore has a lower COD as compared with algae-based WSP systems. The disadvantage is that production of oxygen is limited to the surface layer associated with the mat of duckweed, and the water column remains essentially anaerobic. This project proposes to study the following treatment train: anaerobic or facultative ponds (for COD removal), followed by a duckweed system, combined with an algal-based system, together with an aerated rock filtration step before discharge of the effluent. The advantages of the algal system will mitigate the disadvantages of the duckweed system and vice versa. At present not all of the process design criteria have been developed for duckweed systems, and a detailed study on the kinetics and hydrodynamics of a duckweed system would greatly contribute to the knowledge base in this regard. The combination of the two systems is a novel idea, and information gained on the system design and operation will provide design and operating guidelines to use for new designs and upgrading of existing ponds.

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

The development of nanocomposite polysulphone membrane with reduced fouling properties for use in wastewater treatment
University of the Western Cape
No. 2006

Polysulphone (PSF) membranes are the most common membranes used in ultrafiltration of wastewater due to their mechanical robustness and structural- and chemical stability. Unfortunately PSF is a hydrophobic material, making its surface prone to fouling due to adsorptive mechanisms. Fouling can either be caused by cake formation on the surface of the membrane, or by adsorption of the foulants both on the surface and in the membrane pores. Cake fouling is generally reversible and can be removed by

backwashing or water flushing. Foulant adsorption however is irreversible and can only be remedied by very harsh chemical cleaning. Many studies have been conducted to increase the hydrophilic properties of the polysulphone membrane surface. These studies can be divided into three categories: 1) blending PSF with hydrophilic nanoparticles such as SiO2, ZrO2 and TiO2; 2) grafting with hydrophilic polymers, monomers or functional groups; and 3) coating with hydrophilic polymers. Despite these efforts to minimise fouling of PSF membranes during wastewater treatment, there are still many unanswered questions regarding the mechanisms involved. This study will attempt to develop a novel PSF nanocomposite membrane with minimised fouling properties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 2: Application of appropriate technologies and tools

Ultra-sensitive electrochemical nanobiosensors array devices for real-time determination of estrogenic endocrine disruptors in municipal wastewater (ENDOTEK)
University of the Western Cape
No. 1999

There is a current concern in South Africa that water resources are heavily contaminated with pollutants generally classified as endocrine disruptors or endocrine disrupting chemicals (EDCs). This study will focus on endocrine disruptors that are natural and synthetic estrogenic hormones such as estriol, 17-estradiol and 17-ethinylestradiol and estrone. Estrogenic hormones are the most endocrine-disrupting chemicals because the disrupting potency can be several thousand times higher than other chemicals such as nonylphenol. This implies that natural and synthetic estrogens can be biologically reactive even at low nanogram per litre levels. Consequently, the detection of these trace contaminants in municipal water resources and their elimination are very important areas of current research interest. The level of contamination of municipal wastewater in South Africa by individual synthetic and natural estrogens is not fully known and there is no available technology for their real-time determination. The main methods for the determination of estrogenic EDCs have been through vitellogen (a biomarker for EDCs) enzyme-linked immunosorbent assay (ELISA) on fish samples or by chromatographic (HPLC) analysis of wastewater. They are very technical methods requiring extensive sample pre-treatment and high-level qualified personnel. Thus the development of rapid, simple and low-cost procedures for detection of estrogenic activity in wastewater samples is of utmost importance. The proposed research is on the development of a nanostructured electrochemical DNA aptamer array biosensor for detecting and quantifying estrogenic endocrine disruptors in wastewater samples down to the femto- or atto-molar range. The idea is to determine individual estrogen compounds simultaneously in one measurement using multichannel microchip array signal transduction approach.

Estimated cost: R1 665 000
Expected term: 2010 - 2012

Microbial database-tool for evaluating the BNR processes in KZN
Durban University of Technology
No. 2003

Biological nutrient removal treatment processes are highly organised systems that depend on a synergy between microbial populations and plant configuration and operating parameters. These microbial populations comprise primarily of functional groups of organisms such as ordinary heterotrophs that facilitate COD removal and denitrification, nitrifiers that facilitate nitrification, phosphate-accumulating organisms that are responsible for biological phosphate removal and filamentous bacteria that are responsible for the formation of the core of the floc in activated sludge processes. There is a fine balance between these different groups that has to be maintained in order for optimal functioning of these processes. Selection of these populations is generally based on influent characteristics, operating parameters and process configuration and therefore the microbial population dynamics in full scale treatment processes are closely linked to the former operational conditions. In South Africa, previous studies on these correlations were conducted a long time ago (Ekama et al., 1999), focusing primarily on engineering paradigms. The microbial population investigations were based on conventional microbiological techniques. With the advent of novel molecular techniques, there has been a paradigm shift in microbial population dynamic studies allowing a high degree of accuracy. An IWA specialist group on activated sludge separation problems stated the general situation in conventional and BNR plants in South Africa (Pitman, 2006), but most of the referenced publications were over two decades old. Therefore there is need for more updated knowledge in population dynamics. The proposed research will focus on using these novel molecular techniques to accurately profile functional groups of microorganisms and correlate to plant operating parameters and influent characteristics with the aim of understanding microbial contributions. It is hoped that this will aid in optimising plant performance and prevent problems such as bulking and foaming. The approach will be unique in South Africa and findings will be relevant to the South African wastewater treatment systems

Estimated cost: R900 000
Expected term: 2010 - 2012

Evaluation of the DEWATS process for decentralised wastewater treatment
University of KwaZulu-Natal
No. 2002

Several WRC projects have looked at the anaerobic baffle reactor (ABR) as a decentralised technology option for wastewater treatment. The DEWATS system aims to provide a treatment train consisting of the ABR connected to a wetland or membranes to study final effluent quality. The aim is to reuse the effluent for agricultural trials and thus link the technology to agriculture and food security. This projected will be piloted in KwaMashu, KZN and aims to: (1) understand the capabilities of the DEWATS system for municipal waterborne sanitation, (2) re-assess the provision of sanitation to poor households and its opportunities, (3) gain experience in using different wastewater streams in agriculture, and (4) gain knowledge in disinfecting treated wastewater using gravity membranes at a larger scale. The data from the performance of the ABR will be compared to that of the earlier laboratory and pilot-scale systems and the previously developed model will be assessed and improved where necessary. The performance of the anaerobic filter compartments will be assessed in a similar way to the ABR compartments. While failure is not expected to occur, the performance under different loading rates will be assessed and a model of this part of the system will be developed. Effluent from different stages of the ABR through the process will be supplied for specific agricultural trials to assess suitability for agriculture. The suitability of the soil at the Permaculture Centre will be assessed for different qualities of irrigation water and a selection of appropriate crops made. Water and nutrient balances will be undertaken across different agricultural plots and the two planted gravel filters to assess the impact of using treated effluent. The removal of pathogens at different points through the system will be assessed and quantitative microbial risk assessments are to be undertaken for agricultural workers and for the use of different crops irrigated in different ways.

Estimated cost: R900 000
Expected term: 2010 - 2012

Programme 3: Stormwater and sewerage systems

Investigation into pumps and pressurised flow in separate sewer systems
University of Stellenbosch
No. 2007

In a former WRC study a first-order national audit of sewerage reticulation issues was presented which highlighted amongst others various urgent future research aspects pertaining to sewer infrastructure. The proposal sets out to address a number of pertinent issues with regard to pumps, pump stations, rising mains, and other elements in the sewer system where pressurised flow occurs in separate sewer systems by means of applied research. It is hoped that the research will provide solutions to reducing the high energy input for pump stations. Energy consumption at pumping installations is an ever-increasing concern. From a strategic point of view sewer pump stations form only another component of the entire sewer system. Rising mains are another, and are often separately assessed. However, these two components are integrated hydraulically and should be optimised in combination, not separately. It is hoped this study will link theory to practice when it comes to pumping sewerage. Hydraulics and theory have their place, but a lot of experience has over the years been gained based on practical considerations, particularly as it pertains to local conditions. For example, work on the design and construction of sand/silt/rag traps as well as pump stations by members of the project team has underlined the urgent need to handle insoluble matter of all sorts arriving at sewer pump stations with the flow. This study intends to capture as much of the local knowledge in this field, test and verify it, and present a solution in the form of a tool and guide for use by both academics (e.g. published research to disseminate knowledge among peers; lecture notes) and those in the engineering fraternity (e.g. acting as a design guideline).

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

THRUST 4: INDUSTRIAL AND MINE-WATER MANAGEMENT

Programme 3: Minimising impact of waste on the water environment

Evaluating approaches to and benefits of minimising the formation of acid mine drainage through management of the disposal of sulphidic waste rock and tailings
University of Cape Town
No. 2015

One of the major environmental issues in the mining industry is that of acid rock drainage (ARD), caused by the disposal of voluminous sulphide-bearing wastes. The legacy of the ongoing generation of ARD from the disposal of low grade dump rock, of tailings and from the mine site itself, may continue for decades following active metal extraction. Changes in legislation have put the burden of responsibility for perpetuity on mining companies. This has led to a change in process thinking, in order to reduce potentially harmful emissions from deposits and thus

reduce long-term costs of tailings management and ARD remediation, and the re-examination of the manner in which waste materials are disposed from the mineral processing and extraction stages of metal recovery in order to relieve the environmental burden created and reduce the time frame of risk. Particularly, the delay in the time of ARD formation is no longer acceptable and the need to remove the risk completely accepted. In this project, previous work in WRC Project K5/1831/3 will be extended to address aspects of disposal of dump rock and tailings from mining operations processing mineral sulphides (especially pyrite), specifically with the focus of reducing capacity to form ARD and thereby the ongoing risk associated with the disposal of sulphidic mineral ore wastes, through removal of the sulphidic component of the waste. In this project, we seek to use the understanding of the factors governing ARD generation from dump rock and tailings (similar to those governing mineral bioleaching) with the view to the improvement in planned disposal of its components to mitigate ARD generation. Having identified in our previous project the components responsible for ARD generation and characteristics of the waste for disposal, in order to ensure minimisation and control of this generation, this project will focus on the methodologies used to minimise and control ARD formation and will provide an approach to evaluate the relative cost of ARD prevention based on treatments prior to disposal and ARD treatment following its generation.

Estimated cost: R1 435 250
Expected term: 2010 - 2012

Programme 4: Minimising waste production

Application of emulsion liquid membranes in the recovery of platinum group metals from precious metal refinery wastewaters and mining effluents
Rhodes University
No. 2011

Growing attention has been paid to the environmental implications of liquid effluents from mines and metal refineries. At the same time, water demand of the mining/metal refinery operations and values of precious metals have been increasing while the known reserves have decreased. This led to intense research into the recovery of precious metals from wastewaters. Methods studied include solvent extraction, biosorption, precipitation, ion exchange, electrochemical techniques, cementation, and membrane-based separations. Applicability of a particular method will depend on the speciation and the concentration of the metal in question, as well as on the chemical composition of the effluent in question. These factors can limit the efficacy of individual processes. Solvent extraction with emulsion liquid membranes (ELMs) reduces energy and financial costs, the kinetics of extraction is generally faster, and the extraction yields are higher in comparison with diluent-extractant mixtures. The disadvantages of ELMs include the instability of emulsion globules against shear fluid stress, and the resulting decreases in the rates of mass transfer. These drawbacks can be eliminated by increasing the stability of the ELM through the application of non-Newtonian ELMs, and the application of the Taylor-vortex column instead of the continuously stirred tank. After the design of an efficient extraction system at laboratory scale, the scale-up can be achieved by a simple constancy of the Taylor number, thus reducing the process development costs. The application of this process to precious and platinum group metals (PGMs) has not been investigated. The aim of this project is to fill this knowledge gap, and to examine the chemical changes and toxicological implications of the proposed process.

Estimated cost: R337 450
Expected term: 2010 - 2012

Preparation of magnetic nano composite beads and their application to remediation of mine wastewaters
University of the Witwatersrand
No. 2014

The potential of magnetic nano-composite beads to remediate water environments such as those from mine wastewaters and acid mine drainage water will be known. Molecularly imprinted polymer (MIP) beads have been used extensively for selective extraction of pollutants from various environmental compartments as part of environmental monitoring. Very little work has been focused on using the same materials for environmental remediation. This project will therefore give valuable information in this direction using magnetic nano-composite beads as potential novel materials for remediation of pollutants such as chromium (VI) and uranium (VI) in mine wastewater and acid mine drainage water under laboratory-controlled experiments. The possibility of incorporation of magnetic properties into MIP beads is a new and novel idea that makes it easier to separate them from the wastewater.

Estimated cost: R378 500
Expected term: 2010 - 2012

Programme 5: Improved ability to predict and quantify effects

Development of an analytical sensor for the identification, quantification and detection of heavy metal pollution associated with precious metal refinery wastewater
CSIR
No. 2013

The main aim of this project is the development of an electrochemical sensor for the detection of Pb, Zn, As, Cd,

Ni, Al, Pt and Pd in precious metal mining wastewaters. The data will be used to determine the effect and extent of the pollution on the aquatic environment. The development of the electrochemical sensor will involve the incorporation and optimisation of chemical materials (e.g. ion exchange material) for low-level detection of these metal ions in precious metal mining wastewaters. The secondary objective is the determination, collection and optimisation of the chemical precipitation parameters for the precipitation and speciation of Pb, Zn, As, Cd, Ni, Pt and Pd metals from precious metal mining wastewaters under different chemical conditions. It is envisaged that the research undertaken in this project will contribute to the further development of South Africa's capacity in trace metal pollution assessment. The development of electrochemical sensors will ensure that South Africa is a key player in the development and application of this technology.

Estimated cost: R716 000
Expected term: 2010 - 2012

Programme 6: Beneficiation & treatment of industrial and mining effluents

A tunable immobilised lignocellulosic enzyme (TILE) system for treatment of industrial wastewaters
Cape Peninsula University of Technology
No. 2009

This project will look at biosolubilising lignocellulosics, using a 'Tunable Immobilised Lignocellulosic Enzyme (TILE)' system. This involves rationally selected key enzymes, focusing on integration of their synergistic action to depolymerise lignocellulosic residues. Isolated enzymes are preferred to whole cell organisms because they have greater specificity, are easier to handle and store, and the enzyme concentration used in the process is not dependent on microbial growth. The primary objective is to liberate carbon in a form suitable for uptake as nutrient by biomass, thus removing the carbon and generating clean reclaimable water. This proposal addresses three major global problems: 1) the increasing scarcity of clean water, leading to the need for effective treatment of industrial effluents and reuse of water, 2) agri-industrial effluents which are produced in significant volumes but are problematic to treat cost-effectively, with few successful processes available, and 3) agri-industrial wastes which contain lignocellulosics presenting particular challenges. This work aims to develop a continuous process using immobilised enzymes in a membrane bioreactor incorporating a selected group of enzymes which are immobilised together to effect depolymerisation of the lignocellulosic content of the waste and will include in- situ generation of peroxide and hence prevention of inhibitor build-up.

Estimated cost: R2 200 000
Expected term: 2010 - 2012

Recovery and beneficiation of nutrients, water and energy from brewery effluent by means of algal assimilation, hydroponics and aquaculture
Rhodes University (Ichthyology)
No. 2008

Effluent disposal is an increasingly costly liability for industry and ultimately for the environment. The current proposal addresses the treatment and recycling of brewery effluent at the iBhayi brewery for a pilot study. The project is an integrated, multidisciplinary approach to generate the knowledge required for treating brewery effluent using (1) anaerobic digestion, (2) an algal ponding system, and (3) hydroponic vegetable production to sequester the remaining nutrients from the effluent. Beneficiation will include the use of (1) recycled heat energy from the anaerobic digester and brewery to heat the algal pond, (2) growing vegetables hydroponically on the effluent nutrients, (3) harvesting algal biomass, (4) aquaculture of edible fish and high-value aquarium fish in the recycled water, and (5) fish feed containing the algal biomass and other brewery by-products such as yeast and spent grains and finally (6) the excess recovered water will be available for use in the brewery or in other applications. The unique aspect of the proposed project is the sequencing and integration of the proposed effluent treatment and beneficiation technologies which will result in a novel approach to the way industrial effluent is processed, and the constituents made available for reuse and beneficiation. The 'proof-of-concept' phase of this R&D programme was successfully completed in 2008. The challenge now is to understand the dynamics of the parameters determining the rate processes (i.e. the biochemical and chemical processes and their reaction rates) and mass dynamics in the respective systems and develop economically viable specifications.

Estimated cost: R1 798 000
Expected term: 2010 - 2012

Development of hybrid membrane-chromatography system for simultaneous recovery of valuable products and water purification for recycle in the olive Industry, with a view towards commercial application thereof
University of Cape Town
No. 2010

In South Africa, the olive oil industry uses up to 20m3 of potable water per ton of olives processed. A previous WRC project (K8/814) investigated a hybrid membrane-based system for simultaneous recovery of valuable products and wastewater purification to the extent that it may be recycled back into the olive production process. This process has been successfully demonstrated at laboratory

scale (WRC Report No. K8/814). The wastewater has been fractionated through successive membrane separations to produce 3 separate streams: 1) a concentrated effluent containing high Mw polyphenols that can be discharged as per normal or composted, 2) a low Mw phenolic fraction containing the antioxidant extract which is rich in hydroxytyrosol,and 3) purified water containing salts and some organic acids, which can be recycled as make-up water for the fermentation and brining process. The large quantities of salt (NaCl) used are thus also recycled. Subsequent research has shown that it is possible to use only NF and chromatographic adsorption for the process if there is adequate pretreatment (i.e. particle filtration to remove suspended solids): in this case the high Mw polyphenols are rejected by the NF (Mw cut-off 270 Da), while the permeate is passed through the chromatography column to extract hydroxytyrosol, and can then be sent directly for recycle. The advantage of this approach is the recovery of a valuable product helps to offset the operational cost of wastewater treatment, and this is achieved in one operation. This project proposes to research and develop a scaled-up system though the construction and commissioning of a dedicated containerised wastewater treatment plant and research facility on-site at the Buffet Olives farm. It is intended that the plant will be a stand-alone skid mounted end-of-pipe system, which could then serve as a demonstration model for commercialisation and roll-out to other farms.

Estimated cost: R892 000
Expected term: 2010 - 2012

Extended investigations into recovery of water and salts from multi-component hypersaline brines using eutectic freeze crystallisation
University of Cape Town (Precipitation & Crystallisation)
No. 2012

South African water users are facing challenges in terms of the declining availability of sufficient quantities of water and the deterioration of the quality of the available water. In addition, with the increasing use of water treatment, the result has been an increased generation of inorganic brines and concentrates. Treating these brines, either for the recovery of the salt, or for the reduction of waste streams via a concentration process, is energy intensive and thus costly. The standard design approach for inland desalination plants is one of bulk softening and subsequent concentration of mono-valent salts. This results in mixed brines and sludges of low (or even negative) value, often containing hazardous substances. As a result, brine and sludge disposal occur mainly through forced evaporation and crystallisation of mixed (and often hazardous) salts. The extremely large energy requirements to evaporate the water can be prohibitive and the salt product is still a waste that must be disposed of. Eutectic freeze crystallisation (EFC) is an alternative technology for the separation of highly concentrated aqueous streams. EFC is a technique that is capable of separating aqueous solutions into pure water and pure, solidified solutes and that is highly energy efficient, without the introduction of any solvents. A modelling and experimental programme focussing on the use of EFC has already been undertaken (WRC Project K5/1727, which has shown proof-of-concept for EFC as a feasible treatment for hypersaline brines. However, as for any novel technology, there are still many aspects that need to be investigated and these are the focus of this proposal

Estimated cost: R1 571 490
Expected term: 2010 - 2012

THRUST 5: SANITATION AND HYGIENE EDUCATION

Programme 2: Peri-urban sanitation research

Evaluation of the Mobisan technology as a sanitation option for informal settlements: Assessing performance, operational requirements and community perspectives
Cape Peninsula University of Technology
No. 2017

The provision of water supply and sanitation services has significant potential to alleviate poverty through job creation, use of local resources, improvement of nutrition and health and provision of long-term livelihood for many households. However, it has been found that technical innovations often lack sustainability due to a lack of attention or provision of operational requirements as well as community involvement. Several technologies has been developed and implemented countrywide; amongst these the MobiSan dry sanitation system has been brought in recently as an alternative sanitation technology option for informal settlements in order to improve the sanitation delivery. The MobiSan technology is a dry sanitation and urine diversion stand-alone, portable and self-contained system which does not affect groundwater. It stores urine and faeces separately, with urine being diverted away into a container tank while faeces fall into a ventilated chamber containing sawdust. As with many other sanitation technologies, previous research shows that the main problem with sanitation technologies lies in the lack of efficient Operation and Maintenance (O&M). The aim is, in the context of the MobiSan pilot of the recently-developed O&M guidelines, to understand the operational problems, assess performance in order to ensure its sustainability and to understand the perspectives of end-users of the new technology. The research will investigate the current approaches to the implementation of a new sanitation technology and evaluate the performance and O&M requirements of the MobiSan technology, as well as related community perspectives, sustainability and development opportuni-

ties through the application of recently-developed O&M Guidelines. The research study will assist municipalities with a comprehensive overview of the new sanitation technology provided in the market; it will further provide an understanding of the operational and O&M requirements, and community perceptions of the technology.

Estimated cost: R716 750
Expected term: 2010 - 2012

Programme 4: Technical sustainability of sanitation services

Evaluation of the bucket eradication programme
Hlathi Development Services
No. 2016

The bucket backlog was estimated at 252 254 in 2005. A special fund of R1.2 bn. was allocated to the programme over a three-year period and a further R400 m. was allocated in the 2007/2008 financial year. Between 2005 and March 2008 a total of 229 171 buckets were eradicated and a backlog of 23 083 buckets were due to be eliminated before December 2008. Most municipalities have used waterborne sanitation systems to replace buckets in urban formal settlements as recommended by the Strategic Framework for Water Services (SFWS). This has presented a challenge for municipalities servicing areas without bulk sewers and adequate wastewater treatment capacity and in some cases the available water supply could not support the new waterborne sanitation services. Case studies of two bucket eradication sanitation projects highlighted several problems such as the difficulties experienced by municipalities in replacing buckets with full waterborne sanitation systems in poorly-planned townships in Free State Province, and the problem of high costs of such projects. Therefore it would be of interest to identify successful approaches followed by other municipalities to address these problems. It would be very important to document lessons learned from the bucket eradication programmes, so that these lessons could be used to inform the planning of future programmes of upgrading of sanitation services for households that are still using buckets and other forms of sanitation facilities that are below the basic sanitation service level. It would be important to compare approaches followed by the different role-players that were leading the implementation of the bucket eradication programme. This study proposes to evaluate the integration of sanitation policy principles in the implementation of the bucket eradication programme.

Estimated cost: R920 000
Expected term: 2010 - 2012

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