KSA 3:
WATER USE AND WASTE MANAGEMENT

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 the industrial/commercial and mining sectors of our economy. This KSA also focuses on waste and effluent as well as reuse technologies that can support the municipal, mining and industrial sectors and improve management in these sectors with the aim of improving productivity and supporting economic growth while 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, is 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

Jay Bhagwan: Executive Manager

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, 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.

The prioritised research areas which support Government Outcomes (6, 7, 9 and 9) and the WRC Knowledge Tree outcomes are:

- Improvement of water services institutions – institutional realignment
- Infrastructure – operations and maintenance; capacity and skills
- Water quality – emerging pollutants
- Financial sustainability of water services – cost recovery (tariffs, subsidy and financing)
- Climate change
- Water services landscape – informal areas and rural systems
- Industrial – brines, acid mine drainage and desalination
- Water-and-energy nexus (renewable energy and energy efficiency)
- Beneficiation – integrated technology use for water, energy, nutrient, and product recovery, and an industrial ecology approach for waste and water
- Water security – reclamation, 'new' water
- Water efficiency – reuse, multiple use systems and recycling

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

THRUSTS AND PROGRAMMES

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Scope: The efficient functioning of water service institutions and their viability are 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 to sustainable water service delivery. This programme's objective is to generate knowledge and processes that would support this new form of service delivery. Innovative management techniques are a necessity for viable and sustainable water service provision. This programme intends to find innovative solutions to critical problems with the financing and management of essential services such as water supply and sanitation.
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 in the delivery of water and sanitation services, to the benefit of the population. Furthermore, it ensures greater efficiency and improved management of infrastructure and customers. This programme will support, through knowledge creation, the development of an effective water regulatory environment.
Programme 5: Water services education and awareness	**Scope:** A fully-informed community or individual plays a vital role in the sustainable use of water services, which contributes to water efficiency and improved environmental health. This programme will address education and awareness aspects which contribute to efficient water use, improved hygiene behaviour and sustainable services.

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Scope: The provision and supply of affordable and reliable water of acceptable 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 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 to 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 their 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 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, de-watering, disinfection and beneficiation is encouraged.
Programme 5: Sanitation technology and innovations	**Scope:** To develop innovative tools and technology which support appropriate sanitation that is socially, environmentally and financially sustainable.

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

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

Programme 1: Emerging challenges and solutions for the 21st century	**Scope:** This programme seeks to look at major challenges that may face South Africa in future at a water quality, quantity, and security level. It will explore emerging fields in science and engineering, such as nanotechnology, to provide solutions to these challenges. In addition to seeking new solutions, this programme will also investigate new and emerging industries, their water needs and the associated threats to health and environment. The concept of sustainable

	future industrial complexes and their water management will allow for better planning and regulation of new industries, enabling improved adoption of integrated resource management systems, processes and tools.
Programme 2: Integrated management	**Scope:** This programme focuses on integrated and innovative management arrangements, e.g., public-private partnerships (PPP), to support industry and government programmes which may be site-, catchment- and/or region-specific. While the programme will focus on water, it aims to promote a more holistic approach to resource (water, energy and carbon) management by industries to bring about sustainable approaches to water and wastewater management ensuring that liabilities (waste) are turned into assets (resources) for the benefit of the environment, society and economy.
Programme 3: Quantification, prediction and minimisation of water use and waste production	**Scope:** In order to prioritise those facets of industrial water management that need the most urgent attention, it is important to quantify the water used and waste produced by different sectors. This programme will also look to develop new methodologies and models to aid in quantification, prediction and evaluation of data. The environmental consequences of waste products are almost always long-term in nature and these long-lasting (legacy) effects were often not fully appreciated in the past, and consequently not properly considered when waste was disposed of. Thus, this programme also aims to establish and improve pollution prediction capabilities appropriate to South African conditions and to develop cost-effective techniques and approaches to minimise or reduce the impact that legacy and new waste products have on the environment.
Programme 4: Governance, policy, regulatory, and economical instruments to improve industrial water management	**Scope:** The regulatory authorities are responsible for authorising and regulating the impact of industrial waste on the quality and quantity of our water resources. Traditionally the resource-intensive command-and-control approach was used almost exclusively to manage water quality. Internationally, use is increasingly made of indirect economic or other instruments to supplement or even replace the command-and-control approach to water quality management. These new

	approaches are believed to be more cost-effective and to improve equity. Both the established and new approaches are being investigated and refined in order to support improvements to the governance, policy, regulatory, self-regulatory, and financial mechanisms that could be used to control and reduce the negative environmental effects associated with industrial waste. This programme will largely look at these mechanisms from an industry perspective in order to improve, review and enable implementation.
Programme 5: Water efficiency , cleaner production, beneficiation and treatment of industrial effluents	**Scope:** This programme looks at water use efficiency and associated tools, methodologies and systems as a primary driver of reduced effluent generation. In spite of efforts to minimise waste production it is acknowledged that effluent production will for the foreseeable future remain an expected consequence of industrial activities, and thus this programme aims to support the development of a range of processes and techniques for effective beneficiation, recovery, reuse, recycle, disposal and ultimately treatment of industrial effluents. The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes and green chemistry concepts for chemicals. Approaches such as life-cycle analysis are employed to ensure that the net effect is positive and does not merely represent the transfer of negative effects from one sector or environmental medium to another. In addition, the programme entails the exploration and exploitation of in-process recycling and reuse opportunities prior to end-of-pipe treatment solutions. Expected outcomes include the potential recovery of materials, water and energy for beneficial reuse, and fundamental scientific/engineering support for process development, and thus longer-term initiation of the secondary economy opportunities within South Africa.

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

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

Programme 1: Water use and waste production	**Scope:** This programme focuses on investigations into quantification of water used and waste produced by the sector, currently, and predicting and quantifying the short-, medium- and especially long-term impacts the wastes generated will have. The environmental consequences of mining activity are almost always long-term in nature, with impacts that last for centuries. These long-lasting effects were often not fully understood in the past, and consequently not properly considered. In the present regulatory environment it is increasingly expected of waste producers to quantify the present and future environmental impacts of their past and present operations and to indicate how these will be remedied, as well as how such consequences can be avoided when planning future operations.
Programme 2: Regulatory, management and institutional arrangements	**Scope:** The creation of sustainable arrangements (e.g. public-private partnerships) that enable the mitigation and prevention of the environmental, social and economic legacies of the mining and minerals industries is complex. Priorities include addressing the treatment and supply of bulk water using acid mine drainage (AMD), a realistic estimate of non-point-source pollution relating to the waste discharge charge system and determining the price elasticity for water use of the sector (determine the potential to decrease water use through tariff increases). This programme interrogates such aspects from the perspective of the mining sector. (Note: Policy development falls under KSA1).

Programme 3: Minimising waste production	**Scope:** This programme focuses on investigations into developing technologies and methods to decrease/minimise the generation of waste products in the mining sector, either through cleaner production, by-product generation, life-cycle analysis or through applying other risk assessment methodologies. The programme incorporates novel mining methods and mining-impacted water prevention strategies. Waste minimisation at the national, regional, (catchment), complex or single-site scale is considered. Identification of opportunities to convert liabilities into assets and holistic, long-term research into the beneficial use and recovery of brines, their solutes, and other waste products, are also included.
Programme 4: Mining in the 21st century	**Scope:** The emerging challenges related to avoiding recreating the legacies of past operations call for emerging solutions. Programme 4 will investigate the prediction and avoidance of long-term water impacts and implications associated with establishing new operations within different geographical areas. It will also actively pursue beneficiation initiatives, re-mining of wastes, etc. (especially innovative ideas and piloting/scale-up).
Programme 5: Low volume mined products	**Scope:** Much research attention has been paid to coal and gold mining; however, other quarried or mined products such as radio-nuclides and platinum group metals also require consideration and in some cases present unique challenges. Water use and demand management, water-conserving metallurgical and extraction processes and investigation of the impacts and amelioration of mine discards specific to these products will be addressed in this programme.

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.

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 result in a greater demand for water and annual consumption continues 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 the 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 development 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).

With a 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 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 mega-cities, 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, would 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 more 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.

BUDGET FOR 2013/14

The approved funding of the research portfolio for 2013/14 led to a committed funding budget of R34 843 582.

Research portfolio	Approved 2013/14 (R)
Current projects	17 596 030
New projects	17 247 552
Total	34 843 582

RESEARCH PORTFOLIO FOR 2013/14

Reviews have highlighted that the relative weight of this KSA's thrusts seem to be well-balanced regarding the needs of urban–industrial–mining and rural research needs. Feedback from these exercises has ratified the KSA direction and the many valuable inputs assisted in strengthening the portfolio. During 2013/14 the portfolio continued to build on the strategic changes from previous years, as well as being strengthened towards making greater impacts on the social and health aspects, environment and economy of the country. The primary objective of this KSA 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 DWA framework strategy, Water for Growth and Development (Version 6). We believe that the programmes and projects are strongly oriented to the challenges. The new portfolio of projects continued to provide 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
- Management of brines
- Management of acid mine drainage
- Extending the implementation of water footprints, waste minimisation, cleaner production, cleaner consumption and clean technologies
- Climate change adaptation and mitigation
- 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
- Developing innovative and cutting-edge technologies and solutions
- Producing cutting-edge science and technology
- Investing in emerging contaminants affecting water quality, especially trace organics
- Energy efficiency and generation, as well as the energy–water nexus
- Institutional strengthening – financing, regulation, etc.

COMPLETED PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Mechanism for pricing and financing the implementation of the Green Drop Report to guide the strategic decrease of the risk factor of wastewater treatment works
Asset Research
No. 2085

The poor performance of wastewater treatment works (WWTWs) in protecting the health of the water resource has necessitated that the DWA take action to rectify the situation. Green Drop certification is part of a wider process aimed at ensuring compliance with the DWA's responsibility in terms of its constitutional mandate. The Green Drop is an incentive-based initiative aimed at improving the performance of municipal wastewater service providers. While the

Green Drop seeks to acknowledge excellence in wastewater quality management, it does not reflect on the financial cost and resources required for achieving this, or on the economic costs and implications of not achieving the desired turnaround in wastewater management and performance of the WWTW. This is an important gap in planning for remedial action and one taken up in the research project: what will it cost to improve the performance of WWTWs? This study found that the drivers of the Green Drop Report were:

- Skills availability
- Effluent treatment levels in relation to plant capacity
- Investment in refurbishment and improvements (R&I)
- The risk category of the plant

There is a substantial risk linked to non-improvement in performance of WWTWs. Not only is the current load on WWTWs already too great, hence their underperformance, adding additional loads that could logically be expected due to increases in both income and people, will only add to the already overburdened ecosystems to which the effluents are being discharged. This will add to the economic cost of such pollution. Not only is the economic cost a concern, but also the deteriorating ability of ecosystems to absorb/dilute the effluent loads. This places the entire water system in highly-populated places such as Gauteng at high risk, as the ecosystems are required to act as water purifier of last resort. A contaminated water system is akin to a contaminated socio-ecological and economic system as it affects each and every part of both economy and society.

Cost:	R597 500
Term:	2011 - 2014

Providing water services at tariff levels that cover cost and that are sensitive to demand
Nelson Mandela Metropolitan University; Nelson Mandela Metro
No. 2087

The sustainability of South Africa's municipal water services provision is being challenged by the desire of Government to extend high-quality services, currently only available to a relatively small portion of the population, to the whole. Evidence of failures in delivery are mounting and many reasons for this have been identified, including a lack of political will at local government levels, low budget priority, insufficient capital, lack of capacity and skill and flawed tariff and accounting structures. The project aims were to provide economic guidance to municipalities that they may wish to consider in determining the particular mix of water services they will provide and in the tariff structures they set, and to assess the extent of the under-recovery of financial costs at selected municipalities This study generates new perspectives by surveying selected, but representative, South African municipalities in their capacities as water services authorities (WSAs) on a range of financial sustainability issues – including cost burden on users, cross sub-subsidisation and cost calculations to set tariffs. The study is part of a wider WRC-funded investigation into the setting of tariffs that cover costs and satisfy demand. The study concludes that, in general, there is under-recovery of costs in

the water services sector and this occurs for many reasons. Inter alia, it occurs because there are insufficient transfers, from central Government grant assistance to the poor, to cover the costs of those who do not pay, there is inadequate provision for replacement and maintenance costs (also called rehabilitation cost or deferred maintenance), and external costs are being omitted.

Cost: R1 250 000
Term: 2011 - 2014

Identifying efficiency and inefficiency in municipal water service provision
Nelson Mandela Metropolitan University
No. 2118

Discrete choice experimentation is one form of choice modelling. It utilises a stated preference survey technique to gather data for modelling choice. The aims of the study were to demonstrate that discrete choice experiment analysis and the survey instrument on which it is based could provide useful information about how consumer groups valued water service delivery and how they rated the water services that they were provided. The motivation for undertaking the study was that technical and cost considerations are inducing greater interest among South Africa's municipal providers of water services to adjust the levels of water services offered to various customer groups. Such adjustments have consumer welfare implications and potential impacts on the demand for water services and these implications and impacts need to be considered along with the technical and cost consequences. The scientific credibility of the discrete choice experiment method of analysis and its appropriateness for application to assess the welfare merit of the levels of water services provided is well established. Background on the science of choice experiment analysis and the steps in applying the methodology are found not to be overly complicated. By incorporating some consumer satisfaction questions in the survey instrument it was possible to analyse customer ratings and perspectives on the water services that are provided at three selected municipalities, namely: Breede Valley and Knysna in the Western Cape and Msunduzi in KwaZulu-Natal. The analysis of the customer satisfaction part of the survey yielded findings that were consistent with assessments reported in the form of Blue and Green Drop certification. Three water service consumer groups were identified for the purpose of this analysis – high income, low income and businesses. The different water service consumer groups in the different municipalities did not share a common perspective on the way water services were managed. It was concluded that the discrete choice experiment analysis and survey on which this is based has the potential to yield useful insights into the levels of attributes preferred in the water service mix provided by South African municipalities. Thereby it can inform water service management thinking and policy decision making on potential implications for water service consumer welfare of technological and cost-saving changes made to water service provision.

Cost: R720 000
Term: 2012 - 2014

Programme 2: Institutional and management issues – Water services

A comparative analysis of water management devices in Cape Town and pre-payment meters in Johannesburg
University of the Western Cape
No. 2089

Water management devices (WMDs) have gained policy appeal as a regulated mode of water service delivery in South African municipal authorities and are becoming a prominent instrument for water management in urban low-income areas. Cape Town and eThekwini are two such municipalities that have rolled out these devices with the broad aim of charging viable user fees; enabling users to conserve water; managing consumer debt; providing free basic water and detection of leaks. This study provided an understanding of user perceptions of the usefulness of WMDs. It is a marked departure from previous research studies that have tended to focus on the supply side of water services by analysing the effectiveness of WMDs in promoting cost-recovery measures without seeking to understand how the recipients of the devices perceive them. The research indicates that users are satisfied that they will no longer be prone to debt and are guaranteed of FBW supply, and thus, in the light of the Technology Adoption Model (TAM) and the confirmation/disconfirmation model of consumer satisfaction, WMDs have delivered both acceptable technological innovation and fulfilled most consumer expectations. However, in some cases, water supply has been limited by the installation of the devices to the extent that residents have had to devise a wide range of coping mechanisms. Some of these coping mechanisms have potential or actual significant implications on health and hygiene. In some areas, devices are not functioning optimally as intended. In general, cost-recovery effects need to be better substantiated and communicated, as it is unclear how this forms part of broader consumption pattern restrictions.

Cost:	R500 000
Term:	2011 - 2013

Programme 3: Innovative management arrangements – Rural water supply

Capacity building for climate change adaptation and disaster risk reduction in rural South African Communities: Tsengiwe, Eastern Cape
Umvoto Africa; University of Fort Hare
No. 2126

In South Africa the most common natural hazards are floods, storms, wild fires and drought. The Southern African region is regarded as one of the most vulnerable regions in Africa to climate change and variability, in part, due to its low adaptive capacity and inherent vulnerability. If the changes in climate observed over the last century persist, the potential impacts on water resources are likely to become more diverse and severe. The extent and state of water infrastructure in South Africa varies widely across the country. Vast rural areas are still without access to an adequate,

safe water supply or proper sanitation and there is an urgent need for service delivery to address this backlog. The existing infrastructure in municipalities is under strain and can often not cope with the increasing demand. To sufficiently manage this vital resource, it is imperative to formulate a participatory approach, good governance and communication between all stakeholders. The purpose of the study was to gain an in-depth understanding of the rural challenges in adapting to climate change, to understand the role of community based organisations (CBOs) and community-level coping strategies, and how to cohere and optimise these with local and district municipal resources and initiatives and sustainable water services.
This study engaged with the rural Eastern Cape community of Tsengiwe in planning for climate change adaptation (CCA) at a local level. The study highlighted that DRR provides a useful and practical lens through which to view challenges that can affect water and sanitation services. According to this framework, potential threats to successful and sustainable service delivery are used as starting points for positive change or to initiate plans to mitigate the risks they pose. Tsengiwe was seen as a suitable case study for a follow-up study because the team was able to draw on established connections. A previous study gained an understanding of the institutional hazards and contextual issues faced by Tsengiwe. This information placed the study in a position to facilitate Participatory Rural Appraisal (PAR) processes to assess community perception of risk and deepen the community's understanding of DRR through catalysing community-led processes for CCA.

Cost:	R800 000
Term:	2012 - 2014

Sanitation subsidies in perspective: how to increase the effectiveness of sanitation subsidies in South Africa
Sustento Development Services; CSIR
No. 2136

The South African Government has committed itself to universal access to sanitation by 2014. As part of this commitment, the government provides various sanitation subsidies to assist the poor (household expenditure < R1 100 per month) to gain access to a basic level of sanitation service, i.e., in the case of basic sanitation, at least a Ventilated Improved Pit toilet. These sanitation subsidies are provided by various funding mechanisms across a number of governmental departments. However, the key funding mechanisms are those which subsidise sanitation facility provision directly to households and those which provide sanitation facilities as part of a subsidised housing service. The overarching objective of this research was to investigate the sanitation-related subsidies in South Africa, including economic and social cost issues, to determine overlaps and gaps in sources (MIG, Housing, Equitable Share) of subsidy and to determine what constitutes effective/efficient use of subsidies, with the key purpose to develop a guideline to guide future sanitation subsidy policy and interventions. The key conclusion which can be drawn from the above review is that the provision of sanitation services utilising subsidies may be one of the most difficult regulatory environments in which to operate in South Africa, largely due to the lack of clarity and often conflicting legislation, policies and strategies from national to local government levels. To meet their Constitutional mandates and be able to deliver effective and efficient basic sanitation services to all South Africans, all sectors of government

need to understand the interactions, overlaps, gaps and conflicts in subsidised sanitation-related policies, processes and procedures. The financial component of the basic sanitation service sector would benefit significantly from a set of guidelines which could bring all these confusing and contradictory policy documents and instruments under a single set of guidelines, bringing together water services, housing, indigent, municipal and financial requirements of the subsidised sanitation sector. These guidelines could provide significant support to the sector, at a national, provincial and local government level.

Cost:	R488 765
Term:	2012 - 2014

Programme 4: Regulation of water services

Municipal guidelines for implementing WDM
WRP Consulting Engineers (Pty) Ltd
No. 2130

There is no single water demand management (WDM) intervention that will always provide the best savings at the least cost. Every water supply system is unique in some way and will have its own specific problems that set it apart from other systems. In reality, reducing water losses from municipal water distribution systems is not complicated but does require a dedicated and methodical approach if real and sustainable savings are to be achieved. It is often similar to detective work where the first step in the process is to identify and understand the problem before trying to solve it. Too often, water loss reduction interventions are introduced which are inappropriate to the problems experienced in the reticulation system. The interventions must be selected to address the most serious problems experienced in a specific area to have any chance of success. The key issue is to decide which interventions are the most appropriate to a specific area and how best to implement them. The most common mistake made by many municipalities throughout the world is to believe that water loss reduction is achieved only through leak detection and repair. In such cases, large budgets are often used to search for unreported leaks using the latest hi-tech and expensive equipment. If the water losses are due to inaccurate metering or even background leakage, the leak detection activities will yield little or no results. There are many excellent books and publications on the subject of reducing water losses from municipal water distribution systems. This book does not attempt to replicate or replace any of these previous publications but concentrates on highlighting the key issues in simple and straightforward terms in an attempt to explain what interventions can be undertaken in order to reduce water losses from municipal water supply networks and how best to implement them. The book is based on the extensive practical experience of the authors derived from the implementation of various WDM interventions in over 20 countries.

Cost:	R500 000
Term:	2012 - 2014

Programme 5: Water services education and awareness

Social norms and moderation of water consumption in a major South African city
EPRU
No. 2091

Behavioural economics is increasingly informing policy design around the world. In the utility space behavioural economics is being increasingly used to moderate the water and energy consumption of households. The attraction of these methods is that they are generally very cheap to deploy, require limited infrastructure and offer few, if any, opportunities for corruption. This project assessed whether there was scope to use feedback, informed by several principles derived from the behavioural economics literature, delivered in the post with the water bill to reduce household water consumption within a major South African city (Cape Town). The findings from this study strongly suggest that merely reporting tips about how to save water will not result in a noticeable reduction in household water usage. In contrast; raising the salience of a household's water consumption, either by reporting their consumption in a bar graph or by comparing their consumption to their neighbour via a bar graph, was found to result in water consumption that was lower by roughly 1%.

Cost:	R462 000
Term:	2011 - 2013

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Wastewater reclamation for potable reuse
Umgeni Water; Durban University of Technology; SSI
No. 1894

The main objective of this research project was to demonstrate the applicability of MBR technology for production of consistent, acceptable potable drinking water through domestic wastewater reclamation. The MBR system was evaluated as a pre-treatment process and advanced treatment processes were evaluated for producing water that meets potable standards. The project was divided into two phases. In the first phase, the performance of MBR technologies as pre-treatment step for advanced water treatment processes to produce potable water was evaluated. In the second phase; bench-scale evaluations of advanced water treatment technologies for the production of potable water using the following technologies: ozone (O3), granular activated carbon (GAC), nano-filtration (NF) / reverse

osmosis (RO) and advanced oxidation (hydrogen peroxide and ultra-violet radiation) were evaluated. From the findings recommendations for an effective wastewater reclamation treatment process train for the design of a full-scale reclamation plant at Darvill WWW were made, and the capital and operating cost estimates of the recommended process were presented.

Cost: R907600
Term: 2009 - 2014

Development of design and operating guidelines for high-rate clarifiers in the South African water treatment industry
Umgeni Water; Durban University of Technology; University of KwaZulu-Natal (Westville)
No. 1942

This project was initiated with the intention of contributing to bridging this knowledge gap on the operational, maintenance and process requirements and limitations for high-rate clarifiers. The study was undertaken by first conducting a literature review of the common high-rate clarification technologies being used. The high-rate clarifiers considered in this study were the HR-CSAV (a sludge blanket clarifier which uses a flocculant aid), ballasted sand processes and sludge recirculation processes. This was supported by plant visits undertaken to provide case studies for existing full-scale facilities using these technologies, both in South Africa and abroad. In this study, the high-rate clarification technology was evaluated based on investigations conducted on a 500 m^3/day demonstration model HR CSAV high-rate clarifier, a patented technology developed by Pavel Polasek and Associates. Basic practical guidelines on the selection, design considerations and operation and maintenance for high-rate clarifiers, based on the case study assessments, literature and on the outcome of investigations on the HR-CSAV clarifier, were developed. The report will assist water treatment designers and water treatment practitioners, particularly in South Africa, to make informed decisions on the appropriateness of high-rate clarification processes under local conditions.

Cost: R1 800 000
Term: 2009 - 2013

Decision-support model for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery (with focus on upgrading options, water reclamation and desalination)
Chris Swartz Water Utilisation Engineers; University of Stellenbosch
No. 2119

The initial aim of this project was to develop a decision-support model (DSM) for the selection, costing and application of drinking water treatment and supply options to address water shortages and improve water services delivery (with focus on upgrading options, water reclamation and desalination). After several discussions with reference group

members, a decision was taken to only concentrate on water reclamation projects for potable use, both indirect and direct water reuse. In addition, a user-friendly DSM based on Excel was developed, instead of the Eidos software. Thus the overall objective of this present study was to develop a decision-support model and provide guidance on the costing of water reuse projects as means for decision-makers to compare options for water reuse schemes. These tools are based on a number of drivers, such as technical, water quality, costing, environmental and social and cultural aspects. More specifically, the aims of the model are to collate existing expertise and information for planning and implementation of potable water supply and direct potable reuse projects, and to provide decision-support guidelines and methodologies in the form of a spreadsheet-based, multi-criteria decision support model. This will enable municipalities to identify, evaluate, compare, and select appropriate options for water reclamation and reuse.

Cost: R450 000
Term: 2012 - 2014

Programme 2: Water treatment for rural communities

Compilation of guidelines for the selection and use of home water treatment systems and devices
Tshwane University of Technology; University of KwaZulu-Natal (Howard College); Chris Swartz Water Utilisation Engineers; GO Water Managment; University of Johannesburg
No. 1884

A number of home water-treatment systems (HWTSs) are being used internationally by rural communities without access to potable water services. These HWTSs vary from the simplest, such as using cloth as filter, to the most sophisticated systems, able to treat grey-water to potable standards. Although various devices have been reported on extensively in the literature, little is known locally about the existing options and little has been done to assist local communities in making informed choices on whether a specific device should be selected. This project therefore aimed to evaluate HWTDs for local application and provide guidelines for the selection and use of appropriate HWTSs by rural households. Devices were then selected according to their water-treatment efficiency, local accessibility and availability of materials used in their design, their ease of construction and robustness, their ease of operation and maintenance, and their cost. An ideal rural HWTS should be able to provide water compliant with the prevailing South African National Standard for Drinking Water Quality (SANS 241) over extended periods, and produce at least 25 L of safe drinking water per person per day. Five types of low-cost filters were investigated: a conventional biosand filter (BSF-S), a biosand filter with zeolite (BSF-Z), a bucket filter (BF), a ceramic candle filter (CCF), and a silver-impregnated porous pot (SIPP) filter. Environmental water samples were collected, providing ground and surface waters with low and high turbidities. The flow rates and product water qualities were measured; the SIPP produced too little water (5 L/d) and the other HWTSs produced >20 L/d. The SIPP and BSF-Z filters produced the best quality product water, but only the SIPP consistently met the SANS 241 water quality targets. The costs of manufacture ranged from approximately R130 (for the BSF-S) to R500 for the CCF. The SIPP costs R290 and was the second-most expensive filter,

and the BSF-Z cost R165 to manufacture. The social acceptability of the two HWTSs that had produced safe water (SIPP and BSF-Z) was explored for residents of a rural village, in partnership with the project team. Most of the residents (93%) had never used any water-purification devices, but found the SIPP and BSF-Z convenient. However, while most participants thought the HWTSs were useful, many found them complicated to operate and/or risky to handle, and were afraid of breaking the devices (e.g. during cleaning). Neither of the HWTSs tested in the village was seen as being better than the other. The project demonstrated that HWTSs would be welcomed by rural households as long as they are not too much trouble to operate and maintain, and provided that they are affordable to the users. The SIPP produced reliable water quality but not enough quantity, and the BSF-Z produced a higher quantity of safe water than the SIPP, but required more knowledge in order to care for it.

Cost: R1 200 000
Term: 2009 - 2013

Point-of-use disinfection systems designed for domestic rainwater harvesting (DRWH) tanks for improved water quality in rural communities
University of Stellenbosch; Bergema Wholesale Retail
No. 2124

The main aim of this project was to determine the microbiological and chemical quality of harvested rainwater and people's perceptions on the use of rainwater. In addition this study was aimed at evaluating options for treatment of the collected rainwater. First the microbiological and chemical quality of rainwater collected in existing DRWH tanks was determined. Rainwater samples were collected from domestic rainwater harvesting tanks (DRWH) in a sustainable housing development in Kleinmond, South Africa. Water samples were collected on 8 occasions from 29 tanks during the period of March to August 2012. The chemical and microbial parameters were compared to drinking water standards stipulated by the South African and Australian Quality Guidelines. A survey of users' perceptions on rainwater harvesting was conducted. The social research project was aimed at developing a better understanding of public perceptions, including the degree of acceptance of DRWH, and the way in which the harvested rainwater is utilised. More specifically, quantitative and qualitative data were collected in order to describe the following: (i) the condition of the tank; (ii) the users' knowledge of the DRWH system, including its operation and maintenance; (iii) whether the user would be willing to pay for repairs (if required); (iv) perceived benefits and risks associated with DRWH; (v) level of satisfaction with DRWH; (vi) and views on municipal water. In addition, demographic data on the respondents were gathered, viz., gender, age, highest level of education, household size and employment status, in order to provide a socio-economic background description of the study population. Finally, different point-of-use treatment systems (mainly filtration and solar pasteurization systems) were evaluated for their effectiveness in treating the harvested rainwater to produce water that meets drinking water quality standards.

Cost: R746 000
Term: 2012 - 2014

Programme 4: Water distribution and distribution systems

Energy generation from distribution systems
University of Pretoria; Bloem Water Board; City of Tshwane; eThekwini Municipality; Energy and Water Resources
No. 2095

An initial scoping investigation highlighted the potential hydropower generation at the inlets to storage reservoirs. In South Africa there are 284 municipalities and several water supply utilities, e.g. mines, all owning and operating gravity water supply distribution systems which could be considered for small-, mini-, micro- and pico-scale hydropower installations. Most of these water supply/distribution systems could be equipped with turbines or pumps as turbines, supplementing and reducing the requirements for pressure control valves. The hydro-energy may be used on-site, supplied to the national electricity grid or feeding an isolated electricity demand cluster. Thus the objective of this study was to prove that it is feasible and technically possible to generate energy from distribution systems; and develop guidelines to identify locations which have potential for hydropower generation. In this regard, the application to install hydro-electric turbines in a water distribution system is fairly new in South Africa, and thus three pilot plants were constructed showcasing several of the intricacies in the development process and to demonstrate the technologies:

- Pierre van Reneveld (Tshwane Municipality) – 16 kW
- Brandkop Reservoir (Bloemwater) – 96 kW
- Newlands (eThekweni – pico units x 2)

Cost: R2 500 000
Term: 2011 - 2013

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Effects of urine separation and treatment on wastewater effluent quality
CSIR (Stellenbosch); University of Stellenbosch; Africon Engineering International (Pty) Ltd
No. 1824

The concept of urine separation is still in its early stages, but the prospects of achieving more sustainable urban water management are very good. Urine separation could lead to better wastewater treatment, e.g., increased plant

capacity, improved effluent quality and reduction in energy consumption. With complete urine separation, the need for nitrification and denitrification falls away at activated sludge plants, which would be operated at short sludge ages (5 days) with anaerobic phosphate release and aerobic phosphate uptake. Although urine makes up less than one percent of the volume of wastewater, it contains around 50% of the total phosphate load and up to 80% of the nitrogen load in wastewater. The impact of urine diversion on BNRAS processes was investigated in a laboratory-scale reactor with a University of Cape Town (UCT) BNR system configuration, receiving mixes of grey and brown wastewater collected separately at the CSIR in Stellenbosch. Interestingly, the grey-water and brown water collected for experiments had lower overall concentrations than that measured initially at CSIR. A series of batch tests were done, which pointed to 6 factors to prove the non-existence of nitrifiers in the system, which included (i) no nitrite or nitrate in the effluent (ii) no nitrate generation when fed with excess ammonium in batch tests (iii) no decrease in alkalinity (iv) phosphate release in the anoxic compartment (v) measure oxygen uptake rate yielded a good COD balance and (vi) a low nitrogen fraction of the sludge produced. This meant that nearly all N was used for biological growth and no nitrate was produced, and the P removal proceeded via the normal biological excess P removal (BEPR). Removal performances were all better than those achieved in a control system, with exact design parameters and an equivalent COD feed, from a real domestic wastewater treatment works. A second system was operated according to the Johannesburg (JHB) process configuration, which also received a 50:50 mixture of grey and brown water. The JHB process is similar to the UCT process, but includes an anoxic zone in the return activated sludge stream, to remove any nitrate before entering the anaerobic zone. The mass balances showed that if all the degradable COD was utilized, then the very low effluent standards of 0.1 mg P/L could be achieved in both UCT and JHB process configurations. Furthermore, based on the mass of the COD load on a wastewater treatment works, the reactor can be reduced by 50% if urine was collected separately. From the perspective of an existing system, an activated sludge reactor basin could treat double the design load if urine was collected separately at source!

Cost: R1 200 000
Term: 2008 - 2013

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

γ-PGA, a polymer of D- and L-glutamic acid monomers connected by amide linkages, is a naturally occurring biopolymer, synthesized by a variety of micro-organisms. Most commonly, γ-PGA production has been studied in *Bacillus* species, such as *B. subtilis* and *B. licheniformis*. *Bacillus* is also associated with domestic wastewater treatment and its enrichment has been associated with improved treatment processes. Potential applications of γ-PGA are reported in the medical, food, cosmetic, wastewater treatment, plastic and agricultural and textile industries. In this project, we consider the production of γ-PGA by *Bacillus* species for the partial treatment of domestic wastewater and concomitant production of the polymer for soil improvement and water treatment. This system was selected to

ensure that natural selection within the wastewater ecology was achievable. A number of isolates, 19 in total, were obtained from the Mitchell's Plain WWTP and screened for their growth potential and potential to produce PGA. Isolates showing reproducible growth and evidence of polymer production were selected for further screening in terms of growth. The growth, substrate utilisation and PGA production of these were compared. A sub-set were selected for further research with specific emphasis on media composition in terms of C:N:P ratio and selection pressure of continuous culture under reduced substrate concentration. In parallel to this, the requirements of the wastewater biorefinery were assessed and nature of wastewater as a source of nutrients described. This formed the basis for the review of reactor design and selection of appropriate reactor types. Following a broad review of bioreactor types, reactors supporting biofilm or aggregated microbial growth are selected to allow decoupling of hydraulic and biomass residence time to facilitate growth on dilute media. The fluidised bed reactor with an aerobic granular sludge (AGS) and the rotating bed contactor were selected for further study, and were designed, built and commissioned with an emphasis on simple and cheap construction. These reactors were trialled in the laboratory, using synthetic media and a pure culture of isolate 1, a *Bacillus* species. They were also trialled in the field at Athlone WWTP using wastewater. The latter allowed many challenges to be identified. The review of industrial ecology and the importance of this paradigm in the design of the biorefinery are reported. Further, key features of the wastewater biorefinery in terms of the process flowsheet are described, as is the tension between the goals of bioprocess engineering for maximising product formation and environmental biotechnology for maximising remediation.

Cost:	R356 000
Term:	2010 - 2013

Integration of aquatic chemistry with bio-process models
University of KwaZulu-Natal (Westville); University of Cape Town; eThekwini Municipality; University of Queensland; Umgeni Water; Water & Wastewater Engineering, Stellenbosch University; Universite Laval; Sasol; CEIT; Paper Manufacturers of South Africa (PAMSA)
No. 2125

Advanced process modelling is increasingly being used to design and optimize the operation of wastewater treatment plants. Both bio-process modelling and aquatic chemistry modelling are mature technologies; however, up to now they have not been well integrated with each other. As a result, in 2011, the International Water Association set up the IWA Task Group on a Generalised Physico-Chemical Modelling Framework for water and wastewater treatment processes. The challenge for the task group is therefore to develop a framework for integrating this pre-existing knowledge with current approaches to modelling biological treatment processes. The task group includes two South African researchers, Prof GA Ekama (University of Cape Town) and Mr CJ Brouckaert (University of KwaZulu-Natal), who have extensive experience in speciation chemistry and who have developed a number of models, in particular, the UCTADM2 model of anaerobic digestion (Brouckaert et al, 2010) which already incorporates several features which are consistent with the goals of the task group. This project has supported their continued participation in the Task Group and builds on the results of several previous WRC projects. Thus, a theoretical framework for integrating a

rigorous representation of important physico-chemical processes into established bio-process modelling approaches has been developed. It is presented as a framework for organizing the relevant knowledge about the bio-kinetic system which must be included in the model. In general, speciation reactions, especially acid-base reactions, are orders of magnitude faster than bio-kinetic and phase transfer reactions. It is therefore reasonable to use an equilibrium speciation model to calculate the aqueous phase speciation at each time step in the bio-kinetic model. The recommended approach is the algebraic solution of the speciation equations in a separate sub-routine which is called the main bio-kinetic treatment model. The approach is general and applicable to a range of models and processes. However, its practical application has also been demonstrated in a set of didactic case studies focused on anaerobic digestion. This new approach constitutes a significant step forward in wastewater treatment modelling compared to the widely used IWA models, particularly for those processes where accurate pH prediction is essential. The work presented here also contributes to meeting the goals of the IWA Task Group on a Generalised Physico-Chemical Modelling Framework for water and wastewater treatment processes. The training materials developed are intended to address a critical gap in expertise in the water and wastewater sector. The development and implementation of more accurate and flexible process models can facilitate the improved design and operation of wastewater treatment facilities, resulting in better protection of water resources as well as potential economic benefits.

Cost:	R480 000
Term:	2012 - 2014

Programme 2: Application of appropriate technologies and tools

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

Within South Africa, at least 130 municipal wastewater treatment works, and another 50 at government institutions, have trickling filters. Trickling filters are employed either as part of a process, or as the sole biological treatment process. These trickling filters are not only found at small towns or remote rural settlements, but are often part of large treatment works, such as Rooiwal Northern Works (220 ML/d), Olifantsfontein (105 ML/d), Daspoort (55 ML/d) and Paarl (25 ML/d). Amidst current concerns of under-investment in wastewater treatment infrastructure, always in competition with other services for funding, existing trickling filters deserve more attention. This study compromised three parts:

- An investigation of the historical data for the Daspoort trickling filters to understand N removal
- Changes to operating parameters (arm rotation and recycle ratios) to evaluate if the system could be improved
- Identification of the mechanisms and microbiological processes that play important roles in the nitrogen removal efficacy of the Daspoort trickling filters

The full-scale trickling filter experiments confirmed the historic data for the Daspoort Eastern Works in two respects: (i) nitrogen removal over the trickling filters is very good, with removal efficiencies up to 70%; there is often not enough COD removed to account for the good nitrogen removal in terms of ordinary heterotrophic denitrification. Aside from the observations of good nitrogen removal, it was not really possible to identify operational parameters that led to this performance. None of the experiments on effluent recycle, or distribution arm rotation speeds, improved effluent concentrations significantly, or consistently. It must therefore be concluded that the old trickling filters at Daspoort operated at their optimum already, regardless of this work. Bacteria closely related to anammox bacteria were detected through direct molecular screening of samples from the trickling filters of the Daspoort WWTW. Batch reactors filled with humus sludge demonstrated anaerobic ammonium removal with concomitant nitrite reduction, at a stoichiometric relationship close to that which characterizes known anammox bacteria. However, batch reaction rates decreased progressively over the successive experimental periods, indicating decay of the anammox-like process without growth during batch experiments. With the above as background, it is evident that nitrogen removal over Daspoort trickling filters is not only a function of conventional heterotrophic denitrification, but an anaerobic ammonium oxidation process also plays an important role. A conceptual biofilm process reaction model was developed and the mathematical model of Hao et al. (2001) was integrated into the biofilm compartment of the AQUASIM software. Because of their performance and proven potential low loaded trickling filters should be considered as both most sustainable and most appropriate technology in the right context.

Cost:	R930 500
Term:	2008 - 2013

Evaluation of the DEWATS process for decentralised wastewater treatment
University of KwaZulu-Natal; eThekwini Municipality; WAI; Bremen Overseas Research and Development Agency
No. 2002

eThekwini Municipality, in common with other municipalities in South Africa, is faced with the increasing challenge of providing housing and infrastructure to its population. EWS, as the unit responsible for the provision of water and sanitation, are investigating various sanitation technologies that meet the needs of the different communities, taking into account aspects such as access to the sewer system, terrain, housing density, compliance and availability of land. New housing developments are continuously being established within the urban and peri-urban areas in order to meet the housing backlog, many of which are not able to be connected to the main sewer line. The traditional approach for these developments was to provide septic tanks for the individual households, but this has led to a number of problems due to poor management by the households. EWS has therefore looked to the DEWATS approach as a possible sanitation solution for future housing developments as the DEWATS has been promoted by the NGO BORDA as having the following advantages:

- No energy requirements. The system works on gravitational flow and therefore maintenance of pumps, etc., would not be required; the process is largely anaerobic (lower sludge production, no aeration required) and can be operated without pumping.

- The potential for using the treated wastewater on agricultural land, thereby providing a possible source of income for the community; the ABR does not remove nitrogen and phosphorus and thus could serve as a fertiliser source.
- The possibility of generating biogas for use in the houses as an alternative energy source.

The construction of the pilot plant at Newlands Mashu therefore provided the opportunity to investigate the applicability of the DEWATS system to treat the wastewater from a small housing development, and to identify any operational problems and how these could be overcome. It was decided not to include a primary treatment process in the form of a septic (settler) tank at the head of the process as eThekwini wanted a process that was simple. Furthermore, a preliminary agricultural study was initiated to evaluate the potential of using the nitrogen and phosphorus for agricultural crops. The field trials highlighted several challenges and highlighted the importance of some of the initial design decisions and assumptions that were made. The outcomes from this project provided the following lessons:

- Operating a pilot plant such as Newlands Mashu requires dedicated management. Using students to manage and maintain such as plant is not a sustainable solution as they are present for a relatively short period of time, have specific research aims and are not equipped to deal with the 'bigger picture'. Where further test sites are to be installed and evaluated, it is essential to have a management team consisting of the key stakeholders (in this case EWS and BORDA).
- ABR effluent is more applicable as a source of water for irrigation than as a source of nutrients for crop growth. If used as a water source, the impact will be higher in winter than in summer (due to limited rainfall in winter). If used as a source of nutrients, the volume required would exceed the water requirements of the crop due to limited nutrient value.
- As the effect of using the ABR effluent on crops, soils and the environment will vary from region to region depending on prevailing circumstances, it is recommended that a model be used to simulate water and nutrient balances for different crops under different soil characteristics. This will provide information on the nutrient uptake and the possibility of nutrients leaching into surrounding rivers, and further indicate the sufficiency of the land being used and the ability of the soil to take up all the nutrients, allowing excess water to flow into hydrological systems.
- The effluent from the DEWATS process meets most of the irrigation standards, except for faecal coliforms where further analysis is required.

Cost:	R900 000
Term:	2010 - 2013

Microbial database – a tool for evaluating the BNR processes in KwaZulu-Natal
Durban University of Technology; Umgeni Water
No. 2003

Over a 20-month period, a critical evaluation of two BNR plants, treating domestic wastewater, was carried out with

the aim of establishing a microbial population database that can be used efficiently and easily as a tool for evaluating BNR processes in KwaZulu-Natal. This database was constructed by determining the relationships between plant operating parameters, process performance and the functional microbial populations. Even though the selected plants were initially designed based on the UCT and Johannesburg process configurations, a major deviation from the initial design was noticed. However, the typical and expected biochemical changes for nitrogen and phosphorus removal across the zones (anaerobic, anoxic and aerobic) were observed at both plants (Kingsburgh and Howick WWTWs). Hybridisation with group- and species-specific probes showed the presence of major functional groups such as nitrifiers, denitrifiers, PAOs and GAOs in abundance within these plants. The major operational problems observed were filamentous bulking/foaming and inconsistency in ammonia removal. Temperature, dissolved oxygen and COD: N level showed a significant relationship with the ammonia removal efficiency of the plants. Phosphorus and COD removal efficiencies however were not severely affected by the changes in the prevailing operational conditions. A cumulative logit model was developed during the course of this study to understand the significant relationships of the dominant filamentous bacteria to the prevailing plant operational conditions. Using this model, significant relationships were observed with the dominant filamentous bacteria and the operational conditions such as DO, COD, F/M ratios and NH_3 levels. Based on observations and knowledge gained during this study, the structure for the Microbial Population tool was constructed. This was accomplished using the Microsoft Office Access (2007) software, to create a user-friendly interface that details important plant operating controls in relation to operating conditions and the inherent effect on the microbial populations. The invaluable information and data generated in this project can be used as a basis to expand this research, to include a wider sample size, i.e., a larger number of BNR plants in KZN and nationally. Future research will also focus on the generation of an invaluable real time and interactive microbial population database, accessible online to assist plant operators with troubleshooting. Future research efforts will also determine how representative this database will be for all BNR plants in South Africa. The ultimate intention is to participate in the wider initiative and to lead the way to create a consolidated microbial fingerprint of BNR plants globally, in close consultation with Danish partners. A separate initiative of future research will include the training of plant operators on the application of the database to solve operational problems.

Cost:	R900 000
Term:	2010 - 2013

A gap analysis of technologies, techniques and capacity for the water and wastewater (domestic and industrial) sector in South Africa
University of Cape Town; University of Stellenbosch
No. 2258

Water innovation in South Africa takes place in a complex network of state and non-state actors, and is influenced by a wide range of different institutionary relationships and linkages. The diffusion of knowledge and technology and the translation of sciento-technological advancement into societal and economic benefit is not an uncomplicated or linear process – it is influenced by the cognitive or learning capacity of actors throughout the system, and by

the linkages and relationships that make up the system. A crucial distinction must be drawn between science-and-technology – the domain of research organisations and the focus of traditional R&D policy – and innovation, which includes a far broader array of actors and organisations. One of the outcomes of the study was a policy brief which suggests five opportunities for intervention followed by the inclusion of a modified Innovation Systems Framework applicable to South Africa.

In addition the following recommendations are offered for further discussion and investigation:

- Attract skilled and committed (so called 'right') individuals to career opportunities in the water sector using: (a) attractive marketing tools and programmes; (b) establishing further Centres of Excellence in water studies; and (c) offer attractive bursaries to attract the best school leavers into the water sector.
- Build a well-established STI system by paying particular attention to building linkages (partnership and co-operation), and in achieving desirable impacts.
- Implement successful funding models that offer retainer funds to give researchers a secure source of funding to think about specific and broader challenges faced by the society and local authorities, and the flexibility to develop and engage in multidisciplinary and trans-disciplinary projects.
- Research must increasingly draw on funding sources capable of supporting the various parts of the value chain with the intention of shifting research from the concept phase to commercialization and use value.
- Seed funding and tax incentives should become the norm in incentivising businesses and industries to develop water-related products.

Cost: R450 000
Term: 2012 - 2014

Programme 3: Stormwater and sewerage systems

Investigation into pumps and pressurised flow in separate sewer systems
University of Stellenbosch; BKS (Pty) Ltd; University of Johannesburg
No. 2007

Pumps are essential components in most sewer systems and are often considered by operators and managers to be the most problematic. The project sets out to address a number of pertinent issues with regards to pumps, pump stations, and related elements. This project was motivated by the general lack of published research into sewer pump stations and related problems, combined with the need for such knowledge during the planning, modelling, optimisation, design, operations and maintenance phases of these infrastructure elements. One of the key issues addressed by this research and the subsequent software tool revolves around improved communication between different levels of technical staff involved with sewer pumps, and basic training of operator-level staff.

This project aimed to conduct field research in South Africa, consolidate and organise the information and create a practical tool giving tips on pump station design and operation, as well as facilitating the flow of information between different levels of management. The SEWPUMP Tool developed follows the following broad specification:

- Identification: help to understand and identify problems at sewer pump stations
- Communication: facilitate communication between pump station operators and management
- Training: should transform to a training tool that could be used by individuals for self-study and by managers to facilitate training.

Therefore, the SewPump tool should be seen as a transformer, with three facets or functioning modes for (i) training (ii) operators and (iii) managers.

Cost: R1 000 000
Term: 2010 - 2013

Programme 4: Wastewater sludge and faecal sludge management

Investigation into the long-term risks associated with deep row entrenchment of pit latrine and wastewater treatment sludges for forestry and land rehabilitation purposes
Partners in Development (Pty) Ltd; University of KwaZulu-Natal (Pietermaritzburg); University of KwaZulu-Natal (Howard College); University of Kwazulu-Natal (Westville)
No. 2097

Municipalities in South Africa are used to dealing with wastewater treatment works sludge disposal. Very few, however, have to date tackled the disposal of pit latrine sludge at any scale, with eThekwini being the only notable exception. Wastewater treatment works sludges are generally disposed of in landfills, or are composted. In some cases they are irrigated or surface spread. Landfill and composting are fairly expensive processes, with costs in the order of R500/m^3 being reported. No other method of sludge disposal is more economical than simply burying it in the ground. In the ground, sludge decomposes by natural biological processes and after a few years is barely distinguishable from the surrounding soil. After three years even the hardiest pathogens such as *Ascaris* die off. Despite high loading rates no significant impact on groundwater has been observed in the trials to date over four years of monitoring. When sludge is buried in close proximity to Eucalyptus trees, which form a major part of the South African forestry plantations, growth is enhanced by up to 50% in terms of total timber volume, although it is too soon to say if the magnitude of this difference will be sustained over a full growth cycle.

Cost: R1 000 000
Term: 2011 - 2014

Investigation into pollution from on-site dry sanitation systems
University of KwaZulu-Natal (Pietermaritzburg); Partners in Development; eThekwini Municipality; University of KwaZulu-Natal (Howard College); University of the Free State
No. 2115

Many studies have been conducted on the widespread use of pit latrines. Regrettably, no consistent methodology has been used to monitor or report the extent of nutrient or pathogen movement. Very often, the studies comprise monitoring of local boreholes down-gradient of informal or peri-urban developments. Several case studies report incidences of nutrient and pathogen contamination as a result of on-site sanitation contaminating water resources. Elevated concentrations of nutrients and pathogens have been observed between 20 and 90 m from latrines. Studies also claim that observations from boreholes some 900 m downstream of developments where pit latrines are used have shown increases in pathogen abundance. Only one study warns that the rapid lateral subsurface flow from extreme events may move nutrients and pathogens from pit latrines, but no observations are evident in the literature. Four sites on two geologies were established in this study. A transect of four VIP latrines was monitored on a hillslope and an associated background site was coupled with this transect. Three other sites were established to monitor individual pour-flush latrines. The study found that, in comparison to previous studies, nitrate movement does not appear to be as significant at the KwaZulu-Natal study sites. However, the results are consistent with each other in terms of greatest mobility being during periods of high rainfall. The same can be said for the mobility of *E.coli*. However, at the Slangspruit site, a distinct *E. coli* plume extended to 26 m, whereas the nitrate was only clear up to 3 m. At this site, where the water table was consistently high (i.e. <1 m), it may be suggested that in these circumstances there is a great chance of faecal coliforms contaminating nearby water resources.

Cost: R1 500 000
Term: 2011 - 2014

Programme 5: Sanitation technology and innovations

An investigation into technical sanitation solutions for informal areas
Cape Peninsula University of Technology; City of Cape Town; eThekwini Municipality; Stellenbosch Municipality
No. 2098

Conventional approaches to environmental sanitation are unable to make a dent in existing service delivery backlogs, and are not able to cope with the new challenges arising from informal areas. Several sanitation technologies are being developed using available guidelines and compendiums that are often too general and not specific to informal areas. A number of emerging sanitation technologies provided to informal areas are not often documented or adequately established to ascertain their feasibility. In addition, the developed sanitation technologies are being provided without understanding the main sanitation issues in the context of particular informal areas. This research

was aimed at investigating technical sanitation solutions for informal settlements. The intention of the research was mainly to develop an approach for developing sanitation concepts and solutions that respond to particular conditions of informal settlements. The most important concepts of relevance to informal settlements were found to be those focusing on resource recovery and reuse, low O&M, zero waste generation and economic incentives for both users and service providers. This study has provided an overview of the development of sanitation concepts and solutions for informal areas. It is understood that sanitation technologies are developed to respond to particular sanitation challenges that can be viewed from social, institutional, economic or technical perspectives. From social and technical perspectives, sanitation challenges are related to the profile of the served community and the components of sanitation solutions respectively. These challenges include non-compliance with operational requirements, poverty, density, inadequate design, operation and maintenance.

Cost: R500 000
Term: 2011 - 2014

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

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

This project aimed to develop a continuous process to effect the depolymerisation of the lignocellulosic content of fruit waste using a selected group of enzymes in a bioreactor setup. An additional objective was to add value to the process of breakdown of the lignocellulose components, in the form of various products, bioenergy or biomass. The proposed system aims to address three major problems: (i) the increasing scarcity of clean water in South Africa; (ii) the production of large volumes of agri-industrial wastes; and (iii) the fact that these agri-industrial wastes contain lignocellulosics, which present a particular challenge in their disposal. In this project, fruit waste, called pomace, which has been generated from fruit and juice processing, was targeted for treatment. One of the main objectives of the TILE project was to scale up solid fruit waste hydrolysis to larger volumes using the optimum hydrolysis conditions obtained by running 1 L bioreactors. Initial studies developed a cocktail of commercial enzymes which could be used to realise the aims. The artificial neural network closely predicted the apple pomace hydrolysis in the 20 L and in 1 L optimised reactors. This observation is now further validated by showing that at various substrate loadings, of 5%, 10% and 20%, in the 20-L bioreactor displayed the same profile for glucose and other sugars as in the optimised 1-L bioreactor. The study showed that HMP solids can be efficiently reduced within 24 hours in a 20-L

stirred tank reactor system using a mix of commercial enzyme cocktails (Viscozyme, Celluclast and Novozymes 188). Thus, using the reactor format, enzyme cocktails and conditions previously employed efficiently reduced the bulk solids of two industrial apple pomace substrates (AFP-B and CFP), industrial peach and industrial pear pomace. In addition, it was also confirmed that the TILE system is able to hydrolyse HMP substrate loadings of up to 20% (wet w/v). Overall, this system has been shown to be flexible and robust as it can be used to effectively reduce the bulk solids and release sugars from different pomace substrates, i.e., the TILE system is 'tunable' to various fruit waste types.

Cost: R1 250 000
Term: 2011 - 2014

Programme 2: Integrated management

Adapting water footprints for South Africa and exploring the value of integrating water, carbon and energy (environmental) footprints for the South African industrial sector
Pegasys Strategy and Development (Pty) Ltd; WWF South Africa; University of Cape Town
No. 2099

A water footprint is an indicator of freshwater use that considers the direct and indirect water required to produce a product, measured over the full supply chain. Water footprint studies have been completed for a variety of entities, including countries, products, commodities and river basins. While water footprints have significant potential to contribute to corporate water management and to integrate water into decision-making, significant questions must still be addressed in order for water footprints to be a reliable and meaningful indicator. A range of case studies were conducted to understand the applicability of water footprinting to different sectors using different lenses. Using the WF design process, the water footprinting tool was applied to the following case studies: (i) irrigated carrots from the Ceres area, to represent a local irrigated crop; (ii) imported beans from Kenya, to represent an imported crop; (iii) cheese production in the Western Cape, to represent a livestock-based product with an operational water footprint component; (iv) dishwashing detergent produced in Johannesburg, to represent a consumer good with an operational and a downstream water footprint component; (v) manufactured fruit concentrate, to compare the water footprint associated with the growth and processing of different fruits (vi) extraction of coal from a mine, to represent the extractives industry and explore the grey water footprint; (vii) combustion of coal to represent the power generation industry and (viii) manufacture of products from a chemical facility in the Vaal to highlight the complexities of a large-scale chemical plant. Overall, it can be concluded that water footprinting is indeed a useful tool that companies can use as a first estimation of their water use and impact. The major pitfall is the lack of consensus on the use and reporting of the water footprint studies. In many cases there are no clear regulatory frameworks for disclosure and the reporting of water footprint assessment outcomes, In addition, there is no clarity on the application of water footprint tools; for example, a company that has undertaken an operational water footprint might report this as their sole water

footprint, even though it does not include their supply chains. Due to the disparity in the application of the water foot-print concept, there is a need to agree on an industry wide-approach. Furthermore, the study showed the water foot-print data and knowledge base for industries is not well developed, and more work is required to gain confidence in the tool. Going forward, a standardised guide on the use of the water footprint and its application needs to be developed.

Cost: R2 000 000
Term: 2011 - 2013

Programme 4: Governance, policy, regulatory, and economic instruments to improve industrial water management

Valuing water for South African industries: A production function approach
CSIR
No. 2103

This study applied and tested the marginal productivity approach to estimate the marginal value of water to industrial users in South Africa, as well as the associated price elasticity of demand, based on a sample of 58 companies. The results indicate that the method is vulnerable to statistical issues such as multicollinearity, particularly in the presence of a relatively small sample size, which leads to unexpected results regarding the marginal value of water use. On the other hand, the estimated price elasticities of demand (in the range of –0.66 to –0.78) are in line with theoretical expectations and comparable to estimates for the industrial sector in other countries, and for other sectors in South Africa, and are fairly robust in response to changes in the specification of the model. The estimated elasticities suggest that, as expected, an increase in water prices would lead to a reduction in water use, all else being equal; although the percentage reduction in water use is comparatively lower than the percentage increase in price. This provides some evidence to suggest that an increase in water tariffs would lead to a reduction in water use among industrial users, although this reduction in water use would be outweighed by the increase in tariffs, such that total expenditure on water by industrial users (or total revenues received by the water services provider) would increase. However, water pricing is a sensitive issue, affecting various stakeholders. As such, policy recommendations cannot be made on the basis of this analysis alone; particularly given the limitations of the method (e.g. the possibility of multicollinearity), and of this study in particular (e.g. the relatively small sample size). Further research is therefore warranted. In particular, future research should be aimed at improving the method (e.g. by making adjustments to overcome the statistical issues, or making use of a larger sample size), or at identifying alternative methods. Furthermore, in addition to this purely micro-economic analysis, stakeholder consultation is essential, while the wider socio-economic and macroeconomic impacts of an increase in water prices need to be assessed.

Cost: R780 000
Term: 2011 - 2013

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 3: Minimising waste production

Investigation of carbon flux and sulphide oxidation kinetics during passive biotreatment of mine water
University of Cape Town
No. 2139

While acid waters emanating from groundwater rebound through the Witwatersrand gold basins has received the majority of the media attention and elicited the strongest response from the authorities, acid rock drainage (ARD) from diffuse sources, primarily associated with coal mining, is likely to impact a far larger area. The traditional chemical and physical interventions are not particularly well suited to these discharges. Research into passive and semi-passive systems has met with varying degrees of success. Typically, the processes that target sulphate salinity make use of biological sulphate reduction, often utilising complex organic carbon sources to provide the electron donor. The sulphide product is highly toxic and presents a significant risk to the environment and human health and needs to be carefully managed. The most attractive option is the partial oxidation of sulphide to elemental sulphur, which is stable and has commercial value. The primary aim of the research was to characterise the carbon flux through an integrated sulphate reduction/sulphide oxidation process and determine its effect on the recovery of sulphur in the floating sulphur biofilm. The second aim was to investigate oxygen mass transfer to the biofilm and use this information to inform optimal management of the system. Two packed bed columns were used to investigate the sulphate reduction efficiency and carbon flux. A series of linear flow channel reactors (LFCRs) was used to investigate the effect or residence time and acetate supplementation on sulphide oxidation rate and elemental sulphur yield. The oxygen mass transfer into the biofilm was investigated in a scaled-down reactor, using a dissolved oxygen microprobe. The composition and internal structure of the floating sulphur biofilm was analysed using scanning electron microscopy and elemental analysis. The structure of the biofilm informed the interpretation of the data. The data allowed the specific aims to be addressed and provided significant insights into the performance of the integrated system. The experiments showed that efficient sulphide oxidation was possible within the floating sulphur biofilm in the LFCR, provided the feed was supplemented with organic carbon. A hydraulic residence time of between 1 and 2 days was optimal. In order to sustain optimal performance the biofilm would need to be harvested every 2 to 3 residence times. Under these conditions sulphide oxidation rates of up to 5.5 mmol/L per day could be achieved, with at least 75% of the oxidised sulphide reporting to the biofilm as elemental sulphur. Conservatively, this represents a sulphur recovery of 13.5 g/m^2 per day, for the current reactor configuration. The experiments illustrated that organic carbon liberation from packed bed reactors is unlikely to be sufficient to sustain efficient levels of sulphate reduction beyond the short term, once the readily labile organic carbon has been liberated. Supplementation with relatively significant (1 g/L) concentrations of readily usable organic carbon, such as acetate, was needed to sustain sulphate reduction. While the majority of the sulphate reduction ($\pm$ 75%) was reliant on the acetate, continued hydrolysis of the lignocellulose was observed. Despite this, the VFA concentration in the effluent from the packed bed reactors was negligible after

the first four months. Therefore, further organic carbon supplementation (> 100 mg/L acetate) of the feed to the LFCR was necessary for biofilm development and efficient sulphide oxidation. Under optimal conditions the biofilm formed within 12 hours, following which the oxygen mass transfer into the liquid was significantly reduced. The reduced mass transfer prevented complete sulphide oxidation, so the majority of the sulphide was oxidised to sulphur within the biofilm.

Cost: R279 450
Term: 2012 - 2014

Programme 5: Low-volume mined products

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

This project set out to investigate the application of emulsion liquid membranes (ELMs) in recovering platinum group metals (PGMs) from the aqueous by-products of PGM refining. The by-products are generated as sidestreams which require storage and reprocessing. Of the PGMs, rhodium (Rh) is one of the more inert and therefore difficult to extract. Membranes have historically been viewed as semipermeable barriers between two adjacent phases. From the operational point of view, membranes are easy to bring to industrial scale for the following reasons: the underlying scientific concepts are relatively simple, their operation and scale-up is uncomplicated to achieve, and they are environmentally-friendly and low-cost in terms of energy. Membranes can consist of polymer films and liquids. If the membrane system is based on a liquid matrix, then it is called a liquid membrane. Liquid membrane systems involve contact of an immiscible organic liquid (named the diluent) with a feed phase (i.e. the wastewater or effluent of interest). The application of emulsion liquid membranes (ELMs) reduces energy and financial costs and the time for the metal solvent extraction. This is caused by the faster kinetics of extraction with ELMs and higher extraction yields in comparison with the classical solvent extraction. An ELM was prepared by using 28-30% solution of toluene in kerosene. This diluent phase was then mixed with a stripping phase. Extraction of Rh from aqueous matrices was tested and the results showed that the complete extraction of Rh was possible. This was achieved by the use of an optimised ELM. Carryover of the diluent components into the stripping phase and effluent was observed and further work is recommended to overcome this drawback

Cost: R337 450
Term: 2010 - 2013

THRUST 6: WATERSMART FUND

Development and testing of a water treatment bottle for use during emergency diarrhoeal outbreak conditions
University of Johannesburg
No. 2194

Although there are various commercial water treatment options available for the treatment of water under severe circumstances, most of these are dependent on a consumable(s) and equipment that needs to be delivered to the people. When the consumables run out the water treatment also comes to a standstill leaving the people without treated potable water. The ideal would be to provide a water treatment device that can be used with commercially available options, home-based chemicals or, in extreme situations, things that can be found in the environment. In an attempt to come up with a design that could provide an option to deal with all these situations, members of the Water and Health Research Centre designed a water bottle that can be used for the treatment of smaller volumes of water (< 1 L). The novelty of the water bottle lies in the fact that the design allows for various applications and adaptations without any structural changes needed. This literally means that the user can adapt the use to suit what he or she has available at that stage. The design now gives the user the freedom to transport treated drinking water while having the facility available to treat more water. It can be used by people living in areas without treated potable water, hikers or in emergency situations where treated water might not be available. The combined aim of this study was to produce the water bottle using injection moulding and to test the effectiveness of the water bottle using a variety of commercially available treatment options, household-derived treatment options and worst-case-scenario water treatment options. A prototype of the design has been produced and the preliminary testing was concluded. It was found that the technology is not effectively treating water for a variety of reasons. Further development and testing is required to ensure the robustness of the technology.

Cost:	R432 000
Term:	2012 - 2014

New housing unit designed for ceramic water filters to be more applicable in rural and peri-urban communities in South Africa
University of Venda; University of Johannesburg
No. 2195

The lack of access to safe, reliable water sources remains a problem for many people in developing countries. The Potters-for-Peace ceramic water filter (PFPCWF) has been successfully distributed as a point-of-use water treatment device in various countries around the world, and is intended to convert unsafe environmental water into potable water. A previous WRC study carried out in the Limpopo Province showed that the Potters-for-Peace ceramic filter (sourced from Ghana) is a viable option for use in South African conditions. Part of the study looked at how

rural communities accepted these filters and what possible changes could be made to increase the efficiency of the filters. It was found that if certain design aspects could be addressed, the water filter would be better accepted. The housing unit was successfully designed and developed and a total of 90 housing units were produced by rotor-moulding. These were assessed for user-friendliness and acceptability in a peri-urban and a rural community using the silver-impregnated ceramic POTPAC pot filter. In the assessment of user-friendliness and overall acceptance of the new housing unit by the peri-urban and rural households, the feedback showed an overall satisfaction with the new design, especially with the stability of the unit, the taste of the filtered water, the easy cleaning process, and the fact that the design provides enough water for a family.

Cost:	R500 000
Term:	2012 - 2014

Filter for the removal of suspended solids naturally found in harvested water
Durban University of Technology; independent consultant
No. 2197

In recent times, with the debatable exception of Australia, authorities worldwide have not been inclined to fully approve private rainwater harvesting (RWH) as an alternative to piped municipal water, due to the skills shortage, and reliance on the self-discipline required for adequate maintenance and water quality. What is evident is that very little research on RWH has sought alternatives to the conventional first-flush methods, relying instead on using either diverter or secondary settlement tanks or, in the case of industrial applications, pressure or sand filtration. The aim of this investigation was to evaluate the efficiency of the novel filter in the removal of suspended solids from harvested rainwater. A total of five test sites were selected for observation of the Zeo Xen-Filter Diverter performance within a RWH system. This selection was based on specific criteria such as accessibility, vegetation cover around buildings, average annual rainfall, geographic location, environment and positioning relative to the prevailing wind and sunlight. From microbiological analyses based at the field testing sites, it was evident that the ZX-FD-filtered water contained health-concerning levels of faecal contaminants at concentrations above those stipulated in the SANS 241 drinking water specifications. Thus, whilst the filter is able to remove suspended solids that may harbour pathogenic bacteria, the filter is incapable of removing 'free living' bacteria; therefore further tertiary disinfection of the harvested water is required for potable supplies.

Cost:	R426 400
Term:	2012 - 2013

Developing a low-flush latrine for application in public schools
Partners in Development; eThekwini Municipality; University of KwaZulu-Natal (Howard College)
No. 2198

The objective of this study was to design a robust low-flush system to contribute to the development of a range of on-site sanitation options which take into consideration all aspects of the life cycle of a system, including user behaviour, pit emptying and beneficial disposal of sludge. Building on research that began in 2010, which then led to the development of a pour-flush pedestal toilet and the testing of 20 units in households using 1 to 2 L, it was shown that the pour-flush systems performed well over their first two years of use. Based on this success, in May 2011 eThekwini Metro Municipality approached the research team to consider developing a low-flush latrine which could be used in public schools. eThekwini is increasingly taking over responsibility for sanitation in the rural public schools within the Metro, which number over 400. Some of the schools have VIP toilets, sometimes with a shared pit which has proven exceptionally difficult to empty. Others have full waterborne systems which result in a high level of water usage by the school. A low-flush system could provide the convenience of a flush system with minimal consumption of water. The study thus produced a 2-L mechanical flusher to be attached to the pour-flush pedestal. After the development of a prototype, the technology was piloted in two homes and two schools. The system has been found to be working very well over the testing period and there has been general acceptance of the system.

Cost:	R250 000
Term:	2012 - 2013

CURRENT PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 2: Institutional and management issues – Water services

Adapting and piloting the new concepts of Community-Led Total Sanitation (CTLS) in the South African municipal environment
Cape Peninsula University of Technology
No. 2088

Community Led Total Sanitation (CLTS) focuses on behaviour change rather than toilet construction. CLTS mobilises a cooperative approach based on people deciding together how to create a hygienic environment that benefits everyone. Total sanitation ensures that everyone uses a hygienic toilet and safely disposes of their domestic waste,

creating a safe and clean environment. The CLTS approach encourages responsibility by the community, taking its own action. Cooperation among households is a key element, as is spontaneous emergence from within communities of 'natural leaders' (NLs) as facilitators. The objective of this study is to adapt and test the concepts of CLTS in the South African environment and context.

Expected cost: R2 500 000
Expected term: 2011 - 2014

Constraints on providing sewerage in South African informal settlements: A study of social and institutional management concerns
University of Cape Town
No. 2120

Full-flush toilets are generally preferred by residents and deemed by the National Government as being the most appropriate technology for dense urban settlements. Yet standard conventional (gravity) systems are costly to implement and sometimes impractical in flat terrains where residents, fearing increased marginalisation, have resisted relocation. Further challenges arise because informal settlements are often regarded by planners as temporary, with the result that sanitation services installed are not always of high quality. Municipal officials countrywide report a pattern of shared (communal) facilities in densely-populated informal areas deteriorating rapidly, allegedly a result of mismanagement and apparently senseless destruction. All of these situations are likely a consequence of residents' desire, and increasingly their demand, for security of tenure and a national policy for service delivery that is supply-side driven. While present policy is indeed supply-side driven, it makes no provision for sanitation management costs despite this being an expectation of residents who claim a right to free operation and maintenance of communal sanitation services (O&M). This study intends to analyse the social and municipal concerns with, and attempts to address, current sanitation planning and management processes. Many municipal officials question how to achieve this economically and rapidly, and on a large enough scale that it results in services which residents are satisfied with and will develop a sense of propriety over and therefore protect. The research hopes to assist municipal officials, and, by extension, residents, by first detailing the criteria whereby and reasons that officials and residents consider some sanitation projects 'successes' and others 'failures'.

Estimated cost: R1 000 000
Expected term: 2012 - 2014

Social protest and water service delivery in South Africa
University of the Western Cape
No. 2133

From a planning perspective, lack of simple correlations in the occurrence of water services related protests raises an

important methodological question about whether or not such unrest can be predicted and/or pre-empted. Although useful quantitative and qualitative insights on social protests are provided by Municipal IQ and by the Dialogue Unit of the Institute for Democracy in South Africa (IDASA), a major problem is that much of the evidence on social protests is based on media reports and anecdotal evidence, with a limited range of in-depth scientific analyses. Post-apartheid reforms have not only partially resolved these inequalities, but have also spawned unprecedented social challenges associated with societies in transition. For example, formal institutional responses to the mushrooming of urban informal settlements have often failed to keep pace with urban social change and many such settlements remain with insecure access to water. Similarly, formal institutional responses in rural areas have often fallen short of meeting newer social consumption patterns, livelihood aspirations and expectations for service delivery. A key question for further research is why water-related protests have largely been confined to urban areas, irrespective of socio-economic status. The study will provide for an in-depth scientific understanding of this development and a broadened focus to include both the lived realities of historically disadvantaged individuals (HDIs) in informal rural and urban economies as well as those of other socio-economic groups within South Africa.

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

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 1: Drinking water treatment technology

Investigation into the cost and water quality aspects of South African desalination and reuse plants
SSI Engineers and Environmental Consultants (Pty) Ltd
No. 2121

Desalination and wastewater reuse by various membrane processes ranging from micro-, ultra-, and nanofiltration to reverse osmosis, in combination with other advanced technologies, can be used in different configurations to augment water supplies. With known feed-water and target product-water qualities the basic plants are relatively standard and consistent in price. However, the infrastructures in front of (intakes, pre-treatment, etc.) and following (waste discharge, product water pumping systems) the basic plant building block (membrane system) are major variables in determining the capital and operating costs of the selected solutions. Each location and situation has different advantages and challenges to be evaluated in making the best decisions for implementation. This project will compare and document actual cost and water quality data from various South African projects to establish a first-order knowledge base for desalination and reuse for the augmentation of water supply in a South African context.

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

Advanced oxidative treatment process for water disinfection using an electrohydraulic discharge reactor and TiO_2 immobilised on nanofibres
University of the Western Cape
No. 2132

In this project, the design and methods for applying electrical energy to multiple electrodes will be explored and described. An assembly having at least more than two electrodes may be configured such that the high voltage electrodes are submerged in the inner tubes, positioned at parallel relative to one another, and the grounded electrode is directly submerged into the wastewater setup, resulting inproduction of a cocktail of chemical species, such as OH radicals, ozone and hydrogen peroxide, which can target and attack the pollutants in the water without the addition of chemicals. Electrohydraulic discharges have been studied for several years; however, the integration of innovations in nano-science and nano-photocatalytis has been incorporated into this area of research on a very limited scale. The new system will be designed so as to generate plasma directly in water, which will produce radicals from water ionisation. Furthermore, in this multifunctional reactor multiple electrodes across the water flow path, in combination with TiO_2 electrospun nano-fibre consolidated photocatalysts, are applied that can promote and enhance the formation of oxidants.

Estimated cost: R1 392 800
Expected term: 2012 - 2015

Programme 3: Drinking water quality

An investigation into the presence and impact of free-living amoebae and amoeba-resistant bacteria on drinking water production, storage and distribution to health care institutions in greater Johannesburg, South Africa
National Institute of Occupational Health
No. 2138

Free-living amoebae (FLA) are ubiquitous in groundwater and surface waters used for drinking water production. They feed on smaller micro-organisms like bacteria, fungi and algae. Although mostly non-pathogenic, some FLA, particularly *Acanthamoeba* and *Balamuthia* species and *Naegleria fowlerii* are known human pathogens which may cause life-threatening disease in both healthy and immunocompromised individuals. They can survive in this dormant stage for long periods of time, only to excyst and become active again when conditions return to normal. International studies continue to highlight the potential of FLA containing amoeba-resistant bacteria (ARB) to survive routine drinking water production and treatment processes. The overall aim of the study is to establish whether the

occurrence of FLA and ARB in drinking water production plants has an impact on the quality of the water supplied to health care institutions in greater Johannesburg, to use this information to assist the drinking water production industry to improve the quality of water supplied to these institutions and to assist the institutions to establish appropriate water management programmes in areas where the patients and personnel are most at risk of infection.

Estimated cost: R423 500
Expected term: 2012 - 2015

Programme 4: Water distribution and distribution systems

Practical guidelines for operation and maintenance of water distribution systems in South Africa
University of Cape Town
No. 2135

Proper operation and maintenance procedures are key to ensuring that the investments in new infrastructure provide a continuous and sustainable high level of service. Components of water distribution systems do not last forever, and need to be operated within their design parameters and inspected, repaired and replaced at appropriate times to ensure that the integrity of the infrastructure is maintained. Lack of proper operation and maintenance invariably leads to faster degradation of the infrastructure, with an associated decrease in service levels of both quantity and quality of water supplied. If this process is not checked, it eventually leads to complete breakdown of the system integrity, which requires the infrastructure to be replaced at huge cost. This project will provide clear and practical guidance on the operation and maintenance of water distribution systems. The focus of the project will be on applying current knowledge on water distribution management to South African conditions, and to make this information accessible to South African engineers and managers.

Estimated cost: R757 000
Expected term: 2012 - 2014

Determination of the change in hydraulic capacity in pipelines
University of Pretoria
No. 2140

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 is 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. This research, which builds on previously-completed work, will broaden the database, maintain the current momentum of the original research and will provide improved understanding of the hydraulic behaviour of pipelines

to be able to improve the design philosophy. The preliminary finding was that the presence of biofilm significantly reduces the hydraulic capacity. In this study emphasis will be placed on the review of newly-installed pipelines (sewage, raw and clear water), but existing pipelines will also be included in the field work. A roughness database reflecting the hydraulic capacity time history will provide a sound basis for the design of new pipelines as well as assist in the operation and refurbishment of existing pipelines.

Estimated cost: R1 125 000
Expected term: 2012 - 2015

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

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 analyse 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 - 2014

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 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 SiO_2, ZrO_2 and TiO_2; 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 foulingproperties and will address the electrochemical characterisation of fouling onto the unmodified and modified membrane surface.

Estimated cost: R900 000
Expected term: 2010 - 2012

Exploring knowledge on natural processes for novel approaches to constructed wetland design and performance for wastewater using biomimicry
Golder Associates
No. 2096

This study will look to exploit knowledge on natural wetlands, their processes and biodiversity to better engineer/ design constructed wetlands to meet the challenges of current and emerging pollutants and pathogens. The study should also look to explore the potential of using constructed wetlands to support sustainable livelihoods. The first phase of this project is innovation-focused and will explore, through the process of biomimicry, novel approaches that can be used to improve constructed wetland design and implementation. The potential exists for this process to deliver innovative solutions for wastewater (both industrial, domestic) treatment, transformation and filtration.

Estimated cost: R3 000 000
Expected term: 2011 - 2016

Characterization of indigenous anaerobic ammonium oxidizing (anammox) bacteria grown in microaerobic environments
University of Pretoria
No. 2117

The project builds on the lessons learned in an earlier WRC-funded project conducted By Stellenbosch University entitled 'Fishing for indigenous anammox bacteria'. The main goal of the study was to find out if anammox bacteria exist in some South African anaerobic environments. The study has shown some impressive results with regards to the existence of these bacteria from various habitats. However, the researchers had difficulty in obtaining sufficient biomass to sustain the anammox process using the gas-lift reactors. In addition, the study also showed that oxygen is very inhibitory to the growth of anammox. Furthermore the constant feeding and mixing of the reactor contents resulted in biomass washout thereby hampering the progress of the enrichment process. Based on the abovementioned findings, the principal objective of this proposed study will be to develop an anammox enrichment system that will be designed to endure microaerobic conditions

Estimated cost: R460 400
Expected term: 2012 - 2014

Fate and behaviour of engineered nanomaterials (ENMs) in wastewater treatment systems
CSIR
No. 2122

In contributing towards our collective understanding on the fate, behaviour and transportation of engineered nanomaterials, ENMs, in WWTP processes. This study will be to establish possible mechanisms of ENM accumulation and/or degradation in wastewater sludge, as well as the potential effects of ENMs on the microbial population which could be useful in current wastewater treatment processes. To understand the fate, behaviour and transportation of ENMs in the environment, the following processes, viz: aggregation, adsorption, complexation, entrapment,

degradation, reactivity, mobility or degree of stability, given the size of ENMs which is within the colloidal region, will be carefully investigated. The derived knowledge will provide sound evidence to allow for the search for technologies that can remove ENMs from wastewater efficiently.

Estimated cost: R680 000
Expected term: 2012 - 2014

Performance and efficacy of integrated algae ponding systems in wastewater treatment for water reuse and cost recovery through biomass valorization
Rhodes University
No. 2123

A rapid implementation of robust, easy to deploy and operate, sustainable wastewater treatment technology is urgently required. Furthermore, climate change, together with reduced water availability, has major food security implications for South Africa, its neighbours, and other arid, water-poor countries. These two factors alone have profound management implications for both government and business. Correct implementation and management of integrated algae pond systems (IAPS) developed for South African conditions can produce clean water for recycling and reuse, provide energy, and generate a biomass suitable as a broadcast or liquid fertilizer in organic row crop agriculture and high-value horticulture. Even so, and as with any near market-ready technology, there is an element of risk and/or failure to comply. Performance of the IAPS needs to be closely monitored and its efficacy in routinely producing a final effluent that meets the standard (i.e. <75 mg/L COD and <25 mg/L SS) thoroughly elaborated. Furthermore, an evaluation of all factors contributing to final COD and SS must be carried out and included: design and re-design of the algae settling tanks, introduction of more robust separation/filtration technologies for removal of biomass and/or water, and full characterisation of the residual COD and SS in the final effluent. Armed with this information a document emphasising the merits of IAPS and addressing questions and concerns about its implementation will be available to facilitate informed decision making.

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

Development and demonstration of a woven fabric immersed membrane bioreactor package plant for decentralised sanitation
University of Stellenbosch
No. 2287

South Africa faces a challenge in providing sanitation for all of its people. Decentralised, small-scale 'package' sanitation plants have great potential to overcome some of the logistical challenges and could make a significant contribution to the roll-out of sanitation in peri-urban and rural areas. Internationally, there has been a major swing towards

immersed membrane bioreactor (IMBR) technology for wastewater treatment due to the advantages that IMBRs offer over conventional biological wastewater treatment. IMBR package sanitation plants could have a significant impact on addressing the sanitation backlog. However a major barrier to the application of IMBRs is the cost and lack of robustness of current IMBR membranes. Generally, current commercial IMBR membranes are expensive and cannot withstand rough handling. Further, there is a perception that IMBR technology is 'first-world', complicated, and requires highly skilled operators, and hence cannot be applied for decentralized sanitation in developing regions. To enable South Africa to benefit from IMBR technology this project will demonstrate to wastewater practitioners, vendors of package plants, etc., that IMBR technology can be simple, robust, easy to operate and cost effective.

Estimated cost:	R793 875
Expected term:	2013 - 2015

Programme 2: Application of appropriate technologies and tools

Ultra-sensitive electrochemical nanobiosensors array devices for real-time determination of oestrogenic 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 oestrogenic hormones such as oestriol, 17-oestradiol and 17-ethinyloestradiol and oestrone. Oestrogenic 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 oestrogens 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 oestrogens is not fully known and there is no available technology for their real-time determination.
The main methods for the determination of oestrogenic 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 oestrogenic 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 oestrogenic endocrine disruptors in wastewater samples down to the femto- or atto-molar range. The idea is to determine individual oestrogen compounds simultaneously in one measurement using multichannel microchip array signal transduction approach.

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

Self-regulation of the package plants/small wastewater treatment industry: Development of a framework of standards, a conceptual model for a test facility and an accreditation system for each technology provided by suppliers
Royal Haskoning DHV
No. 2193

The SWWTW industry in South Africa has grown rapidly from a small base and is currently unregulated in terms of process design, construction materials, etc. Most of the suppliers are not process experts but rather entrepreneurs who have funded the development of their product using limited resources. Furthermore, SWWTW's are often purchased on the basis of purchase cost which means that at present product costs have to be minimized. This is achieved by omitting any form of redundancy in the plant such as aerators and pumps, overloading media, and using optimistic upflow rates in settlers. Lack of regulation of the SWWTW sector has led to a number of problems in terms of performance, durability and reliability. This project aims to use the experience gained locally, together with international standards and practices to develop:

- A framework of appropriate standards for the SWWTW industry
- Implementation of the standards in a simple manner without duplication
- A conceptual model with key criteria for an independent testing facility for the different technologies
- An accreditation system for the various technologies which will encompass technical and managerial aspects. This would be based along the lines of the Green Drop system, but taking into consideration the fragmented roles of the sector stakeholders. The study will also evaluate who should manage and audit the accreditation process, the cost of the process and who bears the cost.

Estimated cost: R800 000
Expected term: 2012 - 2014

Programme 4: Wastewater sludge and faecal sludge management

Quantifying the fertilizer value of wastewater sludges for agriculture
University of Pretoria
No. 2131

This study follows on from a previous WRC project (K5/1724/3) on the sustainable agricultural use of sludge. The previous project included a local field-scale study, conducted across a range of cropping systems using anaerobically-

digested air-dried sludge and incubation trials for model N and P parameterization. This study highlighted that sludge application rates that attempt to match nutrient supply to crop demand depend on cropping intensity, availability of water, management practices, and sludge N and P content. In order to accommodate such complex interactions between sludges, soils, climate, and cropping systems, a mechanistic nutrient (N and P) balance cropping-systems model (SWBSci) was developed for use as a reasoning support tool to guide decision makers with the responsible use of municipal sludges in agriculture. The model was calibrated and validated under various cropping systems, proving its potential as such a reasoning support tool. This model is a fairly complex scientific research tool, and requires detailed weather, soil, crop, and sludge parameters in order to be deployed. Interest in using the model to assist with the development of sludge management strategies for different wastewater care works has been expressed on several occasions by industry partners. However, in its current form, routine use of this reasoning support tool by industry part-ners or extension officers is highly unlikely, as parameterization is not completely trivial, and there is a definite need to simplify the procedure to follow in running simulations. In order to render this tool more usable, the model needs to be populated with soils, crops, and long-term weather data parameters around the perimeter of wastewater care works, as well as sludge parameters. Sludge parameterization for the various N and P pools relies on a long-term incubation trial which is tedious, time consuming and impractical in real life. Therefore, practical and affordable methods are required to identify the various N and P pools for model parameterization. It is also vital to add a simple heavy metal module into the model to estimate the accumulation of heavy metals in the soil profile across time. The long-term trial could be continued for another three years to validate and calibrate the heavy metal model. This is because beneficial agricultural use of sludge is prohibited if the concentration of heavy metals in the soil profile exceeds a certain threshold value. The model can then be run for various scenarios for several local cropping systems to generate a database of options.

Estimated cost: R2 100 000
Expected term: 2012 - 2015

Programme 5: Sanitation technology and innovations

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

Investigation into risks of exposure of workers and households to pathogens through current desludging practices and development of guidelines to minimise risks
Partners in Development
No. 2134

There is strong growing evidence that the methods used to empty the pits of on-site sanitation systems result in transmission of disease from sludge to workers or householders. This undermines the impact of basic sanitation and health objectives of breaking the cycle of faecal-oral disease transmission. This study aims to investigate the risks of transmission of pathogens to workers or householders through current emptying methods and to develop guidelines for institutional support to minimise these risks.

Estimated cost: R1 200 000
Expected term: 2012 - 2015

Pour-flush and Portapotty sanitation systems
University of KwaZulu-Natal (Durban)
No. 2137

The nature of the waste material from a pour-flush system is different to that of a pit latrine (in that it has a higher moisture content and contains all the urine) and that of a septic tank (in that it is much more concentrated and does not contain any grey-water).It is believed that moisture content and ammonia concentration affect the rate of biological degradation of any waste stream, but these effects have not been clearly established for pit toilet, pour-flush toilet and septic tank contents. This study will investigate the nature of the feed (specific loading and composition), the extent and kinetics of biodegradation, which need to be determined in order that a rational design procedure can be proposed.

Estimated cost: R1 281 500
Expected term: 2012 - 2015

Demonstration and scaled-up implementation of pour-flush sanitation in South Africa
Partners in Development
No. 2203

While many South Africans aspire to full waterborne sanitation, this is not an achievable goal given the many demands on limited resources. The alternative has been limited to VIP's. However, these are not without their shortcomings including health and safety, environmental and operational issues. In 2009 the WRC commissioned a project to develop and test a prototype for pour-flush sanitation in South Africa. This was done successfully and 20 units have now been in operation for between 7 and 22 months. Funding was received from Irish Aid to demonstrate, on the strength of lessons learned, a large scale pour-flush sanitation pilot and to share the experiences from this pilot with appropriate audiences. Thus the objective of this study is to implement 275 pour-flush units in a rural community.

Estimated cost:	R1 475 175
Expected term:	2012 - 2013

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Industrial brine minimization: determining the physical chemical parameters that affect evaporation rates on multi-component hypersaline effluents
University of the Western Cape
No. 2100

Brines are a major waste by-product from industrial activities. This study aims to understand and provide solutions for the efficient minimisation of industrial brines. The study will evaluate evaporation rates and design and assemble climate-controlled enclosures for the study of evaporation processes of brines. The data will result in the development of protocols for the measurement of evaporation rates from brines which will lead to the development of empirical models for determining evaporation processes of industrial brines under controlled laboratory conditions and the development of theoretical models for determining evaporation rates of brines. Finally, it is envisaged that this understanding will result in the development of novel textured surfaces and absorbents for enhanced evaporation of industrial brines.

Estimated cost:	R1 500 000
Expected term:	2011 - 2014

Evaluation of forward osmosis technology for the treatment of concentrated brines
University of KwaZulu-Natal (Durban)
No. 2101

Forward osmosis is a new technology for industry in South Africa and this scoping project is to assess the applicability for further application of concentrated inorganic brines. The study will aim to evaluate whether forward osmosis can be used as a lower energy consuming technology compared to reverse osmosis. It will evaluate the advantages, limitations and feasibility of using forward osmosis technology to concentrate various high ionic strength wastewaters and to assess the fouling characteristics of forward osmosis on various high ionic strength industrial streams which are known to be badly fouling.

Estimated cost:	R354 000
Expected term:	2011 – 2014

Application of mineral carbonation processes for brine remediation
University of the Western Cape
No. 2128

Currently the typical method of brine disposal is the use of evaporation ponds, which is aimed at reducing the volume of the brine and providing a manageable solid product. Unfortunately, this approach does not stabilize the brine and the cost of long-term storage is still very expensive. Fly ash is another waste material that is being produced in huge amounts by coal-fired power plants. Eskom for instance produces 36.7 Mt of fly ash per annum. The majority of this ash is disposed of in ash dumps while only 5% is applied in the making of building and construction materials. This fly ash presents a major resource that can be utilized in the carbonation of brine, thereby leading to the formation of carbonates which are benign and can be applied as mine backfill. This project proposes to utilize fly ash through mineral carbonation to remediate the effluent brine, which would lead to potable water that can be reused in the power generation process as well as domestic and agricultural purposes. Moreover, this will also lead to reduction of the carbon emissions from power plants.

Estimated cost:	R1 362 750
Expected term:	2012 - 2015

Programme 3: Quantification, prediction and minimisation of water use and waste production

Water management efficiency: The development and testing of an optimisation model at selected Eskom sites for an integrated water solution
University of Pretoria
No. 2289

Pinch analysis is a process integration tool, which was first developed for the design of heat recovery systems during the late 1970s. This work formed the basis for the design of water-using systems, with a design objective of minimising water consumption by maximising the reuse of water, using a graphical technique which was termed Water Pinch Analysis. Water Pinch Analysis thus involves a set of systematic formal techniques to handle the complex problem of hierarchical water allocation to a system consisting of a number of processes, and choosing the best combination of strategies. The WRC has funded several projects (1241/1/06; 1158/1/05; 851/1/01) in the past to test the applicability of the technique for water management in both the industrial and water resource fields. The industry-based studies investigated the applicability for three large water users to varying degrees of success and were valuable in gaining insights into its application, limitations and theory. Water Pinch Analysis exposed the water sector to a new technique and developed new capacity in the research domain. These studies also showed that pinch analysis could be used as a neutral tool to set targets and to indicate their environmental performance to the public and authorities. Thus, this study aims to build on the knowledge gained and to develop, test and apply an optimization model for cooling water systems at selected Eskom sites. This project also aims to build capacity for optimization models for water management efficiency.

Estimated cost:	R1 500 000
Expected term:	2013 - 2016

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Adapting constructed wetlands for real-world applications
Cape Peninsula University of Technology
No. 2104

This project builds on previous research and will use the new fingerprinting techniques that have been developed and customised to define the parameters which will allow the effective use of constructed wetlands to treat wastewaters using natural processes. It will also investigate the reproducibility of constructed wetlands adapted for specific waste-containing waters in varied environments by characterising the microbial communities in these environments, and to understand the extent to which microbial communities in constructed wetlands can accommodate changes in waste impacts and the rates at which they can adapt. Finally it will develop a matrix of

parameters and thus guidelines to use to adapt wetlands.

Estimated cost: R1 100 000
Expected term: 2011 - 2015

Integrated photo-catalytic and anaerobic treatment of industrial wastewater for biogas production
Vaal University of Technology
No. 2105

This project aims to test, at a laboratory scale, the use of zeolite as a support material to improve biogas production and anaerobic reactor stability. In addition, the study will concentrate on synthetic industrial effluents and use a photocatalyst (titanium dioxide) to break down these complex chemicals to simpler ones and evaluate the anaerobic reactor efficiency. Knowledge from these tests can be used in future to improve anaerobic digestion efficiencies by allowing microorganisms to come into contact with simpler compounds and prevent washout of the sensitive methanogenic bacteria.

Estimated cost: R500 000
Expected term: 2011 - 2013

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Toxicity evaluation of metals and metal oxides nanoparticles to aquatic invertebrates and algal species
CSIR
No. 2107

Since the beginning of the 1990s, nanotechnology has matured from a laboratory-based research and development phase into full commercialisation of nanoproducts. For example, there are numerous novel consumer products and industrial applications of nanotechnology including: nanoelectronics, molecular assemblies, tissue engineering, biomedicine, nanocomposites, cosmetics, paints, pesticides and water purification modules. Among the nanomaterials, used in the nanoproducts reported above, with high potential of release in large quantities into aquatic environments are metals and metal oxides. In view of the rapidly increasing quantities of nanomaterials released into different environmental compartments – especially water and sediments – it is imperative that the potential risks that may be associated with nanomaterials attract attention, to ensure long-term safe, responsible, and sustainable

development of this novel technology for optimal benefit of society. Due to the limited data, on potential risks of nanomaterials to aquatic organisms, which could support practical risk assessment and risk management after entry into the environment, this project will investigate the effects of nanomaterials on organisms at different trophic levels. Secondly, the mechanism by which nanomaterials cause toxic effects to the receptor organisms will be explored through use of DNA, reactive oxygen species (ROS) generation techniques.

Estimated cost:	R495 000
Expected term:	2011 - 2014

Programme 2: Regulatory, management and institutional arrangements

Development of risk criteria for water management aspects of mine closure
Golder Associates Africa
No. 2127

The DWA recently produced a series of Best Practice Guidelines that give specific guidance on procedures to be adopted in the development of mine closure plans (BPG G5) and in the prediction of future impacts that are associated with mine closure (BPG G4). While the BPGs provide clear methodologies for undertaking the assessments required to support a mine closure application, they do not provide any practical guidance on how issues such as: agreement on the acceptable levels of confidence for the prediction that will limit the State's liability to acceptable levels; statistical representivity of the datasets used in the prediction and their suitability for addressing the issues that pertain to the particular closure application; the definition and descriptions of uncertainty inherent in the predictions and acceptance that the defined uncertainty meets the requirements of the regulator; and the suitability and adequacy of financial provisions to cater for uncertainties and risks for post-closure water management and treatment. This project will address the above issues through review of international best practice on these topics and engagement with all stakeholders (DWA, DEA, DMR, mining industry and consultants) in order to provide guidance on how to address these issues when considering impact predictions and mine closure applications.

Estimated cost:	R535 000
Expected term:	2012 - 2014

Programme 3: Minimising waste production

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation
University of Cape Town
No. 2108

The main aim of this research is to further the understanding of the precipitation of metal sulphides in the treatment of acid mine drainage via sulphate reduction and metal precipitation. The project will characterise the effect of operating conditions on the physical characteristics of the formed metal sulphide precipitate by investigating the effect of metal to sulphide ratio on precipitation behaviour, the effect of the operating pH on the precipitation process and using a technique based on moment transformations of the number density function n(L) to make inferences about the mechanisms involved in the particle formation processes. The project will also investigate the factors affecting the solid-liquid separation characteristics of the formed particles. The effects of the processing conditions on solid-liquid separation characteristics of the formed precipitates will be quantified using particle size distribution measurements, settling characteristics and zeta potential measurements for surface charge determination. These studies will be carried out on a number of model metal systems. Finally, the project will investigate factors that potentially influence the solid-liquid separation characteristics of the formed particles. As a result of the investigations carried out, it should be possible to identify a number of factors, possibly different additives, which would influence the separation characteristics of the formed precipitates. Thus the effect of these ions (as well as other additives) on the coagulation and aggregation phenomenon will be quantified by measuring their effect on particle size distribution, surface charge and settling characteristics of the precipitate.

Estimated cost:	R884 820
Expected term:	2011 - 2014

Development of a toolkit to enable quantitative microbial ecology studies of sulphate-reducing and sulphide-oxidising systems
University of Cape Town
No. 2109

The catastrophic effects of untreated mine-water discharges are well known and several high profile events have been documented. Mine-water has traditionally been treated using oxidation-neutralisation-precipitation which effectively removes metal, but the treated stream still contains sulphate. Biological treatment systems, based on the activity of sulphate-reducing bacteria have received considerable attention. Their widespread application has been constrained by the provision of a carbon source/electron donor and the management of the sulphide-containing effluent. Both these issues are addressed in the Integrated Passive Treatment System (IMPI) technology which makes use of a mixture of complex, lignocellulosic carbon sources and incorporates a sulphide oxidation step. Both the sulphide oxidation and sulphate reduction processes are catalysed by a consortium of different microorganisms. Different components of the consortium have different tolerances to sulphate, sulphide and heavy metals. As a consequence, changes in feedstock can lead to major changes in the microbial community. This may have catastrophic effects on system performance. Until recently these changes were poorly understood and system management was based on empirical rules of thumb. The advent of molecular biology techniques has facilitated qualitative microbial ecology studies. While these have been useful in confirming the presence or absence of species or groups of species they provide limited information on dynamic changes in population structure, which could be extremely useful

in predicting the response of a system to specific perturbations. This project will develop a molecular toolkit for performing quantitative microbial ecology work in sulphate-reducing and sulphide-oxidising systems. The toolkit will initially be used to characterise the microbial populations in the IMPI demonstration plant at Middleburg Mine. This technology has the potential to treat mine-water effectively and economically over a sustained period of time.

Estimated cost:	R487 500
Expected term:	2011 - 2013

Addressing the challenges facing biological sulphate reduction as a strategy for AMD treatment through analysis of the reactor stage: raw materials, products and process kinetics
University of Cape Town
No. 2110

Mine-waters generated during active mining or resulting from groundwater rebound at abandoned sites have major environmental and economic implications. Active chemical treatment of the waters is the most widely employed technology. Recently there has been increasing interest in active and passive biological treatment processes. These systems rely on naturally-occurring biological and geochemical processes to improve water quality with minimal operational and maintenance requirements. Biological sulphate reduction is a well understood and efficient process that has been frequently demonstrated at laboratory and pilot scale. However, its full-scale implementation has been limited. The challenges facing sulphate reduction systems have been identified as: provision of a cost-effective carbon source; enhancing reaction kinetics when complex carbon sources are used; and management of the resulting sulphide. This study will undertake a critical review of existing technologies, from a technological and economic perspective. Furthermore the feasibility of using microalgal biomass as a carbon source/electron donor will be investigated. The study will also evaluate the requirements for algal cultivation at the scale required to sustain the SRB process. To address the issue of enhanced reaction kinetics the effect of decoupling the hydrolysis and acidogenesis reactions from the sulphate reduction will be investigated. The study will include a review of available technologies and investigate the application of cross-flow microfiltration membranes to recover and recycle biomass to both the hydrolysis/acidogensis and sulphate reduction reactors.

Estimated cost:	R1 050 000
Expected term:	2011 - 2014

Treatment of mine water using a combination of coal fly ash and flocculants in a jetloop reactor system
University of the Western Cape
No. 2129

The generation of contaminated high-sulphate mine-water and waste coal fly ash are undesired by-products in coal mining and coal-fired power stations, respectively. Mine-water is contaminated by contact with oxygen and pyrite-

bearing rock, or leaches from mine tailings due to infiltrating rain. Mine-water produced in coal mines could be acidic, neutral or alkaline depending on the geology of the mines. Acidic mine-water, often termed acid mine drainage (AMD) is produced when rock that contains more acid-producing minerals than acid-neutralizing minerals was disturbed during mining. Prior work has been done on the fly ash neutralization process and stability of solid residues formed during neutralization, as is recorded under the 'general information' section. This study will optimize the jetloop reactor system which will make this system using fly ash for remediation viable in an industrial environment, and thus a serious contender for low cost mine-water treatment and recovery.

Estimated cost: R1 033 000
Expected term: 2012 - 2015

A detailed acid-base accounting study of the Karoo formations in the Waterberg coalfield
University of the Free State (Institute for Groundwater Studies)
No. 2142

Coal mining has a pronounced impact on surface and groundwater quality and quantity. Local experience indicates that the influx of water may be as low as 1% of rainfall for deep bord and pillar mines with no subsidence, to as much as 20% for some opencast mines. Such differences have significant impacts on the quantity and quality of surface and groundwater resources in a local area and further afield. The Waterberg is the only remaining large area with proven coal reserves in South Africa and they are being targeted for large-scale mining in the foreseeable future. Most of this will be opencast mining, resulting in large volumes of spoils and also discards (due to the fact that a number of coal seams will be mined with approximately 50 m of interburden between the coal layers) being handled on surface. This project will provide detailed in-depth acid-base potential studies in the area in order to determine how spoils should be handled in future by the mining companies, due to the complexity and volume of the spoils and discards. If handled correctly, acid generation can be minimized. This study will consolidate the existing information, and obtain new information regarding the possibility of acid generation of the overburden, interburden and discards.

Estimated cost: R1 775 000
Expected term: 2012 - 2014

NEW PROJECTS

THRUST 1: WATER SERVICES – INSTITUTIONAL AND MANAGEMENT ISSUES

Programme 1: Cost-recovery in water services

Development of innovative institutional management scenarios for water services in rural areas
PDG
No. 2209

Rural water supply challenges continue to prevent South Africa from achieving basic service provision to all. While many of the challenges are technical (topography, geography, technology), the dominant obstacle to successful rural water service delivery is finding an institutional model(s) that complements local government as Water Services Authorities and can (i) overcome these technical challenges, (ii) manage scarce resources in an efficient manner, and (iii) provide a continuous and sustainable service. This project seeks to review the available institutional management options for rural water services, as well as introduce possible alternative and innovative management solutions. While many of these models have been debated and assessed before, there has been limited success with these models in South Africa. The study also seeks to go beyond regulatory and technical aspects, and cover a spectrum of socio-political dynamics, economics, and culture, as well as investigate a wider range of potential institutional partners (Water User Associations, mines, etc.). This is particularly relevant given that the DWA Institutional Reform and Re-Alignment process has highlighted the institutional gap around the management of local water resources.

Estimated cost:	R1 620 113
Expected term:	2013 - 2015

Programme 2: Institutional and management issues – Water services

Development of a framework for sanitation governance in South Africa
Hlathi Development Services
No. 2206

South Africa is fast becoming the world's capital of service delivery protests. Municipal IQ, a local government data and intelligence service institution, recorded 372 service delivery protests between January 2012 and the end of May 2012. Poor sanitation service delivery featured strongly in most of these service delivery protests. Several studies have identified poor governance as the underlying cause of poor basic service delivery. A report on the civil society perspective of local governance in South Africa recommended that the problem of poor governance should be addressed by a combination of institutional, political and community-focused interventions. A COGTA report

of 2009 identified weak national regulations and provincial oversight of service delivery as a problem. The Local Government Turnaround Strategy which was launched in 2009 has so far not made any visible improvements in the performance of local government as shown by the increase in the number of service delivery protests. The 2012 SA Medium Term Review of the priorities of Government identified poor governance of municipal service delivery as a major concern. The participatory local governance envisaged in the Constitution of SA and local government legislation was non-existent; communities were disconnected from decision making processes. They have been disempowered and turned into passive spectators of their development which is driven by external consultants. Good sanitation governance depends on effective engagement between government, institutions and stakeholders, transparency and accountability within the rules of engagement. The main goal of the proposed study is to develop a framework for effective sanitation governance in South Africa. It will provide government with a tool for facilitating the implementation of good sanitation governance in all spheres of government while also ensuring accountability to citizens through the building of appropriate stakeholder platforms for facilitation of partnerships for sustainable sanitation service delivery that involve municipal councils, communities and civil society organizations. The study will investigate sanitation governance at national, provincial and local government levels. An in-depth analysis of selected case study municipalities that demonstrate elements of good governance will be conducted to document good practice which will inform the development of a framework for sanitation governance in South Africa.

Estimated cost:	R700 000
Expected term:	2013 - 2015

An investigation into the social, institutional and economic implications of reusing reclaimed wastewater for domestic application in South Africa
Cape Peninsula University of Technology
No. 2208

This study is situated in the context of the social and environmental problems South Africa will be facing over the next five years. With the effects of climate change and depletion of the current water resources, alternative water supply such as reuse is becoming common. Experience at Windhoek demonstrates that a direct wastewater reclamation system can be a practical, responsible way of augmenting potable water supplies in arid regions, but requires comprehensive planning, training and ongoing commitment for its continued success. National and local policies should support reuse of wastewater, taking the constraints of the region as well as the potential threats of wastewater reuse into consideration. Active participation through educational programmes is needed to encourage planners and engineers to design systems that cater for reuse or that can at any time be changed to a reuse scheme. Despite people's acknowledgement of the water scarcity of their countries, it is found that the general public in most communities has little knowledge of its water and wastewater treatment and distribution systems. To gain public acceptance of direct reuse of reclaimed wastewater, experts (including engineers, scientists and physicians) should agree that reclaimed wastewater is safe to use from a public health standpoint. In addition to this, the list of promoting factors such as water shortage, gradual introduction of water reuse, and agreement amongst experts

should be brought forward. Current literature, with the exception of work on Australia, seems to be almost silent on community awareness and/or engagement on the issue of using wastewater for reclamation. This need to engage communities is a principle enshrined within the South African Constitution and is reiterated in the water service regulation strategy, which emphasises the need for a citizens' voice. The lack of understanding or underestimation of this need cannot be more vividly illustrated than by the numerous service delivery protests riddling South Africa, stemming from community experiences and perceptions of unsatisfactory, inefficient service delivery, with drinking water quality being no exception. The results of this project will assist the government and its various services with an understanding of the implications of using treating wastewater effluent for drinking and its consequences from social, economic and institutional perspectives.

Estimated cost:	R1 180 000
Expected term:	2013 - 2016

An investigation into the barriers to implementation of effective wastewater charges by municipalities in South Africa
Prime Africa Consultants (previously CIC International)
No. 2210

There is a lack of understanding, at a municipal level, of the core principles underlying the setting of wastewater treatment charges (some municipalities also refer to these charges in their bylaws as sanitation tariffs). Wastewater treatment charge structures currently used by many municipalities are outdated and are, with a few exceptions, minimally related to the realities on the ground. Green Drop results over the past few years have shown that most municipalities treat water ineffectively, and anecdotal evidence lays some of the blame for this state of affairs at the insufficient budgets available for water treatment. Although many other problems hamper effective wastewater treatment, including an absence of ring-fencing of income from wastewater rates, the most basic point of departure for a sustainable wastewater treatment sector, is to get the price right, i.e., the wastewater charge. The wastewater charge is not only informed by the costs of wastewater treatment. Municipalities are also aware that excessive municipal rates may serve as disincentives to investment. Thus arises an interesting competitive phenomenon between municipalities (especially metros). Much excellent work has been conducted in South Africa on informing water-related tariffs, yet, in spite of this, municipalities still seem to face barriers in implementing these tariffs. This is to the detriment of an effective wastewater treatment sector in South Africa. The aims of this research are to investigate these barriers, to recommend corrective actions, and to raise awareness among municipalities around the development and implementation of effective wastewater treatment tariffs.

Estimated cost:	R600 000
Expected term:	2013 - 2016

Monitoring, management and communication of water quality and public acceptance in the direct reclamation of municipal wastewater for drinking purposes
Chris Swartz Water Utilisation Engineers
No. 2212

There has been a lot of interest recently in direct water reclamation (direct potable reuse). Being an arid region, southern Africa faces serious challenges with availability of conventional water sources. The shortage of available water in the region is leading to large-scale interest in, and application of, water reclamation and reuse of wastewater as alternative water supply sources to sustain development and economic growth in the region. Water reclamation plants have been constructed and are in operation in Beaufort West (direct potable reuse), George (indirect potable reuse) and Mossel Bay (reuse for industrial purposes), while direct potable reuse in Durban (eThekwini Municipality) and Hermanus are at an advanced planning stage. Water reclamation and reuse has been studied in the region since the 1960s, which led to the first direct water reclamation plant being built in Windhoek, Namibia. Ongoing research and development at the Windhoek plant has led to this plant currently being internationally considered as an effective multi-barrier treatment system from a health perspective. However, no guidelines exist locally for water supply authorities (municipalities) currently managing or planning for direct potable reuse (DPR) projects, in terms of what the specific health-based targets are, what to monitor for (microbiological, chemical, organic micropollutants, EDCs and chemicals of emerging concern (CECs)), and how to undertake the process of ensuring public (social) acceptance. While considerable work has been done overseas on providing a (regulatory) framework for DPR projects, which includes monitoring requirements and guidelines for ensuring wide public acceptance, very little has been done locally. The main concerns are health risks associated with the consumption of direct reclaimed wastewater. The main outcome of this project will be the development of a framework for direct potable reuse in southern Africa, consisting of public acceptance, health-based monitoring programmes (for compliance and operational barriers, including engineered buffers), funding sources and regulatory approval. The main impacts of implementation of the potable water reuse framework will be: improved sustainability of supplementary and alternative drinking water supply to towns and cities in Southern Africa to alleviate water scarcity; to empower communities to take part in the decision-making processes; to improve health; and to stimulate economic development.

Estimated cost:	R547 400
Expected term:	2013 - 2015

Adaptive climate change technologies and approaches for local governments: water sector response
Development Bank of Southern Africa; Department of Environmental Affairs and Tourism; SALGA; Department of Cooperative Governance and Traditional Affairs; University of Cape Town; CSIR; University of Pretoria; Hydrosoft Institute; Department of Water Affairs
No. 2283

Project aims:

- To develop a water sector guide of the most relevant adaptation technologies and approaches to climate change over the short-, medium- and long-term for local governments in South Africa
- Identify which local municipalities will need to consider adaptation technologies and approaches to climate change
- Develop a set of criteria to classify adaptive technologies and approaches
- Identify which water distribution and wastewater options are appropriate as adaptive technologies or approaches to climate change at a local government, community and household level
- Map these technologies for near-, medium- and long-term planning and preparation for climate change for the different types of local municipalities (rural, urban and metros)
- Ascertain the institutional and capacity requirements of local government to roll out a climate change adaptation strategy
- Define the practical implementation steps and planning horizons that will be required
- Provide a comprehensive review and way forward for current research (inclusive of all WRC studies) that could provide future solutions for the gaps in the sector, and to meet climate-change projected needs

Estimated cost: R1 500 000
Expected term: 2013 - 2016

THRUST 2: WATER SUPPLY AND TREATMENT TECHNOLOGY

Programme 3: Drinking water quality

Water safety and security: emergency response plans
Emanti Management
No. 2213

Protecting public health is the primary goal of community drinking water systems, and having an up-to-date and workable ERP helps achieve this goal in any crisis situation. The ERP must include plans, procedures, and identification of equipment that can be implemented or utilized in the event of an intentional attack on the CWS or in the event of a natural disaster. The ERP must also include actions, procedures, and identification of equipment which can obviate or significantly lessen the impact of attacks or disasters on the public health and the safety and supply of drinking water provided to communities and individuals. The purpose of this project is to provide guidance on developing or revising Emergency Response Plans (ERPs) for small- and medium-sized community drinking water systems. An ERP is a documented plan that describes the actions that a Community Water System (CWS) would take in response to various major events. A major event refers to: (i) credible threats, indications of terrorism, or acts of terrorism; (ii) major disasters or emergencies such as hurricanes, tornadoes, storms, earthquakes, fires, flood, or explosion regardless

of cause; and (iii) catastrophic incidents that leave extraordinary levels of mass casualties, damage, and disruption severely affecting the population, infrastructure, environment, economy, and government functions. Community Water System characteristics vary greatly, so CWSs should be able to apply the information contained in this document to meet their particular needs and circumstances. The output of the project, i.e., the guidance document, should be able to be used as a flexible template.

Estimated cost: R1 500 000
Expected term: 2013 - 2015

An assessment of incentivising community engagement in drinking water supply monitoring
University of Cape Town
No. 2214

One of the key challenges we have identified in previous research projects is that reporting of faults in water supplies from rural communities is limited or non-existent. There are many reasons for this, from a simple 'not knowing who to contact', to complex social relationships within rural communities that result in citizens wanting to avoid blaming or pointing out non-performance of government or municipal officials (particularly relevant in smaller communities where everyone knows everyone else). Information communication technologies (ICTs), such as mobile phones, have over the past 10 years been used to mobilise communities, increase public activism, and allow and encourage anonymous reporting. Whilst this has been met with great enthusiasm as a possible method to increase public awareness and government accountability, there have been equally many examples of failed uses or projects with unintended consequences. ICT applications have also seen an increase of use in the WASH sector, but experiences from the health sector (which has been using these technologies for significantly longer) have shown that, whilst projects are often successful when run within the context of an organisation with trained staff or volunteers using the tools, the perception that the general public will similarly embrace and use mobile tools to report problems or to collect information is generally incorrect, and projects in this context have been shown to fail or to be unsustainable. Anecdotal evidence suggests that the communities will only engage if there is a direct benefit to them, despite the tools and data submission being free. Some ICT projects have therefore started incentivizing reporting by communities. The incentives offered vary from airtime, to stipend, to winning a prize and so on. However, the reasons for success are unclear and currently there is no formal research on this topic; much of the evidence is anecdotal and based on best guesses. There are some direct incentives to reporting a problem, such as the report directly leading to the fault being resolved, but it is uncertain if even this is enough to adequately ensure the long-term success of a project. In order to assess if and in what ways rural communities would use such tools, and what the appropriate incentives for the usage would be, this research project proposes not only to assess the use of cellphones but to investigate the use of incentives in the reporting of water supply faults.

Estimated cost: R1 170 000
Expected term: 2013 - 2016

Detection and quantification of emerging organic pollutants in Durban waterways, and remediation options integrating nanostructured materials and advanced oxidation processes
University of KwaZulu-Natal (Westville Campus)
No. 2215

Anthropogenic organic compounds or problem organics are emerging contaminants of concern because their environmental significance is not fully understood. They have been detected in water systems in many parts of the world but there is limited information regarding their characterization and quantification in the Durban water ways; yet they are associated with population and practices in specific locations. Previous studies carried out on South African water systems have focused on heavy metals, biological contamination and, to some extent, priority organic pollutants, such as PCBs. Research carried out specifically on Durban and KwaZulu-Natal's water systems is mostly limited to heavy metals and pathogenic pollutants rather than chemical contaminants, and any research that was carried out is now outdated having been done more than 25 years ago; thus it needs updating with new contaminants. Prior work in other parts of the world has shown that such compounds are usually in the nanogram/L range, are continuously discharged into the environment, and not only pose a threat to the environment, and human population centres, but also require new and sensitive techniques for their detection. The current water regulatory monitoring does not emphasize monitoring of these micro-organics, probably because knowledge about their existence in local waterways is limited and their detection requires new and sensitive methods of quantification. The coexistence of chemicals with various chemistries in water bodies also poses a challenge as it requires development of multi-residue detection techniques, one of the challenges that this research will address. This project will determine the presence of emerging organic contaminants in Durban waterways. It will investigate those organic contaminants that are not routinely monitored but may have ecotoxicological effects, as well as those persistent organics whose presence and effects are being re-evaluated. The work will include a crucial screening analysis that will provide a fundamental baseline in terms of class of compounds, local variations and risk factors associated with the various emerging pollutants. In addition, the project team will focus on three major classes of emerging pollutants; specifically, pharmaceutical products and drugs of abuse, pesticides, and personal care products.

Estimated cost:	R750 000
Expected term:	2013 - 2017

Extending EDC Toolbox I to include thyroid and androgenic bioassays
University of Pretoria; Griffith University
No. 2303

Project aims:
- To participate in the Global Water Research Coalition EDC Toolbox
- Inter-laboratory study to establish the suitability and application of the thyroid and androgenic bioassays for the detection of EDC activity in water samples

Estimated cost: R430 000
Expected term: 2014 - 2016

A national water R&D and innovation roadmap for South Africa
Mutualfruit Limited
No. 2305

Project aims:

- Identify the completeness of the inputs required for Roadmap development
- Baseline South Africa's Water RDI landscape
- Select a set of attractive and addressable market opportunities.
- Establish HCD requirements
- Define scope and principles for implementation framework
- Define RDI response (policy, financial, institutional) for attractive and addressable market opportunities
- Shape outline for HCD programme
- Design an implementation mechanism to ensure successful delivery of the plans

Estimated cost: R1 898 300
Expected term: 2013 - 2014

THRUST 3: SUSTAINABLE MUNICIPAL WASTEWATER AND SANITATION

Programme 1: Emerging treatment technologies – Preparing for the future

Integrating agriculture in designing low-cost sanitation technologies in social housing schemes: a case study of Kwadinabakubo, eThekwini Municipality
University of KwaZulu-Natal (Pietermaritzburg)
No. 2220

The disposal of effluent generated from low-cost sanitation technologies such as the decentralized wastewater treatment systems (DEWATS) still poses challenges to the environment. Such effluent has been shown to contain high concentrations of essential nutrients necessary for crop production. WRC Project K5/2002 demonstrated the capacity of different soils to retain these nutrients from the effluent. Integrating agriculture in the planning and design of low-cost sanitation technologies could provide safe and sustainable mechanisms for disposing of such effluent by retaining

the nutrients for crop production and releasing water into hydrological systems. There is no information or any guidelines that could inform town planners and policy makers in designing new social housing developments that can integrate agriculture in the design of low-cost sanitation technologies. This project aims to build on previous work by the Soil Science department at UKZN to generate information on recycling of nutrients from DEWATS technology, which will inform policy makers and town planners in the design of new social housing developments that integrate agriculture.

Estimated cost: R1 880 000
Expected term: 2013 - 2016

Programme 2: Application of appropriate technologies and tools

Development of web-enabled (and supportive spreadsheet-based) wastewater risk abatement planning tools
Emanti Management
No. 2217

With the release of DWA Green Drop Certification 2012 requirements, it is clear that DWA is moving towards a risk-assessment based regulatory approach, and that the Wastewater Risk Abatement Plan (commonly referred to as W2RAP, and very similar to the water safety planning approach used for drinking-water quality risk assessments) is the primary tool with which it will assess and monitor the performance of wastewater services at Water Services Authorities (WSAs). The W2RAP process assists WSAs by (i) evaluating and documenting wastewater processes and (ii) prioritising wastewater services risks and therefore providing targeted support to address gaps and weaknesses. The project aims to use the principles and approach outlined in the WRC-developed W2RAP guideline document to produce the following outputs:

- Wastewater Risk Abatement Plan Tool (web-based and supportive spreadsheet-based tools, and allows development and tracking of a W2RAP)
- Wastewater Risk Abatement Planning Status Checklist Tool (web-based and supportive spreadsheet-based tools, and allows the user to determine status of W2RAP processes)

Estimated cost: R511 600
Expected term: 2013 - 2014

Nutrient and energy recovery from sewage: demo-researching an integrated approach
University of Cape Town
No. 2218

Humans produce a significant amount of sewage, containing large quantities of nutrients (phosphates, nitrates and micro-nutrients). For example, humans typically excrete 1.6 to 1.7 g phosphorus per day, most of which (approximately 60%) is found in urine. Considering that natural phosphorus reserves are on the decline and are expected to be depleted by 2033, the use of sewage waste has the potential to be a major source of new phosphorus. An alternative technology that utilises seeded electrochemical precipitation (SEP) has the potential to increase the yield and process efficiency of struvite recovery. The use of SEP has been investigated for the removal of calcium carbonate by Hasson and co-workers. This technique has not yet been applied to struvite precipitation, thus providing the opportunity for a novel nutrient-recovery technique. The first aim will be to investigate current nutrient- and energy-recovery technologies based on a systems approach to technology sustainability assessment, which will focus specifically on situation analysis and technology review, in which the analysis of nutrient flows, expected nutrient supply limitations and emerging organic food production will be examined. The second aim will be achieved by investigating the use of seeded electrochemical precipitation as a means to produce struvite crystals of a similar or better quality and size when compared to conventional precipitation techniques.

Estimated cost:	R1 400 000
Expected term:	2013 - 2016

WWTP modelling to support the Green Drop programme
University of KwaZulu-Natal (Howard College Campus)
No. 2221

Simulation of wastewater treatment processes is a rapidly developing technology, increasingly used to achieve better designs of new plants and improved operation of existing ones. The use of modelling offers the possibility of supplementing this relativistic approach by providing performance criteria which have an absolute basis. Furthermore, process models reflect a deeper understanding of the process than is needed for routine operation and compliance monitoring, and the discipline of constructing a model almost always reveals aspects of the process which were not previously understood. Both eThekwini Water and Sanitation (EWS) and Umgeni Water experience considerable difficulties at some of their WWTPs arising from the presence of significant loads of industrial effluents, and there are frequently questions as to whether poor treated water quality is due to industrial components in the wastewater or to deficiencies in the treatment processes. A series of WRC projects has led to the development of steady-state and dynamic WWTP models at UCT and, more recently, with the collaboration of UKZN. However, these models have up to now been based on data from laboratory equipment, and have not yet been applied to full-scale plants. Thus this project aims to:

- To set up and evaluate wastewater treatment plant models for a number of representative WWTPs in the eThekwini/uMsunduzi region
- To use the models to monitor plant performance over extended periods
- To establish norms of expected WWTP performance, based on its configuration and the characteristics of the incoming wastewater

• To establish methodologies for identifying critical barriers to improved performance

Estimated cost: R700 000
Expected term: 2013 - 2016

Best practice in wastewater treatment in small to medium sized municipalities in South Africa – roadmaps to Green Drop excellence
Sarah Slabbert and Associates; Water Group Holdings (Pty) Ltd
No. 2304

Traditionally, 50% of municipalities used pond systems. Equating excellence in wastewater management with an activated sludge system was one of the unintended consequences of the Green Drop regulation. As a result, municipalities that previously had pond systems, invested in an activated sludge system and decommissioned their pond systems. In many instances, especially with influent volumes of less than 1 ML per day, the result is 'overkill', which is unnecessary, expensive and requires skills that many of these municipalities do not have. If the correct design principles are followed, ponds are still a relevant technology for small wastewater volumes, as are sequencing batch reactor (SBR) and rotating biological contactor (RBC) systems. The focus of this project will be on key aspects such as: ponds as technology of choice, appropriate design, the importance of desludging and the ability of the plant to meet different effluent compliance standards.

Estimated cost: R500 000
Expected term: 2013 - 2014

Programme 3: Stormwater and sewerage systems

Pressure drop prediction for efficient sludge pipeline design
Cape Peninsula University of Technology
No. 2216

There is still no widely accepted design correlation of sludge viscous properties as a function of solids content, causing frustration to design engineers, who, in the absence of obtaining costly rheological data, have to make estimates which could compromise efficient design of pump and pipe systems. During wastewater treatment operations the objective is to remove solids such as grit and naturally floating materials, and the remaining solids are called sludge. The sludge needs then to be dewatered to be efficiently transported by pumping through pipelines. Measurement of the sludge rheology in-line and real-time has been attempted by many with varied success. A patented system using ultrasound has been developed using velocity profiling and pressure drop measurements to achieve this. The addition of real-time, in-line viscometry measurements will reconcile the differences that exist between rotational and tube viscometry

which caused the delay in the development of a more widely-accepted model. With water becoming scarcer it will become important to pump sludges at higher concentrations which will necessitate a better understanding of the flow properties of such viscous non-Newtonian fluids (sludges). This project aims to:

- Expand the existing sludge database obtained from tube viscometer measurements to validate/improve the pressure drop–flow rate predictions developed and published previously
- To measure the pressure drop versus flow rate for the wastewater plants, in existing pipes as well as the concentration of the sludges to independently test the design protocol developed
- To test the application of the in-house developed UVP viscometer over a range of sludge concentrations

Estimated cost: R224 000
Expected term: 2013 - 2016

Programme 4: Wastewater sludge and faecal sludge management

Development of the Anaerobic Digestion and Pasteurisation Treatment (ADAPT) concept for the safe disposal and beneficiation of faecal sludge
Rhodes University
No. 2306

Project aims:
- Establish the functional components of an ADAPT unit (anaerobic digester and pasteuriser) at a sewage works to demonstrate the practicality of this system to treat faecal sludge and generate a pathogen-free effluent
- Understand the biological processes that take place in the anaerobic digester and how it affects the operation of the ADAPT unit
- Test the effectiveness of pasteurisation to generate a pathogen-free effluent suitable for use as a fertiliser for horticulture and crop plants

Estimated cost: R1 180 000
Expected term: 2013 - 2015

Towards integrated sanitation and organic waste management – improving faecal sludge management on municipal level by upgrading local wastewater treatment plant with value-added processes (example: Tlokwe Local Municipality)
North-West University (Potchefstroom)
No. 2307

The proposed study aims to apply some of the lessons from the iPit study and apply it to peri-urban settlements in Tklowe. In particular, the project teams intends to use anaerobic technology to treat faecal sludge with and without additional organic substrates and by upgrading the current digester at the local wastewater plant to treat faecal sludge – the current digester is being operated without a lid with no biogas harvesting. Laboratory-scale studies will also be conducted using faecal sludge as the main feedstock and the performance evaluated at different loading rates for process optimisation. The project team will draw upon previous experiences in the iPit project to optimise digester performance for faecal sludge (SRT – 20 h). The iPit toilet design will not be field tested in this study but could be at later stage should the proposed project be up-scaled. The Tlokwe Municipality is eager to improve the performance of the local wastewater treatment plant. Their outstanding achievements within the Green Drop assessment and long-standing collaboration with NWU prove their commitment to continuously advance technology and skills at their facilities. Therefore this project aims to implement a best-practice example at Tlokwe WWTP, making the treatment plant a valuable asset to the community: a resource source instead of a waste disposal plant. This will result in direct economic and environmental and health benefits. The plant's energy-efficiency will increase and methane emissions will be reduced, sources for water pollution contained and an additional renewable energy resource (biogas) will be utilized.

Estimated cost: R1 050 000
Expected term: 2013 - 2015

Programme 5: Sanitation technology and innovations

Energy generation using low-head hydro technologies
University of Pretoria
No. 2219

Energy is the lifeblood of worldwide economic and social development. When considering the current status of global energy shortages, the emphasis to reduce CO_2 emissions, development of alternative energy generation methods and growing energy consumption, it is clear that there is a need to change the way energy is created and used. Energy experts say South Africa has moderate hydroelectric potential, and that the establishment of small hydroelectric projects around the country could help provide a sustainable future energy supply. The US Department of Energy estimates that there are 6 000 to 8 000 potential sites in South Africa suitable for small hydro-utilisation below 100 megawatts, with the provinces of KwaZulu-Natal and the Eastern Cape offering the best prospects. This project therefore aims to:

- Review the feasibility of generating energy in low-head systems
- Develop guidelines to identify locations where low-head hydropower generation systems can be installed
- Develop an assessment model including a cost–benefit tool

- Demonstrate the technology by means of pilot-plant installations, testing different turbine technologies
- Provision of educational material to illustrate and describe the process.

Estimated cost: R500 000
Expected term: 2013 - 2015

THRUST 4: SUSTAINABLE AND INTEGRATED INDUSTRIAL WATER MANAGEMENT

Programme 1: Emerging challenges and solutions for the 21st century

Integrated bioremediation and beneficiation of bio-based waste streams
Rhodes University
No. 2225

An integrated approach (ReBenFruWaste) for the remediation of fruit waste streams with high organic loadings with simultaneous beneficiation through the production of valuable products is proposed. The integrated approach will be evaluated on existing food waste streams, but could lay the foundation for the treatment and beneficiation of biorefinery waste streams when bioeconomies come to fruition. This project has four main aims:

- Analysis of existing food waste streams (fruit and olive mill waste streams) for sugar, lipid, phenolic and lignocellulosic content
- Bench-scale fermentations to evaluate (i) conversion of high sugar streams to ethanol (renewable fuel) and (ii) utilization of high streams with high lipid, phenolic and lignocellulosic content as feedstock for high-value enzyme production by *Aspergillus niger* strains
- Characterization of enzyme production and bench-scale demonstration of enzyme applications in different bioconversion processes, from lignocellulose conversion, treatment of resilient phenolic waste streams to the production of valuable fine chemicals, such as antioxidants
- Final cleaning of remaining waste streams through anaerobic digestion (can be combined with municipal waste treatment)

Estimated cost: R750 000
Expected term: 2013 - 2016

Programme 2: Integrated management

Effluent treatment: retrofitting of integrated algal pond system (IAPS) to existing conventional ponds as well as combination of industrial and domestic effluent treatment
JR Muller & Associates
No. 2227

The Algal Integrated Waste Pond System (AIWPS) for treatment of effluent was originally developed by Professor Oswald of the University of Berkeley, California. This technology was pioneered in South Africa by the Water Research Commission, when Oswald visited South Africa as their guest in 1994. The AIWPS technology is deemed to be appropriate for Southern African conditions, due to SA weather conditions (i.e., high levels of sunshine), simplicity of operation, low installation costs, low operational costs and ease of installation at source of effluent generation. The AIWPS system was adapted, and is locally known as the Integrated Algal Ponding System (IAPS). It is considered to be the ideal treatment system for rural areas and for small- to medium-sized local authorities. An opportunity has been identified at Reitz Municipality, where a conventional ponding system is presently in operation and a new abattoir has started operation. Thus, the pond capacity has to be vastly increased to accept the increased load and volume from the abattoir. The loads are complementary:

(i) town: high volume, low load (CDD); (ii) abattoir: low volume, high load. This combination of the two effluent streams represents the ideal transfer of technology of the IAPS-system, i.e., in the design of the Reitz system, the technology from TT191/01 and TT191/02 has been incorporated into the Oswald AIWPS-system design and provision has further been made for recirculation and changes to effluent flows to the individual ponds. The performance of the retrofitted and combined domestic/industrial IAPS-system is to be monitored over a two-year period to afford the bacteriological systems the opportunity to stabilise and adapt over two periods of seasonal climatic changes.

Estimated cost:	R1 150 000
Expected term:	2013 - 2016

Programme 3: Quantification, prediction and minimisation of water use and waste production

Using membrane distillation crystallization for the treatment of industrial wastewater
University of Cape Town
No. 2223

The sustainable treatment of acid mine drainage and industrial wastewaters is necessary if sustainable growth and responsible management of water is to be achieved in South Africa. Membrane distillation crystallization offers a sustainable wastewater treatment process because it can utilise excess heat from processes, and produce pure water

as well as salt(s) products, thus converting waste material into something of value. Membrane distillation crystallization is also an attractive wastewater treatment technique because it requires low operating temperatures (40-60°C); the hydrostatic pressure encountered in the process is lower than in reverse osmosis and less expensive material such as plastics can be used in the process. Another major advantage of MDC to the application of AMD is that the process is able to operate in very acidic or basic streams and thus the AMD streams would not need to be pre-treated or neutralized beforehand. This project therefore aims to investigate the applicability of MDC for the treatment of industrial wastewater, with a specific focus on the treatment of mine wastewater. The project also aims to contribute to the field by investigating concentration polarisation and its effect on the process, while at the same time developing better crystallizer control strategies. Ultimately, this project could offer a more energy-efficient and sustainable industrial wastewater treatment process that reduces wastewater production.

Estimated cost: R1 400 000
Expected term: 2013 - 2016

Revision of Natsurv 2: Water and Wastewater Management in the Metal Finishing Industry (Edition 2)
University of Stellenbosch
No. 2224

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However, South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 2: Water and Wastewater Management in the Metal Finishing Industry' and documents water and wastewater management within the metal-finishing industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Estimated cost: R700 000
Expected term: 2013 - 2015

Revision of Natsurv 4: Water and Wastewater Management in the Dairy Industry (Edition 2)
University of KwaZulu-Natal (PMB)
No. 2226

In the 1980s the Water Research Commission and Department of Water Affairs embarked on a series of national surveys for 16 industries. The Natsurv reports of the different industries have been well used by the sector. However,

South Africa and its industrial sectors have grown, or in some cases shrunk, considerably since the 1980s. Thus, the landscape has changed. New technologies and systems have been adopted by some of the industries and some of the information contained in the national surveys can be considered out of date. Through the UN CEO mandate, water stewardship discussions, water allocation and equity dialogues, we are also seeing a growing awareness around water use, water security and waste production. Thus, this is considered an opportune time to review the water and wastewater management practices of the different industrial sectors. This project reviews 'Natsurv 4: Water and Wastewater Management in the Dairy Industry' and documents water and wastewater management within the dairy industry as part of the first stage of revisions of the Natsurv Series 1 to 16.

Estimated cost: R700 000
Expected term: 2013 - 2015

Revision of Natsurv 1: Water and Wastewater Management in the Malt Brewing Industry (edition 2)
CSIR; Tshwane University of Technology
No. 2285

Project aims:
- Provide a general overview of the malt-brewing industry in South Africa, its changes since 1980 and its projected change
- Evaluate and document the generic industry processes
- Determine the water consumption and specific water intake
- Determine the wastewater generation and typical pollutant loads
- Determine local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14 000 (among others)
- Provide recommendations for best practice

Estimated cost: R700 000
Expected term: 2013 - 2015

Revision of Natsurv 3: Water and Wastewater Management in the Soft Drink Industry (edition 2)
Dube Ngeleza Wiechers Environmental Consultancy Pty (Ltd); University of KwaZulu-Natal (Howard College)
No. 2286

This project aims to obtain an overview of the soft drink sector within South Africa and changes since 1980s:

- To evaluate and document the generic industry process
- To determine the water consumption and specific water intake
- To determine wastewater generation and typical pollutant loads
- To determine the local electricity, water and effluent prices and by-laws within which these industries function
- Critically evaluate the water (inclusive of wastewater) management processes adopted and provide recommendations
- Evaluate the industry adoption of the following concepts: cleaner production, water pinch, energy pinch, life cycle assessments, water footprints, and ISO 14000 (among others)
- Provide recommendations for best practice

Estimated cost: R700 000
Expected term: 2013 -2015

Programme 5: Water efficiency, cleaner production, beneficiation and treatment of industrial effluents

Micro-nutrient requirements for anaerobic digestion of concentrated industrial effluents: Development of a speciation/precipitation model to optimise micro-nutrient dose for methane production from industrial waste streams
University of KwaZulu-Natal (Howard College Campus)
No. 2228

Anaerobic digestion of industrial effluents is used to convert organic material at concentrations that are too low for economic recovery to methane gas. Balanced anaerobic digestion requires inorganic micronutrients to proceed. In many industries, including hydrocarbon and certain chemical industries, effluent streams may contain a number of the micronutrients required for balanced growth, but there may be several micro- (and macro-) nutrients that are not present in the stream. To date, research in the field has been predominantly experimental and empirical; there are no studies which provide guidelines for predicting the micronutrient requirements for a particular application beyond the general micronutrient-to-COD ratios. Therefore, this study will test the hypothesis that a model describing the partitioning of micronutrients between soluble, precipitate and potentially bound and adsorbed phases can be used to determine the amount of the micronutrient available for anaerobic digestion, and can therefore be used to predict the microbial response to different micronutrient dosing strategies.

Estimated cost: R400 000
Expected term: 2013 - 2016

Phase 2: Recovery and beneficiation of nutrients and water from brewery effluent by means of unique combination of algal assimilation, constructed wetlands, hydroponics and aquaculture
University of Cape Town; Rhodes University
No. 2284

Project aims:

- Develop a better understanding of (i) the changes that take place in HRAP algal community structure at different times of year and/or at different flow rates, and (ii) the underlying mechanisms responsible for some of the results obtained in the HRAP during Project K5/2008, such as the mechanism/s responsible for majority of the ammonia and phosphate removal.
- Develop technology to convert brewery effluent grown algal biomass into fish biomass without mechanically harvesting the algae and allowing filter-feeding fish to bioconvert algal biomass into fish biomass

Estimated cost: R850000
Expected term: 2013 - 2016

THRUST 5: MINE WATER TREATMENT AND MANAGEMENT

Programme 1: Water use and waste production

Limiting and mitigating the impact of coal mines on wetlands
CSIR
No. 2230

By virtue of their positions in the landscape and relationship to drainage networks, wetlands are frequently impacted by coal-mining activities, especially opencast methods. These impacts will be ongoing, since coal is a strategic resource and will continue to be mined extensively to support the country's development. At the same time, however, regulatory authorities and the public now have an improved understanding of the range of economic, social, ecological and hydrological costs of wetland loss and degradation. The rules of the game have changed, with regulators increasingly insisting that mines avoid, minimise and mitigate their impacts on wetlands, and internalise the true costs of wetland loss into their balance sheets. Many mining proposals entailing large-scale wetland loss have encountered delays in licence approvals, unrealistic rehabilitation commitments and unwelcome public and media attention. As a result, the coal-mining sector has realised that it needs to proactively and systematically address the business risk posed by its impact on wetlands. Thus, in 2011 the CSIR and SANBI embarked on a three-year

cooperative applied research project, funded by the Coaltech Research Association. Supplementary funding is also being provided by the SANBI Grasslands Programme and Working for Wetlands, for particular components of the work. The project's focus is on developing mechanisms for limiting and mitigating the impact of coal mining on wetlands, and providing guidelines to the coal-mining industry and regulators in this regard. Based on interest expressed by the WRC in supporting this project to expand on its original scope and thereby improve its impact, this project proposal was prepared. It highlights areas where DMR and WRC resources can add further value to the work already underway, by allowing further work to be undertaken that was not part of the original scope of the funding. The project aims to compile an atlas to guide both mining companies and regulators with regard to high-risk wetland identification and offsite mitigation principles and methods. The sensitive wetlands atlas will identify key wetlands or subcatchments in the grassland biome of Mpumalanga that are particularly important or irreplaceable in terms of biodiversity, water resource management and other ecosystem services. The atlas that will be produced will guide both mining companies and regulators in their planning and decision-making. The project will pilot the mainstreaming, into the coal-mining sector, of information generated through the National Freshwater Ecosystem Priority Areas (NFEPA) project. The aims of the project are fourfold:

- To improve planning and decision-making around coal mining by developing products, for both regulators and mining companies, that highlight high-risk wetlands and ecosystem services
- To improve the science and practice of wetland rehabilitation in a coal-mining context, by improving current wetland rehabilitation guidelines with particular focus on post-mining landscapes and mitigating mining pollutants
- To enhance the quality of planning and regulatory processes by providing improved data on resource economics and risk assessment with respect to wetlands and coal mining
- To compensate for unavoidable residual loss of wetlands due to coal mining by developing and testing a systematic framework for wetland offsite mitigation, as well as identifying wetland offset receiving areas

Estimated cost: R1 056 000
Expected term: 2013 - 2015

An industrial ecology approach to sulphide-containing mineral wastes to minimise ARD formation: characterising potential for ARD, design for disposal and extraction of products with value
University of Cape Town
No. 2231

Project aims:

- Develop a method for characterizing the long-term ARD generation potential that takes into account the likely impact of microbial colonization and the relative time frame of acidification and neutralization, building on the proposed concept of the biokinetic test (Hesketh et al., 2010)
- Provide an expanded techno-economic assessment and holistic environmental assessment of the sulphide

separation step for removal of risk of ARD formation
- Develop appropriate uses for the benign tailings generated in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden
- Develop appropriate uses for the sulphide-rich tailings resulting from the separations in line with the principles of industrial ecology based on maximizing resource productivity and minimizing waste burden

Estimated cost:	R2 565 000
Expected term:	2013 - 2017

The BioSURE Process: a sustainable, long term treatment option for acid mine drainage treatment
VitaOne8 (Pty) Ltd
No. 2232

The BioSURE Process was identified as one of few treatment options suitable for the treatment of AMD in the Witwatersrand and elsewhere. However, it has been rejected by Aurecon, in their feasibility study for the Witwatersrand, as a viable option for the long-term treatment of AMD, the reason cited being a lack of full or demonstration-scale operating data. The full-scale operation undertaken by the East Rand Water Care Company (ERWAT) has in fact demonstrated that the BioSURE Process can be used as a cost-effective treatment technology for AMD. The process is attractive because it makes use of primary sewage sludge or other sources of organic wastes as substrate and produces a good quality effluent. Since it converts permanent hardness into temporary hardness, conventional cold-lime softening processes can be used to desalinate the water while valuable by-products may be recovered. The effluent quality after desalination is suitable for consumption in various industries as a substitute for high-quality potable water. ERWAT, in its role as a service provider, is very well positioned with its access to sources of primary sewage sludge and biodegradable organic waste. As an operating company and with the past experience of operating a 10ML/day plant, it can play a significant role in the treatment of AMD. A survey of the industries indicated that there are reliable and consistent sources of waste, other than primary sewage sludge, from various industries to treat approximately 20-30 ML/day of AMD in the Central and Eastern Basins. This waste is currently being disposed of in landfill sites at high cost. Considering the quantity of primary sewage sludge generated by ERWAT and Johannesburg Water's wastewater treatment plants that can practically be used, a significant volume of AMD can be treated in the Witwatersrand. Co-treatment with industrial waste and recovering costs for treatment of industrial waste will reduce the overall treatment cost of AMD. It is therefore important that more aspects should be considered than only the need to treat AMD. These aspects include the requirements to treat and dispose of sewage sludge and the urgent need to provide additional capacity to process biodegradable organic solids. This project is required in order to improve the BioSURE Process and to properly document its operating philosophy and limits to applicability, in order to make it truly available for implementation. It is planned to:

- Compare the performance of the biological sulphate-reducing reactors using primary sewage sludge and carbohydrates such as silage and combinations thereof

- Test the performance of the process using a feed of high acidity, low pH AMD
- Investigate the removal of hydrogen sulphide using a process to regenerate iron hydroxide with a biological iron-oxidising process integrated with the recovery of valuable magnesium sulphate using a eutectic freeze unit
- Investigate the integration of the effluent treatment process with the so-called SANI process for COD and nitrogen removal

Estimated cost: R1 557 600
Expected term: 2013 - 2015

Feasibility study on the use of irrigation as part of a long-term neutralised acid mine drainage management strategy in the Vaal Basin
University of Pretoria
No. 2233

Water resource planners within DWA foresee that the salt load associated with the AMD from the Witwatersrand gold mines will have to be reduced significantly or prevented from contaminating existing supplies. Otherwise large quantities of good quality water will be required (in essence wasted) to dilute the salinity to an acceptable level within the Vaal River system. The water quality decanting from these mines can be highly acidic or alkaline, very saline, and dominated by calcium sulphate, sodium sulphate, magnesium sulphate or sodium bicarbonate. Technologies exist to neutralise and remove these salts from water, preventing environmental degradation following its release, but the techniques are expensive and energy intensive, and create high volumes of brine. Work done in the early 1980s showed that when calcium sulphate–rich mine water is used in irrigation a significant quantity of gypsum precipitates (becomes insoluble) in the soil, effectively reducing salt loads in the irrigation return flows. The more soluble sodium-based salts do not precipitate. In subsequent WRC-supported research, this gypsum precipitation mechanism was confirmed in commercial-scale systems under pivot irrigation with coal mine water. Multiple crop species grown under sprinkler did not show foliar injury symptoms and yields were higher than for dryland production. Furthermore, gypsum precipitation did not result in any observable physical or chemical changes that would adversely affect soil productivity. Following these findings, the team concluded that there are four components to consider in managing irrigation with saline water: the chemical quality of the irrigation water, the hydrological setting of the irrigated area, the management of the leaching fraction, and the fate of the AMD. The AMD issue in the western, central and eastern basins has now reached a critical point requiring short- and long-term mitigation measures. Issues of a similar nature in the Mpumalanga coal fields and elsewhere are anticipated in the near future. This project aims to build on previous WRC research on the feasibility of using irrigation to remove salts from neutralised AMD through gypsum precipitation in soil, by assessing whether irrigation can be a feasible component in an integrated AMD management plan, as a cost-effective and sustainable method to prevent a significant salt load from neutralised AMD from ending up in the Vaal River System, while also utilising the water in an economically productive way. This work will assist in identifying whether irrigation can be part of an integrated solution to the AMD problem in the Vaal Basin as well as other basins with AMD issues. Decision makers will be provided with better information on the feasibility of using a potentially

more cost-effective and environmentally-sustainable way of reducing the salt loads from AMD. The use of irrigation to remove salts from neutralised AMD will potentially reduce the financial and environmental burden resulting from other treatment options, for example, reverse osmosis plants. Using neutralised AMD productively will result in income for farmers, job opportunities and increased agricultural production in the region, which will be especially beneficial in regions with scarce irrigation water resources.

Estimated cost:	R600 000
Expected term:	2013 - 2014

Mine water atlas of South Africa
Golder Associates Africa (Pty) Ltd (Midrand)
No. 2234

Large volumes of water are used by the mining and other industrial sectors for extraction and concentration of metals and non-metallic minerals, and generation of the electricity required for crushing ore, on-site processing, smelting, refining and other aspects of treating resources to improve their properties. Demand for water by the mining industry is limited and localized but becomes high when associated refining, smelting and manufacturing operations are considered. Mining has been an integral part of South Africa's history and economy. In 2007, the South African mining industry employed 493 000 workers and represented 18% of South Africa's 588 billion USD gross domestic product. Mines are most heavily concentrated in the eastern half of the country. While most mines are designed as closed systems, water pollution can result from problems in the mining or milling processes and aquatic ecosystems can be affected. In discussions with mining and/or water stakeholders in South Africa, it has emerged that a national mine-water atlas would be extremely valuable as a tool for water management planners and as an educational resource for water users, legislators, and the public. The Mine Water Atlas of South Africa is thus intended to be a comprehensive reference of the extent of the influence of acid rock drainage (ARD) on the country's surface and groundwater resources: summarizing the location, geography, geology, water quality and hydrologic characteristics. The information shall be presented in a graphical format supported by descriptive narratives and tables to better facilitate the reader's understanding of the material. The information, maps, and tables in the Atlas will portray general, regional conditions. The Atlas will be a significant and timely contribution that can inform the implementation of commitments made in the past two years. Decision makers can also look to the Atlas for background information and tools to assist in fulfilling commitments made in other recent events and declarations.

Estimated cost:	R2 700 000
Expected term:	2013 - 2015

Programme 3: Minimising waste production

Continuous eutectic freeze crystallization
University of Cape Town
No. 2229

While treating coal mining–impacted waters using reverse osmosis, facilities such as the Emalahleni Water Reclamation Plant and the Optimum Water Reclamation Plant produce large volumes of hypersaline brines. These brines are disposed of in evaporation ponds, and thus are lost to the usable water pool. With increasing use of desalination, and hence brine production, the loss of water is predicted to increase exponentially. The total combined brine production rates for the coal and gold mining industries in South Africa are projected to be ±17 000 m^3/day in the next 20 years from current values of ±3 000 m^3/day. Conventional treatment methods, such as concentration in evaporation ponds, have many disadvantages including extensive land use and low productivity. In addition, evaporation ponds recover neither the water nor the salt. Eutectic freeze crystallisation (EFC) is able to reduce the volume of brines by as much as 97% and concurrently produce pure salts as well as potable water. For example, pure calcium sulphate, pure sodium sulphate and potable water, in the form of ice, can be produced. Eutectic freeze crystallisation works on the principle that when brine is cooled to the eutectic temperature, both ice and salt crystallise out of solution. The ice, being less dense than water, will float, and the salt, because it is denser than water, will sink, thus effecting gravity separation. There is a major misconception that any freezing process is expensive but, thermodynamically, it is cheaper to freeze one kilogram of water (333 kJ) than to evaporate one (2 300 kJ). Energy savings of 85% have been reported when comparing EFC to evaporative crystallisation. An extensive experimental programme focussing on the use of EFC has been undertaken over the past 6 years and proven the concept of EFC as a feasible treatment for multi-component hypersaline brines. Firstly, it was shown that thermodynamic modelling can accurately predict the identities of the recovered salts, as well as their recovery temperatures. Secondly, it was shown that EFC can be used for the treatment of hypersaline brines and inorganic effluents produced by major South African industries. Thirdly, it was shown that EFC can be used to recover multiple salts from multicomponent brines. Lastly, it was shown that EFC can produce almost pure salts and ice. However, all of the work so far has been done in batch mode, an essential mode for testing proof of concept and initial feasibility. Although the batch mode has provided crucial information, it has not been sufficient to showcase the potential of the technology. The next challenge is to develop EFC to the point that it can be used in continuous mode. In this project, important knowledge about operational considerations for continuous EFC, including residence time, degree of undercooling, crystalliser solids content and operating limits, will be generated. This knowledge is crucial for making the transition between batch and continuous, as well as to be able to design an EFC plant on both a pilot and industrial scale. This is the essential focus of this project.

Estimated cost:	R2 276 600
Expected term:	2013 - 2018

THRUST 6: WATERSMART FUND

Programme 1: Watersmart Fund

Water quiz development
Overstrand Conservation Foundation
No. 2290

The aim of this project is to develop and implement a cellphone-based water quiz linked to an information database designed to stimulate school pupils throughout Southern Africa to spontaneously learn about the value, sources, conservation and sustainable use of water resources, as well as threats to water security.

Estimated cost:	R500 000
Expected term:	2013 -2014

Development of the micro-flush toilet
Maluti GSM
No. 2291

Project aims:
- Develop a two-stage flush mechanism which has a 'trickle flush' to clean the pan and a 'gush flush' to simulate the pour-flush action than enables low-volume flushing
- Develop a fully operational prototype of the micro-flush toilet
- Trial the prototype at different applications to evaluate performance
- Refine design with feedback from users
- Develop a marketing strategy to raise awareness of the micro-flush concept and create demand for the product in homes, schools and clinics throughout South Africa
- Demonstrate the effective performance of the micro-flush toilet for a range of downstream treatment systems
- Establish links with a ceramics manufacturer with a view to taking the project forwards into full-scale production (additional investment required for production)

Estimated cost:	R480 000
Expected term:	2013 - 2015

Water-wise hotels
Jeffares & Green (Pty) Ltd
No. 2292

The AquaSmart Hotels tool was developed to create awareness regarding water conservation within the hospitality industry by assisting members and owners of hotels, lodges, B&Bs, etc., to determine where and how water is being used within their establishment and providing alternative options which could reduce their water consumption. The AquaSmart Hotels tool consists of two Microsoft Excel workbooks. The first workbook is the tool and the second workbook is a database where water consumption information for the hotel can be stored. This guide provides detailed instructions on how to use the tool and database as well as general information on water conservation within the hospitality industry.

Estimated cost:	R313 531
Expected term:	2013 - 2014

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