South Africa's 20-year journey in water and sanitation research

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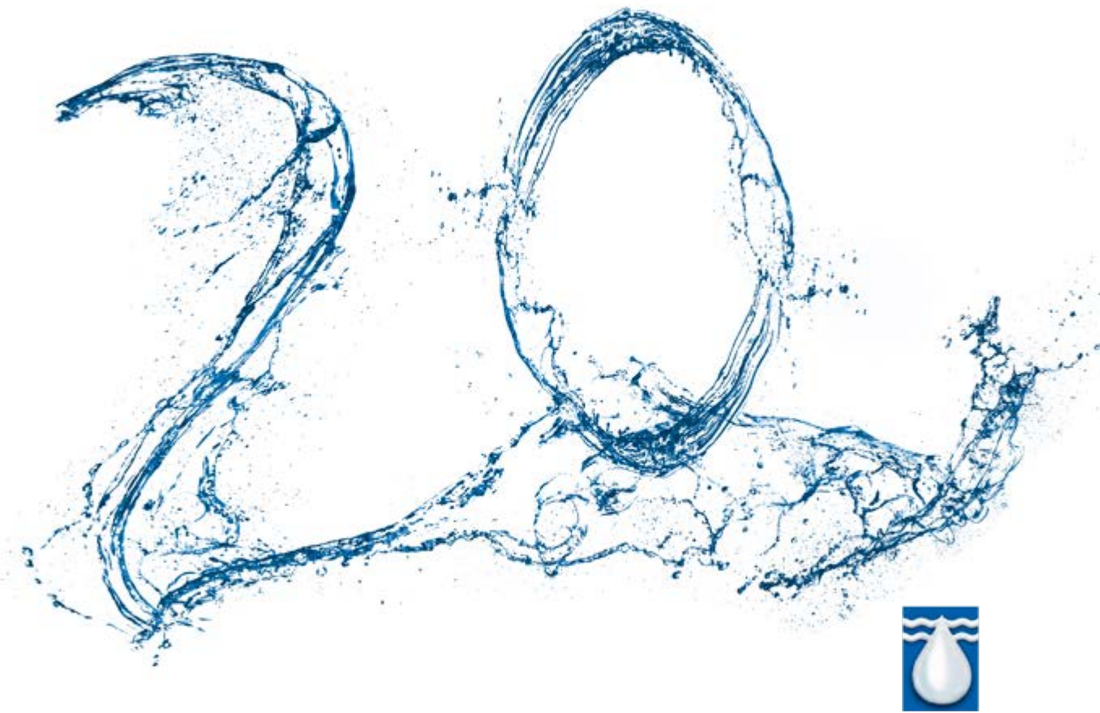

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Contents

Minister of Water and Sanitation,
Nomvula Mokonyane

Minister's Foreword

The role of R&D in solving South Africa's water challenges. Water is life: Sanitation is dignity.

The water that quenches your thirst in Siyabuswa, Mpumalanga and Qunu, Eastern Cape, does the same for communities in Sandton, Gauteng and Bishopscourt, Cape Town, and of course countrywide. Water does not discriminate.

It is without a doubt the research, undertaken by the Water Research Commission (WRC) and its network of partners and experts that has informed our many water legislation and water management successes in South Africa over the past two decades.

After the end of apartheid, South Africa's newly elected government inherited huge services backlogs with respect to access to water supply and sanitation. About 15 million people were without safe water supply and over 20 million without adequate sanitation services. The government thus made a strong commitment to high service standards and to high levels of investment subsidies to achieve those standards. Since then, the country has made satisfactory progress with regard to improving access to water supply: It reached universal access to an improved water source in urban areas, and in rural areas the share of those with access increased from 66% to 79% from 1990 to 2010.

We can look back on the past 20 years with great pride. Today we stand on the shoulders of giants who pioneered democratic South Africa's water legislation. We undertake to continue this proud tradition of building upon the solid foundations that had been put in place.

WRC CEO, Dhesigen Naidoo, WRC Executive Manager, Dr Inga Jacobs, Water and Sanitation Minister, Nomvula Mokonyane, Acting Director-General, Trevor Balzer and Deputy Minister, Pamela Tshwete at the National Water Summit in 2014.

The demands on South Africa's water resources are growing as a result of population growth rate, rapid urbanisation, economic development, demand for higher levels of service and as aquatic eco-systems are negatively impacted and require rehabilitation. In addressing the water and sanitation challenges in South Africa, research plays a primary role, because the decision-making that's based on scientific research is what's going to be sustainable going into the future.

New ideas and innovations informed by research and development (R&D) in partnership with the WRC will be welcomed so that we can continue to break new ground informed by science and technology.

The Department of Water and Sanitation (DWS), as the WRC's shareholder, works closely with the WRC to provide the sector with knowledge and capacity. This is focused on ensuring sustainable management of water resources and enhancing water services.

The role of research

South Africa, during the past twenty years of democracy has seen a series of factors that reshaped the water science and technology landscape.

The Department depends upon the WRC and its network of partners and experts to continue to contribute towards improving the quality and the capacity of South Africa's research base and its ability to undertake water related research and development initiatives. The initiatives supported by the WRC have been of importance to our water sector, providing the scientific basis for the development of new policies and strategies as well as process- and product-directed technologies.

The DWS recommits to ensuring that the WRC remains at the cutting edge of water-related research in South Africa.

Looking ahead

The recent renaming of the Department indicates our intention to promote integrated approaches to meeting South Africa's societal and water-sector needs. In the first week of August 2014 we convened a two-day Summit where all stakeholders in the water family came together and defined our working relationships.

In order to ensure the delivery of water and sanitation services to all South Africans, the Department is charged with the responsibility of integrating its work, through infrastructure development for the eradication of backlogs and sustained delivery of quality services to the people of South Africa. To facilitate effective and timely investment, a comprehensive investment framework for the water and sanitation sector is being developed.

Capital investment in new water and sanitation infrastructure for the entire value chain including the refurbishment of existing infrastructure over the next ten years is projected to require an estimated R670 billion.

We require of the WRC continued assistance in strategic identification of needs in the water sector and we continue to commit to investing in knowledge creation, transfer and dissemination in strategic research areas.

Nomvula Mokonyane
Minister of Water and Sanitation

The WRC has – during the 20 years of democracy – mobilised the development of research expertise over a wide range of disciplines, resulting in a significant expansion and upgrading of expertise in the South African water sector.

Dhesigen Naidoo,
Water Research Commission CEO

WRC CEO's Foreword

Democracy in action: improving people's lives through water research

Access to water was historically dominated by those with access to land, as well as political and economic power. In 1994, we inherited a South Africa with an antiquated water law derived from a history of conquest and expansion. Inevitably, water under apartheid was used in the interests of the privileged class and the white minority.

In the twenty years since, the world has become a remarkably different place. South Africa has been through a rollercoaster ride of divided experiences. The black euphoria of liberation in 1994 combined with cautious optimism among the white folk was a cocktail that characterised the start of our fledgling democracy. Over time we experienced galvanising of the South African "rainbow nation" under the stewardship of Tata, former President Nelson Mandela, arguably one of the greatest leaders in human history.

The world has seen leading economies undergo severe challenges. We've seen the rise of the economies of the South, significantly China, India and Brazil leading a shift in the global economic balance. Africa has emerged as the continent with the strongest average growth rate, albeit it from a lower baseline, but continues to show the promise of sustainable growth despite the lukewarm global recovery.

The story of South Africa during this period of time is reflected by the story of water resources, water use and sanitation, and in particular our water laws. South Africa's antiquated water law, embodied in the 1956 Water Act, was in force in 1994 and its effects were humiliating to the majority of our people. We could not allow such a situation to continue, especially against the ever-present background of our Constitution and in the context of a democracy that was struggled for so hard and for so long.

Deeply rooted in South African society, the WRC not only endeavours to ensure that its commissioned research remains real and relevant to the country's water scene, but that the knowledge generated from this research contributes positively to uplifting our communities, reducing inequality and growing our economy while safeguarding our natural resources.

At the dawn of democracy in 1994, it was the late Prof Kader Asmal who was called upon to address the water services challenges inherited from apartheid. As Minister of Water Affairs, Prof. Asmal brought to the water sector the first real legislative framework for comprehensive water management in South Africa. This resulted in various successful water management initiatives, policies and strategies. The WRC was a proud and crucial role-player in these efforts, providing the science behind the decisions. We should not forget that it was the new water law, based on solid WRC research in preceding years, that spearheaded the recognition of the concept of "the environment as a prime water user".

South Africa had to make fundamental policy changes. Over the last two decades, led by the Ministers of Water, we have brought about the National Water Policy and new legislation, in particular, the National Water Services Act of 1997 and the National Water Act of 1998. We have transformed organisations; changed mind-sets; and changed attitudes!

Research to policy: exploring issues and clarifying strategies

The impact of the WRC's research is now benchmarked in terms of policy uptake, in terms of broader public dissemination and understanding of trends in water research and development (R&D) in South Africa and how it compares to international standards and trends. Efforts are made to continuously and carefully define and redefine the role of the WRC in the water knowledge value chain. Critical to this is how we complement other players playing in this chain and how we support each other through various partnerships and other agreements.

In nearly every facet of life, advances are being made in building an inclusive society, rolling back the shadow of history and enabling opportunities for all. Access to services has been broadened, the economy has been stabilised and a non-racial society has begun to emerge. Millions who were previously excluded have access to education, water, electricity, health care, housing and social security.

To accelerate progress, deepen democracy and build a more inclusive society, South Africa must translate political emancipation into socio-economic well-being for all. It is up to all South Africans to fix the future, starting today.

New horizons: regional cooperation, climate change and the frontiers of science

Several of South Africa's challenges can only be addressed through regional cooperation. This is true of the water sector too. While South Africa is a water-scarce country, several neighbouring countries have abundant supply. There are other areas in which complementary national endowments offer opportunities for mutually beneficial cooperation.

Climate change has the potential to reduce food production and the availability of potable water, with consequences for migration patterns and levels of conflict. South Africa is particularly vulnerable to the effects of climate change on health, livelihoods, water and food, with a disproportionate impact on the poor, especially women and children. While adapting to these changes, industries and households have to reduce their negative impact on the environment. Research will continue to play a crucial role in climate mitigation and adaptation.

Science is breaking new frontiers in lowering the cost of water purification.

The role of the WRC in the water knowledge value chain

The WRC is South Africa's premier funding agency dedicated to water research. The strategic approach of the WRC focuses on promoting integrated approaches to meeting South Africa's societal and water-sector R&D needs, providing integrated solutions to the complex, inter-disciplinary problems facing the water sector, encouraging strategic identification of needs in the water sector and investing in knowledge creation, transfer and dissemination in strategic research areas.

By delivering on these strategic goals the WRC has emerged as one of the key research, development and innovation leaders in the South African water sector. This publication demonstrates how over the past 20 years of democracy, the WRC provides solutions to invariably complex, inter-disciplinary problems and invests in knowledge creation, transfer and dissemination.

Futures planning for the water sciences

The WRC continually reviews its research agenda through an objective and transparent process. Regular stakeholder consultation ensures appropriate prioritisation of water research in South Africa; it also ensures that potential areas for research synergy and collaboration as well as knowledge gaps and intersections are identified.

Thus our new impact areas for 2014 and beyond are: 'informing policy and decision making', 'empowering communities', 'transforming South African society', 'new products and services for economic development', 'sustainable development options', and 'human capital development in the water science sector'(i.e. capacity building).

The WRC and its network of partners will forge ahead in the effort to realise the goals of the National Development Plan 2030 and a future water prosperous South Africa that could boast sustainable economic growth enabled by water security, while simultaneously guaranteeing a dignified quality of life for all through universal safe water and sanitation access.

Dhesigen Naidoo,
Water Research Commission CEO,

Introduction

"I have walked that long road to freedom. I have tried not to falter; I have made missteps along the way. But I have discovered the secret that after climbing a great hill, one only finds that there are many more hills to climb. I have taken a moment here to rest, to steal a view of the glorious vista that surrounds me, to look back on the distance I have come. But I can rest only for a moment, for with freedom comes responsibilities, and I dare not linger, for my long walk is not yet ended."

Nelson Mandela, "Long Walk to Freedom"

These, the immortal words of our late former President Nelson Mandela and founding father of South Africa's democracy, were brought to life in 2014, when all South Africans were afforded the opportunity to take a proverbial rest and reflect on what freedom and democracy means to them, as we ushered in South Africa's celebratory year of 20 years of Freedom and Democracy.

For the Water Research Commission (WRC), South Africa's premier national funding agency dedicated to water and related R&D, this momentous occasion presented an opportunity for us to reflect, not only on how our freedom and democracy were achieved, but also on the progress we have made over the past 20 years in the delivery of water science to South Africa.

As we focus on the benefits of freedom we should also reflect on the strides we have made in achieving the vision of a better life for all. Much has changed since 1994, and similarly, the pre-1994 water and sanitation landscape has undergone a major transformation.

In 1994 at least 12 million people did not have access to safe water supply.

The state of water and sanitation pre-1994

Water flows through human society and its settlement. Yet, in many parts of South Africa as a result of apartheid spatial patterns, this flow was redirected and/or interrupted as a result of resettlement projects that moved non-white South Africans from the centre of town to the outskirts, and thus further from work and affordable amenities. In rural areas, resettlement had agriculturally related outcomes, and involved changes in land allocation and land tenure. Resettlement left people in their new settlement situations with less arable and/or grazing land, and further from their land and from wood and water.

Services designed to promote agricultural production in the new setting were poor and soon collapsed, leaving people unable to continue within the new production regime. These spatial changes involved with resettlement brought about changes in people's access to resources. The apartheid government forced the black majority onto less than one quarter of the land, through a variety of legislative instruments. The most notorious of these was the 1913 Land Act, under which at least 3 million black South Africans were forcibly resettled.

In pre-1994 South Africa, most black South Africans were not provided with access to basic municipal services such as clean water, sanitation, refuse collection and electricity. In the homeland areas particularly, these municipal services were often non-existent. In black urban areas, if they did exist they often did not meet basic needs and were intermittent in nature. It was estimated that at the time of the elections in 1994 at least 12 million South Africans did not have access to potable water. The lack of basic services contributed to high incidences of waterborne diseases such as diarrhoea and cholera.

Although the legislation governing access to water in South Africa was not, in itself, overtly racist, access to water was linked to ownership of land through the concept of riparian rights, and 'private' ownership of groundwater or small tributaries found on or under private land. Race-based access to land therefore resulted in race-based access to water, and the natural resources of the country were concentrated in the hands of a small, white minority.

The black population in South Africa suffered, therefore, under a double deprivation in relation to water: lack of water services was compounded by a lack of access to water for economic purposes, including irrigated agriculture. New houses and residential sites were significantly smaller than before resettlement, with temporary structures becoming de facto permanent homes for resettlers in a number of cases. Compensation for lost land or resources has by and large been inadequate and often very slow, making it even more difficult for people to get back on their feet.

In addition to the inequalities in land ownership and municipal services, the state of water in pre-1994 South Africa was also influenced by a range of other sectors and services most notably education and South Africa's foreign policy, to mention only a few.

Following the Bantu Education Act of 1953, government instituted racially segregated education and per capita spending on black education was held at only one-tenth of spending on white education. According to the Presidency's 20-Year Review, the apartheid regime actively sought to make black students only fit for unskilled and semi-skilled occupations.

The implications for the water and sanitation sector was that a predominantly white and male professional cohort presided over the water R&D community. Black schools had poor facilities compared to white schools, usually without electricity, water, sanitation, libraries, laboratories or sports fields. Moreover, little or no career guidance as to the opportunities in the water and sanitation sector were communicated to black schools. Black teachers were often under-qualified and poorly trained particularly in mathematics and science.

Black students had limited access to quality higher education and were prohibited from attending so-called white universities except for the University of South Africa (UNISA) and the Natal Medical School. Remnants of the apartheid education and training system still linger on today in the form of the skills and capacity gap and the immense challenge of transforming the education and training system to one capable of producing the skills required by a rapidly growing economy.

In the water sector specifically, most water and electricity sector staff are employed in 1) technical and trade workers 2) professional 3) clerical & administrative workers and 4) machinery operators and drivers. The majority of vacancy rates are found in the 'Technicians and Trade Workers' category level (46%), followed by the 'Professionals' level (20%) and lastly the 'Elementary Workers' level (12%). Economic growth has led to an increased demand for a skills resource base, especially in the fields of engineering, technology and artisans, and it is expected that demand will continue to outstrip supply.

In the water services domain there is an increasing demand for civil, mechanical, chemical and electrical engineers, hydrologists, hydraulic specialists, microbiologists, construction project managers, technical project managers, process controllers and technicians. However, while employers are able to identify the occupations that are in demand there seems to be very little intervention in terms of developing continuous training programmes for employees.

The institutionalisation of apartheid generated resistance and activism. In 1955, the Freedom Charter was adopted as a vision for a democratic, non-sexist and non-racial

Workers at De Hoop Dam. In the water sector there is increasing demand for various technical and scientific skills.

"Along the miles of steel that span my land threadbare children stand knees ostrich-bulbous on their reedy legs, their empty hungry hands lifted as if in prayer."

Dennis Brutus, 1962

South Africa. On 9 August 1956, a diverse group of more than 20 000 women marched to the Union Buildings to demand the abolition of the pass laws and other discriminatory laws. Indeed, apartheid policies, which facilitated the movement of able bodied black men into the urban environment in order to provide a ready labour pool, lead to a disproportionate number of women and women-headed households in under-developed rural areas.

In 1996, 33.9% of the population between 15 and 65 years were unemployed, with unemployment rates for African women being 52.4%, African men 34.1% and African people 42.5%. 26% of the employed earn R500 or less per month (<$85) while 62% of the employed earn less than R1501 per month (<$250) (Census 1996).

The apartheid state adopted a hostile foreign policy position towards African countries that were in the frontline of resistance against the apartheid system, including southern African countries such as Angola, Botswana, Mozambique, Lesotho, Swaziland, Zimbabwe and Zambia. These countries were subjected to frequent military attacks, including bombing raids and land-based incursions. Apartheid South Africa also organised and provided arms and training to opposition groups in these countries, thus fuelling civil wars, particularly in Angola and Mozambique.

The death toll ran into the millions of people that died as a result of this destabilisation, and the economies of the neighbouring states were devastated. South Africa was ostracised internationally, and labelled as a pariah state, with the United Nations General Assembly condemning South African racial discrimination as "reprehensible and repugnant to human dignity" by a vote of 95 to 1.

As a result of this, South Africa's water foreign policy was also limited to project-based bilateral agreements. In fact the Southern African Development Community's foundational objectives included the establishment of an institutionalised common front against apartheid South Africa, and to combat against South Africa's military aggression and economic hegemony. It was only after the abolition of apartheid that South Africa was allowed to join regional political institutions, as part of the process of resuming its position among sovereign states. This historical development has had its effect on the nature of regional hydropolitics today, with neighbouring states adopting an arguably cautionary approach to South Africa's leadership role in several multilateral fora and institutions. However, over the past two decades, South Africa has been successful in slowly reducing the distrust with which it was perceived.

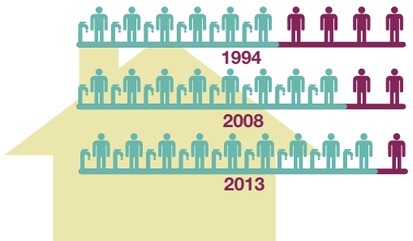
The water landscape post-1994

The first democratic elections in 1994 brought with it a new social order characterised by a new constitutional, policy and legislative framework. The Constitution of 1996 laid the foundation for a democratic and inclusive state founded on the values of human dignity, human rights, freedom, non-racialism, non-sexism and the rule of law. The next step for the democratic government was to work towards reconciliation and social cohesion and ensure that mechanisms were put in place to deal with the legacy of apartheid and redress past imbalances. The state also faced challenges in terms of integrating the country into a rapidly changing global environment.

By the early 2000s, South Africa had transformed its governance landscape and built institutions needed to uphold our constitutional democracy, such as the National Assembly, National Council of Provinces, provincial legislatures and municipal councils. Balkanised apartheid-era administrations and homelands had been amalgamated into a unified and decentralised governance system with national, provincial and local government spheres.

South Africa's political transformation also brought with it a host of progressive reforms in the water sector, as discussed in Chapter 1. The Water Services Act was ratified in 1997 and the landmark National Water Act in 1998. The 1998 NWA is regarded as one of the pioneering pieces of legislation that has influenced the international wave of reform, and as one of the most innovative and far-reaching water acts in the world. However, South Africa's challenge has not been the development of its progressive water reform policy, but rather the implementation thereof.

The post-apartheid government also developed several key strategies aimed at reducing poverty and socio-economic inequality through meeting people's basic needs for social security, education, employment, housing, infrastructure and basic services. These include a housing programme, land reform, electrification, a community based public works programme, a primary school nutrition programme, a welfare programme, a poverty relief fund, and a rural community water supply and sanitation programme.



water supply
95%

Access to safe water: 1994: 60% of the population (population 39 million); 2008: 88% of the population (population 49 million); 2013: 95% of the population (population 53 million)

These strategies were based on the understanding that economic growth is a prerequisite for human development and the eradication of poverty in South Africa. The rural community water supply and sanitation programme aimed to provide 25 litres of potable water per South African within 200 metres of their dwellings. The Land Reform and Restitution programme aims at restoring land to black South Africans who were deprived of the right to land or forcibly resettled during the apartheid era. The social welfare programme through grants has arguable been the democratic government's most effective poverty-reduction tool, with the number of grant beneficiaries increasing from 2.7 million people in 1994 to more than 16 million people by 2013.

Democratic South Africa also focused its attention on vulnerable groups affected by discriminatory laws such as women, children and orphans, young people, people with disabilities and the poor. A range of laws, policies and programmes have been developed to ensure greater representation and inclusiveness, ensure the provision of basic services, create jobs, reduce poverty, eradicate violence, and promote and protect the human rights of vulnerable groups. Additionally, South Africa has also seen major achievements in access to a basic level of essential municipal services, especially for communities deliberately excluded by apartheid.

South Africa was one of the first countries in the world to entrench the human right to clean water in its legislation, and our democratic government has worked tirelessly over the last 20 years to realise this human right for all its citizens, and has made great strides in this regard.

The latest available figures indicate that around 95% of our people now have access to water, while 80% have access to safe sanitation. It is important to realise that providing more taps and toilets is not just about boosting numbers – it is about bringing safety, dignity, health and job opportunities to our poorest communities, especially women and children, who are most vulnerable.

The provision of clean water is thought to be one of the major factors in the reduction of infectious diseases in Europe and America in the last 130 years. A WRC project on the state of diarrhea in children in poor communities in South Africa revealed higher levels of diarrhea in situations where a communal tap was used instead of on-site taps. This seems to imply that an on-site tap lowers the risk of water borne disease. Communal taps require water to be carried and stored and higher contamination levels were observed after handling and storage.

The focus now in the fifth administration is on reaching those remaining communities without access to basic services, particularly in informal settlements in urban areas and in remote rural areas. Various government departments have made serious commitments in this domain particularly given the challenges with the quality and functionality of municipal services in some municipalities due to poor operation and maintenance. This has been a contributing factor to the rise in municipal service delivery protests in recent years. These challenges relate to institutional and governance weaknesses and a lack of capacity in some municipalities.

Over the last decade, attention has also shifted to increasing the capacity of the state and to improving the quality of administration and service delivery at provincial and municipal levels. There is also a focus on improving the management of the intergovernmental system and improving coordination within and between the three spheres of government.

Considering the history of disempowerment and lack of education of the black population in South Africa, the provision of both domestic water supply and irrigation water requires appropriate and committed capacity building. Capacity must be built in communities and in individuals around issues such as health and hygiene, financial management, operation and maintenance of water supply systems, farming and marketing. This cannot be achieved in a short space of time, but requires the dedication of funds and capacity from government departments.

In particular, capacity building and empowerment must benefit women if the transfer of benefits to community and other household members is to be maximised. At the same time, women must be involved in management and decision making structures, and must be listed as farmers, landowners or household heads where appropriate.

After 1994, the National Skills Development Strategy (NSDS) was drafted with the aim of increasing the number of skilled people to meet the needs of the growing economy. The new system increased the range of available pathways for learners to obtain skills and increased the degree to which learners could move between these pathways, thus broadening access to skills development opportunities. Five-year national skills development frameworks were also put in place, the most recent (2012 – 2016) of which ensures the alignment of Sector Skills Plans with the government's strategic priorities as articulated in the 10 MTSF Outcomes. It also provides for common commitment to an inclusive society with strategic focus areas of equity impact, class, race, gender, age, disability and HIV&AIDS.

The NSDS calls for a wider spectrum of learning programmes to lay a broader foundation for occupational competence, stipulating success indicators and deadlines on agreed-to targets. It emphasises the importance of programme delivery partners and the need to uplift their capacity to increase the number of learners served, with particular focus on public institutions that cater for learners unable to pay market-set fees. Tens of thousands of learners are now being put through learnership programmes each year, although we have experienced challenges in

South Africa's basic housing programme was implemented after 1994.

basic water supply
6 000

The South African standard relating to a "basic" level of water supply, sufficient to promote healthy living, is based on the internationally accepted standard of 25 litres per person per day. This amounts to 6 000 litres per household per month, based on a household of eight people.

1) a drop in the number of qualifying artisans and 2) the placement of learners in experiential learning and sustainable employment.

In terms of economic growth, South Africa has also seen incremental improvement with the economy growing at a rate of 3.2 percent each year from 1994 to 2012, despite the global setback of the 2008 recession. In 2005 prices, gross national income per capita also increased from R28 536 in 1994 to R37 423 in 2013. While this is an improvement over pre-1994 growth rates, it is modest compared with other emerging economies, and has not been adequate to meet the objective of reducing unemployment. South Africa will need to sustain higher economic growth rates in order to substantially reduce unemployment in future.

The growing economy and a widening of the middle-class band have also resulted in sharp increases in the demand for road, rail, port, water, electricity and telecommunications infrastructure. In the second decade after 1994, demand for such infrastructure exceeded supply and power outages became more and more frequent. Since the mid-2000s, government has placed greater emphasis on economic infrastructure, and investment has increased dramatically, with a continuing growth trajectory into the new future. Major areas of infrastructure investment include new ports, expansion of container capacity, new national roads, new airports and improvements to international airports, new public transportation systems, new dams and new power stations.

In her mid-July budget speech, the Minister of Water and Sanitation, Ms Nomvula Mokonyane indicated that her budget would immediately address the 10% of existing services that were dysfunctional and a further 26% where the provision of water was not reliable. She said capital investment in water and sanitation infrastructure for the entire value chain, including the refurbishment of existing infrastructure over the next 10 years, was projected to require an estimated R670 billion. On the basis of current projected budget allocations, about 45% of this is currently funded.

While economic growth and poverty reduction objectives are some of government's top priorities in post-1994 South Africa, so is sustainable development. The necessary legislation has been put in place and commitments have been made to reducing pollution, improving the quality of the environment and addressing the impacts of climate change with South Africa even hosting the 17th Conference of the Parties that meets annually to assess progress in dealing with climate change. The meeting was held from the 28 November to 9 December 2011 in Durban. Implementation, monitoring and enforcement of these commitments will receive greater attention in the fifth administration.

Finally, in terms of its global positioning, South Africa has gone from being a pariah state to a widely respected member of the international community. It has managed its entry into the international community tactfully, building new

relationships and partnerships while maintaining sovereignty over domestic economic and social policy. Today, South Africa is party to 25 agreements with its neighbours on shared rivers.

The 1998 NWA includes provisions for international arrangements, and provides for bilateral and multilateral bodies to implement international agreements pertaining to the management and development of water resources shared with neighbouring countries. It therefore emphasises regional cooperation of water resources. The establishment of the NWA has also been instrumental in influencing the national water management frameworks of neighbouring states.

In summary, in 1994 the country embarked on an ambitious project of democratic nation-building and socio-economic transformation. Twenty years later, South Africa is a markedly different place to the South Africa of 1994, in almost every respect, and the water and sanitation sector has reflected similar changes.

About the book

This book intertwines the country's journey since democracy with the journey and developments in water R&D since then. It's a story of scientific transformation – some may even call it a scientific revolution – it's a story about innovation, but most importantly, it's a story about people. In the chapters that follow, we track the journey of South Africa and the journey of water research in South Africa – from informing policy and decision-making, empowering communities, transforming South African society, providing new products and services for economic development, promoting sustainable development solutions, and supporting human capital development in the water and science sectors.

This is not meant to be an anthology of the WRC's work over the past 20 years. It is a snapshot of some of the key developments and successes in WRC projects. It is by no means comprehensive and is designed to give a taste of the work of the WRC and its role in defining democracy for all South Africans.

Water service delivery in South Africa forms part of our challenge to meet the milestones in our very own National Development Plan and the United Nations' Millennium Development Goals (MDGs). Water nourishes our bodies and our crops; it trickles through the machinery of industry; it cools mining operations deep in the bowels of Gauteng and the North West. Rivers and water pipelines are like arteries, pumping life across our beautiful country. South Africa's waters run through the veins of each and every one of us. Water is our life blood, our future, and the promise of a better tomorrow. As a knowledge-based organisation, it is the responsibility and commitment of the WRC to ensure that the power of knowledge on water is given to all South Africans who can in turn use it to empower themselves and those around them. This is our commitment to water service delivery.

Chapter 1

Informing policy and decision making

"To be free is not merely to cast off one's chains, but to live in a way that respects and enhances the freedom of others."

Nelson Mandela

This has been both the opportunity and challenge of the post-1994 South African water and sanitation sector, that is, changing access to water and water services in South Africa, redressing the wrongs of the past, particularly in relation to racial and gender discrimination, and the eradication of poverty. In order to addresses these challenges, the effective management of South Africa's water resources requires an informed and reliable scientific foundation to provide appropriate evidence-based information to guide decision-making. Through its funded research, the WRC provides this foundation, aiming to ensure that the country's water resources are managed sustainably. This chapter outlines the tremendous road we have paved in terms of water policy development and highlights a few key WRC initiatives that have contributed to this.

The effectiveness of any sector is however only as good as its leadership. And so we begin with an overview of the water and sanitation sector's ministerial leaders and shape-shifters that influenced the sector's strategic direction defining pivotal turning points in our country's water history.

At the helm over the past two decades…

The Department of Water as the custodian of South Africa's water resources, leads the management of water resources, and is responsible for the formulation and implementation of policy governing this sector. The department also has an overriding responsibility for water services provided by local government. With its vision of being dynamic and people-centred, the department is strategically positioning itself to ensure that the whole value chain, from 'source-to- tap' and 'waste-to-source', functions effectively.

The Department has undergone several strategic reorientations and subsequent name changes since 1994: from Department of Water Affairs and Forestry, to Department of Water and Environmental Affairs, to the more recent coupling of Water and Sanitation. Additionally, each of the six ministers and the accompanying deputy ministers spearheaded key strategic initiatives that directed the course of the department.

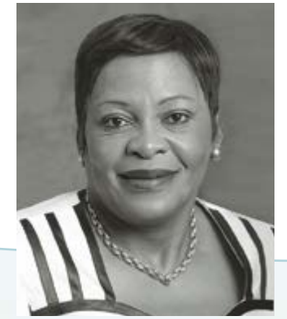
Prof Kader Asmal
1994 – 1999

Ronnie Kasrils
1999 – 2004

Buyelwa Sonjica
2004 – 2006 and
2009 – 2010

Lindiwe Hendricks
2006 – 2009

Edna Molewa
2010 – 2014



Nomvula Mokonyane
2014 to present

Ministers of Water during Democracy, 1994 – 2014

"In a few short years as Minister of Water Affairs and Forestry, I feel I was able to introduce some far-reaching changes, changes that have genuinely improved people's lives and particularly the lives of South Africa's women. For this I will be forever grateful and proud. If, in the fullness of time, anyone cares to remember my time as head of this portfolio, I should like to be remembered as the minister who provided taps and toilets, who planted a few trees, and opened a dam or water scheme here or there. I should like to think that I contributed to a more hopeful future, expressed by Philip Larkin's astute words: If I were called in to construct a religion, I should make use of water."

- Prof Kader Asmal

Prof Kader Asmal

(1994 – 1999):
Some, for all, forever –
transformation through water policy

In one of President Nelson Mandela's many strokes of genius, he appointed as his first water minister a human rights lawyer who knew little about the science of water but a great deal about water's role in creating an equitable and humane society. Minister Asmal had a huge task, not only to develop new, equitable legislation, but to simultaneously start addressing the enormous water and sanitation services backlog inherited from the Apartheid government. He brought the first real legislative framework to the sector for comprehensive water management in South Africa. To Asmal and the team he assembled, water could became a means to redress the injustices of apartheid.

Prof Asmal announced the South African Water Law Review as one of his first initiatives on taking office in May 1994. In 1998, South Africa gave birth to a landmark water law. The new logo was grounded in the ethical precept of the 'public trust' and the concept of national custodianship of the water resource. One important aspect of this was the establishment of the Reserve. The Reserve called for meeting the basic water needs of all people and of the ecosystems "on which humans depend" before granting water entitlements to industry, irrigation and other economic uses. The Reserve turned water allocation on its head and grounded it in principles of equity and ecological health.

As Minister of Water Affairs and Forestry, Prof Asmal spearheaded the recognition of the concept of "the environment as a prime water user." While serving as Minister of Water Affairs and Forestry, he also served as the chairman of the World Commission on Dams (1997–2001). His time as Minister of Water Affairs is widely regarded as being very successful. Much of that success being attributed to Prof Asmal's dynamism and ability to work with the then still largely Afrikaner dominated civil service.

He saw water as an instrument for transformation, and produced a series of discussion papers and white papers leading to the National Water Act of 1998, which won him, and South Africa, the Stockholm Water Prize. He remains the only recipient of this prestigious world prize who is not a scientist.

International Rivers

Prof Kader Asmal with former President Nelson Mandela at the launch of the World Commission of Dams report in 2000.

Minister Ronnie Kasrils

(1999 – 2004):
Minister of Toilets

Minister Ronnie Kasrils' strategy in the earlier days of his term focused largely on water services provision. This strategy was added to as a result of the KwaZulu-Natal cholera outbreak in 2000. Referring to it as "the human waste factor" Kasrils put sanitation firmly on cabinet's agenda. His awareness led him to the Water Supply and Sanitation Collaborative Council (WSSCC), a Geneva-based UN agency run under the auspices of the World Health Organisation (WHO). During Kasril's term, South Africa hosted the AfriSan Forum in South Africa, just a few weeks before the WSSD– the UN Summit on Sustainable Development – in August 2002, and his job was to put sanitation on the agenda.

In this regard also, Minister Kasrils did much to strengthen ties with the global water sector, among others, using the incredible opportunity presented by South Africa's hosting of the World Summit on Sustainable Development. In 2001, the Department launched Masibambane, a donor-supported programme that created a single-window funding arrangement channelling donor contributions towards outcomes collectively prioritised by sector players. The South African budget was complemented by a European Union grant, as well as contributions from the bilateral co-operation programmes between South Africa and the United Kingdom, Ireland, Netherlands and France. The European Union contribution of €50 million for the 2001/02 and 2002/03 financial years was followed by a further €25 million for 2003/04.

He advocated for the provision of water to improve food production, especially for emerging farmers, and implemented South Africa's Free Basic Water policy. In late 1999, Kasrils visited the isolated rural community of Lutsheko in the Eastern Cape. A new departmental scheme providing the village with a supply of water from community standpipes had recently been completed. Despite the fact that the scheme was in full working order, Minister Kasrils noticed that some residents were getting their water from the almost dry riverbed nearby. On enquiring, he was informed that even though the costs were minimal, R10 per month, many residents were so poor that they could not afford to pay for the water supply. They had reverted to their original unreliable and unsafe sources to avoid paying for water.

Based on this observation, Minister Kasrils resolved to explore an alternative policy approach. The government solution, announced in September 2000 was to provide free basic water and sanitation services. Based on an approach pioneered in Durban, it was proposed that a basic water supply of 25 litres per person per day would be provided free to each household every month (this amounts to approximately 6 kiloliters per household per month). The costs of maintaining a basic sanitation facility – normally understood as a ventilated improved pit latrine (VIP) – would also be covered. Any level of service 'consumed' over and above this would have to be paid for.

"Let us use water for the common good, to enrich the lives of all our citizens. Let us all work for a better South Africa. Let water wash away poverty."

- Ronnie Kasrils

Minister Ronnie Kasrils during the launch of the first State of the Rivers report in the Kruger National Park.

Buyelwa Sonjica

(2004 – 2006 and 2009 – 2010): The sectoral view

As Minister Buyelwa Sonjica declared plans to eradicate the bucket system and made significant gains in this regard. She also initiated an assessment of the state of South Africa's wastewater systems and interventions to deal with the challenges. During her tenure a Water Indaba was held to debate the challenges faced by the water sector and to agree on the best action plan to meet the needs of all water users. It was during her stewardship that the Blue Drop and Green Drop certification process was also launched.

The restructuring of Local Government started in 1998 with the introduction of institutional changes, this set in motion the development of the Municipal Infrastructure Grant (MIG) which came into fruition in 2003. The MIGs catalysed the Department's withdrawal from direct water services delivery, and consolidated the various parallel programmes for municipal infrastructure funding. Before this, the Department utilised capital funds, initially from the RDP fund, and later funds from its own budget allocation (Community Water Supply and Sanitation Programme Funding) as well as Masibambane Funding, to directly finance infrastructure development. MIG funding was channelled directly to municipalities according to an allocation formula.

Additionally, in 2003 a new vision for the water services sector was necessary and the Strategic Framework for Water Services was approved by Cabinet. The Strategic Framework updates the 1994 White Paper. While the 1994 White Paper focused on the role of the Department in the direct delivery of basic services to people living in rural areas, the Strategic Framework mapped out a vision for how the water sector as a whole will work in providing water services. It addresses "the full spectrum of water supply and sanitation services and all relevant institutions". A series of more detailed strategies were also developed during Sonjica's term of office including: a national institutional reform strategy; a regulatory strategy; a support strategy; and a monitoring and evaluation strategy.

"Water can either be a contributor to growth or a constraint, and we must make sure that it is not the latter. We must think how to get more jobs per drop and more products per drop."

- Buyelwa Sonjica

Minister Buyelwa Sonjica meeting with the Kat River Community Forum in the Eastern Cape in 2005.

Lindiwe Hendricks
(2006 – 2009):
Addressing the backlogs

Minister Lindiwe Hendricks faced some serious challenges during her tenure – including the cholera outbreaks in Limpopo in 2008, tracking backlogs in access to infrastructure and the identification of pollution as being responsible for the crocodile die-offs in Kruger National Park rivers. Tracking backlogs became particularly politicised in the second decade of democracy and there was an intensification of efforts to meet sectoral targets. Hendricks conceded to the huge challenges facing the water sector and announced corrective measures to avert a crisis. She also started initiatives to improve the drinking water quality standards in underperforming municipalities. It was during Minister Hendricks' tenure that Cabinet approved the implementation of phase two of the Lesotho Highlands project, which will supply water to Gauteng and the rest of the Vaal River water supply area.

Former Water Minister, Lindiwe Hendricks.

"We need to build strong institutions to be able to handle future water challenges such as those brought on by the impact of climate change."

- Lindiwe Hendricks

Edna Molewa
(2010 – 2014):
From source to tap and back to source

In 2011, Minister Edna Molewa launched the Business Process Realignment process. The process aimed to co-ordinate the appraisal and strategy for the reorganisation of the water sector and its institutions into a well-oiled machine for development and implementation of solutions. This is to ensure a highly productive and delivering water sector to the economy, meeting social needs and those of the environment, and carefully organising for South Africa to be internationally competitive while ensuring a direct improvement in the daily quality of life of all who live here.
In particular, it was vital to ensure that the poor and marginalised are real beneficiaries of increased efforts to expand the frontiers of human dignity through the proliferation of water and sanitation services. The three components of this exercise affected the WRC intimately. The first was the review of, and possible amendments to, the three cornerstone pieces of legislation – the National Water Act (1998), the Water Services Act (1997) and the Water Research Act (1971 and amended six times since, most recently in 1996).

The second was the Institutional Reform and Realignment, which, among other things, re-examined the rationale and business case for the WRC. The third was the development of the second version of the National Water Resource Strategy (NWRS II). Many parts of this exercise had implications for the WRC directly, among other things through the amendment of the founding legislation, an update of the business case and model of the WRC, and the WRC contributions to the revised NWRS. The process as a whole has strongly informed the development of the new multi-year strategic plan of the WRC.

During her term of office as Minister of Water, Molewa was a strong contender for dealing with South Africa's water challenges along the entire value chain, from 'source to tap and back to source'. She faced several challenges during her tenure, such as the possibility of fracking in South Africa and the functionality of municipal infrastructure and sustainable service delivery.

Minister Molewa, along with Deputy Minister Rejoice Mabudafhasi, implemented a series of research projects to investigate these and provide solutions such as the Interim Water Supply Programme. Minister Molewa launched the WRC report on the state of South Africa's non-revenue water, which revealed that we are losing 36.8% of our clean drinking water in the distribution system due to leaking pipes, dripping taps and illegal water use. Minister Molewa also announced a process to streamline South Africa's policy and legislation with regard to water services and water resources management "to meet the growing demands for water and achieve the goals of a developmental state."

"In 1994 a mere 59% of the population had access to clean drinking water. At this moment in time (2014) a massive 95.2% of our people have sustainable access to a clean water supply."

- Edna Molewa

Water & Environmenta Affairs Minister, Edna Molewa, addresses the media during National Water Week activities in 2013.

Former Deputy Minister of Water & Environmental Affairs, Rejoice Mabudafhasi, undertakes sampling of the Eerste River.

Nomvula Mokonyane

(2014 to date): Water is life, sanitation is dignity

On May 25 2014, Mokonyane was appointed Minister of Water Affairs and Sanitation, a new Ministry created to combat water issues and serious sanitation problems across the country. Minister Mokonyane started her tenure with a promise to refocus her new Department of Water and Sanitation on the 'basics' of water services delivery. One of her first actions was to launch a National Water Summit with Deputy Minister Pamela Tshwete, which allowed for open and frank discussions around the state of the water sector in South Africa. She also announced a review of current water legislation, with the possible amalgamation of the NWA and the Water Services Act.

Minister Mokonyane emphasised the guiding frameworks for the Department in this administration, these being the National Development Plan (NDP), the Manifesto of the ruling party, the African National Congress and the NWRS II. She also highlighted the 'integrated water approach,' that entails a sustainable and holistic value chain of water supply from source to tap and from tap back to source.

Mokonyane also noted that decisive leadership was needed to assert authority across government, and bring about radical socioeconomic transformation.

She stated that municipalities must ensure that the management and maintenance of infrastructure are carried out as stipulated in their budgets. "We will no longer hear about the excuses of ageing or non-functioning water infrastructure," said Minister Mokonyane. According to Minister Mokonyane, all water service authorities (WSAs) are now going to be instructed to set aside at least 7% of their total budgets towards maintenance and management of infrastructure. The money will also be used to ensure that each municipality guarantees that there is capability and capacity to carry out this task efficiently and effectively. Further, the Minister warned that Government is set to introduce legislation to make sure that this matter is implemented without fail.

She supported Cooperative Governance Minister Pravin Gordhan's attention to meeting the service delivery challenge in South Africa, and added that the Summit was a fitting platform to discuss related game-changers in a radical way. Resolving the water and sanitation challenge was not just about the provision of money, but about capacity, efficiency of the system, proper planning and planning within a dedicated space to ensure that everybody becomes a beneficiary of the service and ensures quality service delivery. Other game-changers include the role of science and

"In finding solutions to the current challenges, this calls for our collective wisdom in changing the lives of women. In a place like Kwa-Mhlaba Uyalingana, for example, women should no longer share water with animals or walk barefooted and pregnant to fetch water in the river whilst there is the Jozini dam next to their village."

– Nomvula Mokonyane

Water and Sanitation Minister, Nomvula Mokonyane, at the National Water Summit in 2014.

Deputy Minister of Water and Sanitation, Pamela Tshwete (centre) addressing the youth during a river field trip to Modderfonteinspruit as part of the Department of Water's Youth Summit in 2014.

technology for renewal and innovation as well as development and research; the role of the private sector in helping to unlock the growth and development of the water and sanitation sector; as well as the role of civil society in the water and sanitation space.

Minister Mokonyane also emphasised the need for the private sector to invest in social infrastructure, and therefore contribute to social transformation, and the de-racialisation of communities through better water and sanitation plans. She concluded by highlighting, as one of the game changers, the participation of ordinary communities, and participation of the disenfranchised.

Minister Mokonyane stressed that we cannot have 'business as usual', that we need to embrace the spirit of 'oneness', with water being life and sanitation being dignity. In this regard, we have to revisit water ownership patterns and water use rights in South Africa.

In crafting a shared vision for water and sanitation in South Africa for the next five years and beyond, one of the key outcomes of the Summit was the development of the National Water and Sanitation Summit Declaration, tabled and approved in the Closing Plenary. The declaration acknowledges the importance of doing things differently through communication and partnerships focusing on people-centred solutions; the need to realize solutions in the identified deliberation areas of: meeting the service delivery challenge, enabling water and sanitation policy, developing and implementing water research, technology and innovation choices, enhancing the state of South Africa's water resources, and understanding and defining the role of the private sector; and, charting a pathway toward national water security and sustainable universal access to water and sanitation services within the longer-term NDP timeframe of 2030. It also commits to the development of the Water and Sanitation 10-Year Plan (2015-2025) as the water and sanitation pillar of the NDP.

"The challenge with fetching water from rivers is that river water is not as clean as it used to be in my era. I grew up fetching water from the rivers, but over the years, urbanisation, farming, and mining have dominated water usage, which has also resulted in polluted rivers."

– Pamela Tshwete

Graeme Williams/South Photos/Africa Media Online

Voters queue at a polling station north of Pretoria on 27 April 1994. This day did not only signify the start of South Africa's democracy, but also a new chapter in the history of the country's water sector.

A new National Water Act for a new democracy

Before 1994, the frameworks governing the public service were highly centralised and regulated, resulting in a bureaucratic, unresponsive and risk-averse public service.

In addition, the public service lacked transparency and accountability, providing space for abuse of power and corruption. Post-apartheid South Africa needed a reformed governance system that would allow all South Africans to claim political and social ownership of the country. This meant changing the systems of governance to be geared towards transformation by addressing the legacy of apartheid. There was a need to modernise the public service, to make it more efficient, effective, accountable and people-centred, so that it would be able to fulfil its transformative role.

SA's new water legislation takes shape

The technical and social deficiencies of the 1956 Water Act had become increasingly evident over a number of years, but it was not until 1994, when the first democratically elected government came to power in South Africa, that the opportunity presented itself for a thorough review of the existing law.

The new government's policies focused strongly on equitable and sustainable social and economic development for the benefit of all South Africans, but many existing laws, including the law relating to water, were found to be not at all appropriate to achieving these objectives. The fact that access to water was to a large extent tied to land ownership via the riparian system, together with restrictions on land ownership by the majority black population, meant that most people in the country could not claim access to water under the 1956 Water Act.

Few countries have been able to create the environment for peaceful change that existed in South Africa after the political settlement was negotiated in the early 1990s, and few new governments have had the opportunity to scrutinise all the existing laws of the country, and to make dramatic changes to ensure that they are consistent with the new democratic order. There is no doubt that this rare window of opportunity facilitated the profound changes that culminated in the passage into law of the National Water Act (Act 36 of 1998).

A number of factors contributed to the development of South Africa's sweeping new water policy and water legislation. During the early 1980s, real data from the national water quality monitoring networks, which were established from 1970 onwards, began to offer concrete evidence for the steady, and in some areas rapid degradation in the quality of water resources in South Africa. At the same time, world concern regarding environmental issues and sustainable development was becoming more urgent.

Added to this were the astonishingly rapid political and social changes in South Africa, which introduced a suite of new and complex values into decision-making around resource utilisation and management. The way was cleared for an almost total revision of water policy and legislation, in a relatively short period of time compared to similar reform processes in other countries.

Setting the wheels in motion

During March 1995 two important developments took place. The first was the release of the publication *You and Your Water Rights* on which public comment was invited, and the second was the intention to establish a Water Law Review Panel.

Three phases were identified to guide the water law review process. The first phase was to include public consultation and consisted of the distribution of the above publication, the soliciting of comment and the facilitation of countrywide workshops, particularly in rural and poor communities. The second phase was to be the setting up of a monitoring committee (the Panel) to consider responses and to recommend principles. The third phase was to consist of the drafting of new legislation by a second monitoring committee that also included legal experts.

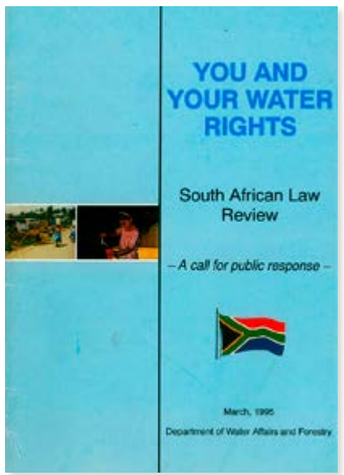
pre-1998 water act

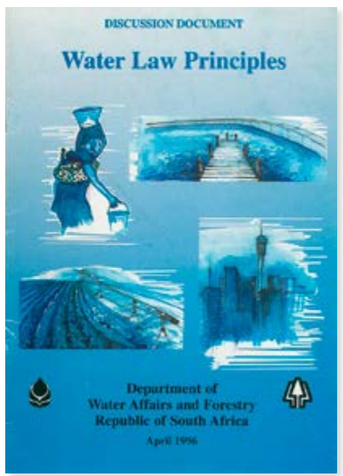
38 years

The Water Act preceding the National Water Act of 1998 was in force for 38 years

"The call of the new Government and of the people is of fairness and equity. This is the demand of the Constitution and the basis of the review we are undertaking. This will call for brutal honesty."

– Prof Kader Asmal, 1995





The booklets, *You and Your Water Rights* and the *Discussion Document on Water Law Principles*, were crucial in the dialogue leading to South Africa's new water legislation in 1998.

The publication of You and Your Water Rights can be seen as the start of the water law review phase with the call for submissions and comment on what a new water law should address and include. During December 1995 various road shows were held to mobilise public comment and 173 written submissions were received in response to the booklet.

Scientific and technical groundwork

The establishment of the new democratic government in South Africa presented the opportunity for aquatic scientists and water resource managers to propose measures for the protection of aquatic ecosystems that would eventually be included in national policy and legislation. However, the roles of the Department and the WRC, in laying the scientific and technical groundwork, should not go unmentioned.

It is reasonable to say that, for most of its existence up to that point, one of the Department's principal preoccupations was the creation of storage for surface water runoff by building dams. It was not until the late 1970s, midway through a period of intensive dam construction, that the Department began to give serious consideration to the environmental impacts of its activities. In the early 1980s the focus in this respect was on issues such as the restoration of dam sites after construction or on decommissioning, and reducing visual impacts.

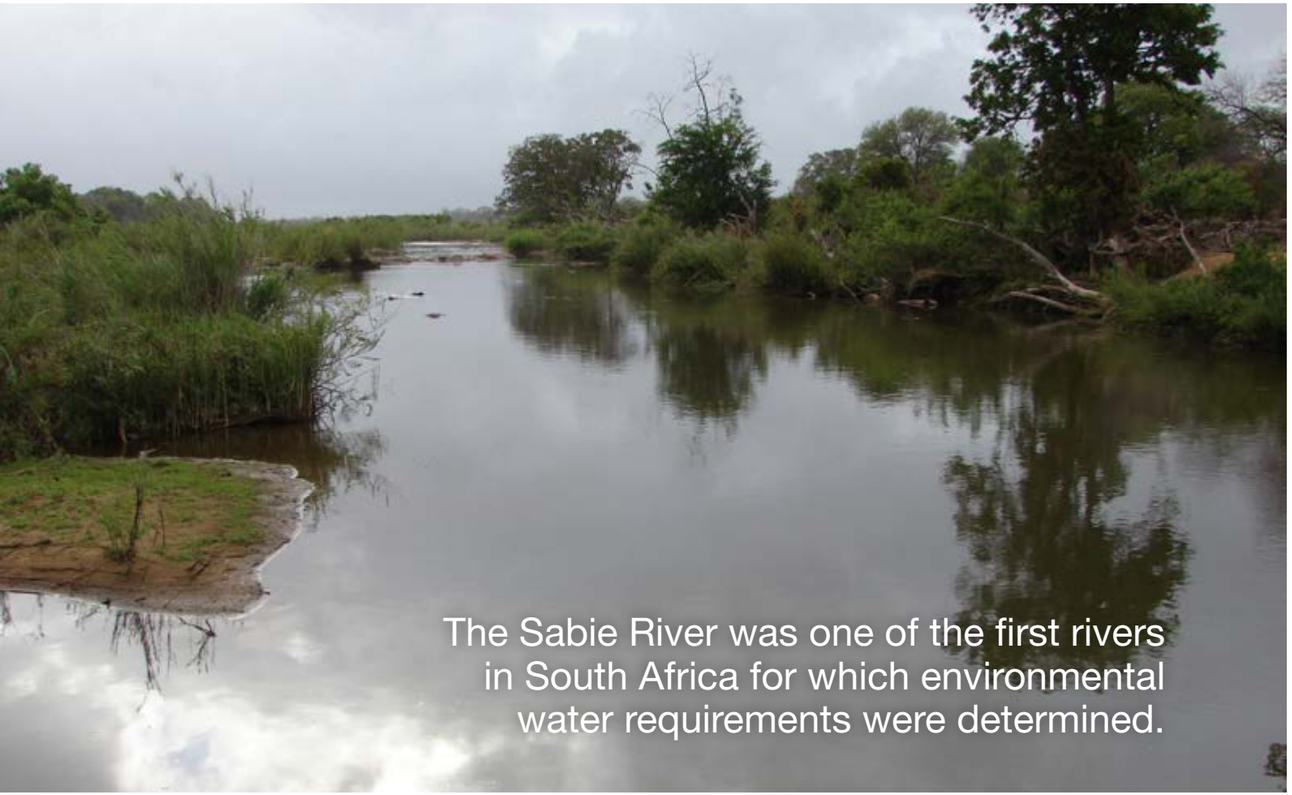
In the latter years of that decade, the focus of impact assessments broadened considerably to include the aspects of the biophysical environment that are habitually included in an environmental impact assessment (EIA) today. What was remarkable about this period was that EIAs for proposed dams were being carried out before there was any legislative requirement to do so, and before regulations were made prescribing the processes and procedures by which the assessments were to be undertaken. Instead, the Department, in collaboration with the WRC and the national body of aquatic scientists, began to develop appropriate procedures, and implemented them with some success until the regulations were eventually published.

Among the many environmental impacts of dams, those linked to damming a river and altering, usually profoundly, the flow regime of the watercourse downstream of the dam wall, were among the most severe, a fact that aquatic scientists had been pointing out to the Department for many years. In order to mitigate these impacts it was necessary to know what the downstream flow regime should be – the quantity, pattern and timing of releases from the dam – to maintain the ecological functioning of the river at some acceptable level.

Accordingly, in the early 1990s, the Department embarked on a series of studies to determine inflow stream requirements or IFRs, the precursor to the Ecological Reserve, for all rivers on which dams were mooted for construction. The first of these studies was carried out in February 1992 for the Lephalala River, a tributary of the Limpopo River in the north west of the country. The studies ultimately led to the development of a distinctly South African approach — the Building Block Methodology - for assessing the ecological water requirements for rivers.

At the close of this first phase of the Water Law Review, Cabinet had accepted the recommendations of the Panel that water to meet basic human needs and water to maintain ecological functioning – jointly, the Reserve – should 'enjoy priority of use by right'. The use of water for all other purposes was to be authorised by processes that were not defined in the Principles document.

The Wolwedans Dam, outside Mossel Bay, was one of the first dams in South Africa for which an environmental impact report was completed.



The Sabie River was one of the first rivers in South Africa for which environmental water requirements were determined.

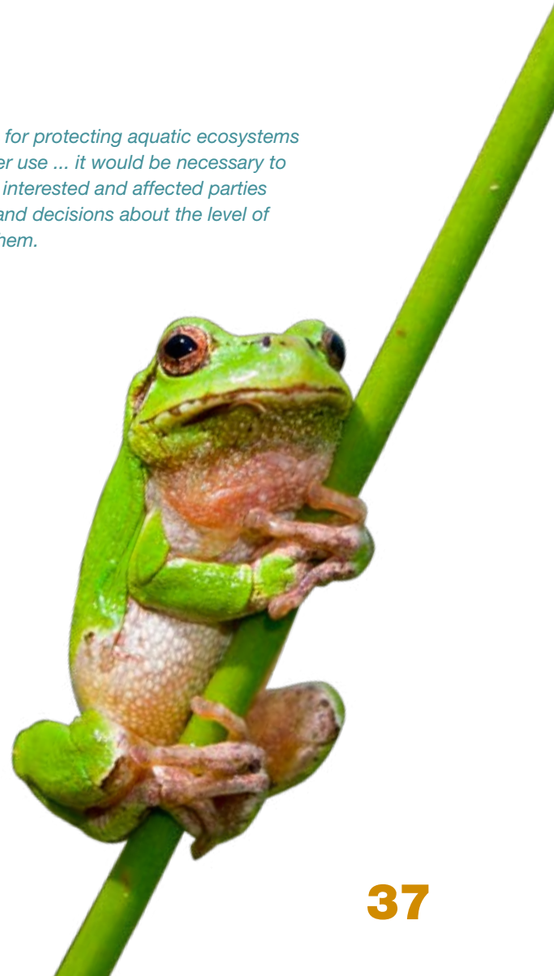
The White Paper on a National Water Policy tor South Africa (1997)

Cabinet later adopted the *White Paper on a National Water Policy for South Africa* (NWP) in April 1997. The framework for managing water resources was considerably expanded and the Policy also proposed the introduction of a national Water Resource Classification System.

A distinction was made between resource-directed measures, by which objectives would be set for the desired level of protection for the aquatic ecosystems of each water resource, and the more traditional source-directed controls, by which the uses of a water resource (abstraction of water, discharge of wastewater, for instance) that impact on its quality would be controlled to achieve the agreed level of ecosystem health, and so ensure its sustainable use.

The links between the protection of aquatic ecosystems and their use were thus firmly established in the Policy. It was explicitly recognised that because achieving objectives for protecting aquatic ecosystems would involve controlling water use (in particular, in many cases, curtailing existing use), it would be necessary to involve water users and other interested and affected parties in making recommendations and decisions about the level of protection to be afforded to them.

Because achieving objectives for protecting aquatic ecosystems would involve controlling water use ... it would be necessary to involve water users and other interested and affected parties in making recommendations and decisions about the level of protection to be afforded to them.



National Water Act (1998)

The State President assented to the NWA on 20 August 1998, thereby giving legal effect to Government's intentions for managing water resources as they were expressed in the NWP. Central to the NWA of 1998 is the principle that water is a scarce natural resource that belongs to all of the people of South Africa, and that it must be used beneficially and in the public interest.

By 1998, South Africa had a new water law which, after almost two centuries of one based on riparian rights, returned the control of all water resources in the country to the State. Government, acting through the Minister and the Department, was declared to be the public trustee of the nation's water resources, and all water, wherever it occurs in the water cycle, now enjoys a consistent legal status.

The Act is premised on balancing the three legs of social benefit, economic efficiency and environmental sustainability, and sets out the legal framework for the national government to protect, use, develop, conserve, manage and control water resources in the country. It also incorporates the principle of subsidiarity – management of water resources at the lowest appropriate level – through catchment management agencies (CMAs).

The Act provides the means to protect the integrity of aquatic ecosystems, which are acknowledged to be the resource base on which the sustainable use of water resources depends, by means of an integrated system of water resource protection that includes a Water Resource Classification System, the Ecological Reserve, and Resource Quality Objectives. The Ecological Reserve and Resource Quality Objectives depend on the Management Class at a water resource, and the class, in turn, reflects the outcome of stakeholder consultations in terms of the needs of the users of the water resource and the agreed water requirement for the aquatic ecosystems.

The South African National Water Act (Act 36 of 1998) was hailed by the international water community as one of the most progressive pieces of water legislation in the world.

A significant part of the WRC's research portfolio has been dedicated to supporting the implementation of South Africa's water policy, which is entrenched in the National Water Act and the Water Services Act. The country's water policy centres on promoting equitable access to water services, the sustainability of water resources, beneficial use of water, safe supplies of water, and tackling water-centred issues which relate to social development and growing the economy.

The WRC's role in informing policy and decision-making of the early wave of policy reform

The WRC played a critical supporting role in much of the work leading up to the national water policy of 1997 and the drafting and early implementation of the NWA. The organisation also helped to mobilise significant in-country capacity in the water sector to support the water policy and processes involved in promulgating the NWA.

Many years of cutting-edge WRC-funded research had no place in the water legislation that preceded the NWA, but it was sufficiently advanced to be taken up into the new water law principles, the policy and the NWA. These include, explains former WRC Research Manager, Dr Heather MacKay, studies in the areas of environmental flows, integrated catchment management and small-scale irrigation. The WRC was also able to fund consultancy research projects or initiate directed research projects to assist with various technical aspects and questions that arose during the drafting process.

"There is no doubt in my mind that in the lead up to the 1997 water policy (which was really a period of about 15 years, with a window of political opportunity to effect change opening from 1994 to 1996), the WRC laid the foundations for water policy which was well grounded in science; in other words, research-based policy," says Dr MacKay. "The fact that the WRC was so good at addressing long-term issues during the years from 1971 to 1995 is why we were in such a strong position to deliver high-quality, technical policy and legislation with in-country capacity from 1996 through 2000."

The WRC continues to support the development of management competence to facilitate the NWA's implementation and a number of projects were embarked upon to help people understand the new concepts that it entailed. Some of these include the following:

- It has become critical to clearly establish existing lawful water entitlements; hence the urgency of providing a consolidated source of information on previous legal decisions and judgments with respect to water. A remedy has been found through the compilation of a comprehensive work that brings together all facets of water law during the greater part of the 20th century, from 1912 up until the promulgation of the NWA.

- The right to sufficient water cannot be denied, and is enshrined in the South African Constitution. Yet, the new constitutional rights are not yet fully understood by the spectrum of stakeholders. The WRC has embarked on a number of studies to close this gap. A major achievement is the human rights framework, a succinct, accessible presentation of an array of complex human rights principles that have key practical uses for those involved in WRM and service provision.

- A number of WRC studies have investigated the feasibility of the Free Basic Water (FBW) policy. It affords a basic amount of water to each South African household free of charge. Enshrined in national water policy, it can only be implemented by the provincial government. Studies have suggested that with good management, FBW would be sustainable in the long-term as long as national government provides sufficient levels of equitable share revenue to municipalities.

The profound changes to water policy and law in South Africa were as a result of, and were enabled by, the equally profound changes in the political dispensation. The measures to protect aquatic ecosystems in the NWA are a significant improvement on those in the previous legislation, and the Act is acknowledged to be one of the most progressive in the world in this respect.

The NWP and NWA clearly established a new kind of vision and a radically different way of conducting the business of natural resource management. The policy and legislation are far more sophisticated and complex than anything which existed previously; the implications for the roles of government, civil society and professional service providers are profound.

Yet, 16 years down the line, it is evident that implementation of the Act has been only partially successful. In an article published in *Water Alternatives* in 2013, former Deputy Director-General: Policy and Regulation of the Department of Water and current Chair of the WRC, Barbara Schreiner, discusses some of the challenges facing the implementation of this remarkable piece of legislation and the failure to achieve the initial high ambitions within the South African water sector.

"The NWA was hailed internationally as the Rolls Royce of IWRM legislation. But implementation has proven extremely difficult," notes Schreiner. "It would, perhaps, have been better to write a Volkswagen piece of legislation, one that is more suited to the technical and human resource capabilities of a developing country."

She went on to highlight that, in the process of implementing a sophisticated and nuanced piece of legislation, many of the basics like maintaining the monitoring infrastructure, and ensuring compliance with licence conditions, have been poorly addressed. "Where there is limited capacity, which is true in all developing countries, it is, in my opinion, better to focus on the key challenges in the particular context, than to strive to do it all at once."

The Department is currently amending the NWA to address some of the challenges that have arisen during implementation over the past 15 years. And the WRC, at its side, continues to provide the necessary scientific evidence to complete the picture.

The WRC has also informed various other water and related policies subsequent to the NWA.

"The NWA was hailed internationally as the Rolls Royce of IWRM legislation. But implementation has proven extremely difficult."

– Barbara Schreiner WRC Chair

Research in areas such as the Inkomati catchment has contributed significantly to water resource management in South Africa.

SA's Free Basic Water policy provides for 6 kilolitres per household per month free of charge.

Free basic water

Apart from issues such as water resource limitations and induced scarcity, South Africa has specific challenges relating to inequities in the physical, social, administrative as well as institutional access to this important resource. This applies especially to the poor and disempowered majority, whose ability to pay for water is limited and who don't have water allocations.

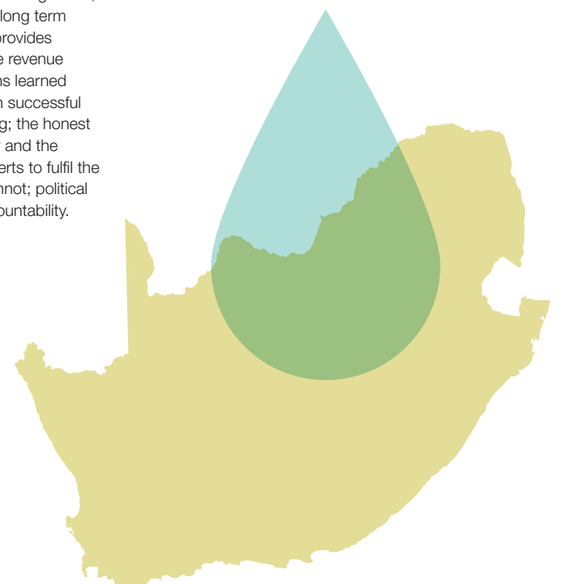
As part of its strategy to alleviate poverty in the country, the South African government announced a policy for the provision of free basic water to all in 2000 to ensure that no one was completely denied access to water supply because they were unable to pay for the service. This consisted of providing 6 000 litres per month free of charge to each household.

When the South African government started rolling out its FBW policy in 2001, critics argued that it was not feasible, especially in poor rural municipal areas. However, a WRC-funded study in 2005 found that FBW could work.

The WRC study, concluded in 2005, investigated the rollout of FBW in rural areas. Five areas came under the spotlight – uThukela Water Partnership and Vulindlela Water Project in KwaZulu-Natal; Alfred Nzo District Municipality and Ngqushwa Local Municipality in the Eastern Cape; and Nhlungwane Water Project, a small community-run scheme in the uMzinyathi District, in KwaZulu-Natal.

From the case studies it was concluded that, while difficult, implementing FBW in rural areas remained feasible. A common factor in efficient, cost-effective provision of FBW was found to be the contracting of organisations with the necessary expertise to successfully manage water provision within a budget by local authorities without sufficient own capacity.

FBW in the rural areas of South Africa is difficult, but possible. With good management, FBW could be sustainable in the long term as long as national government provides sufficient levels of Equitable share revenue to municipalities. From the lessons learned in this research, the key factors in successful implementation are good planning; the honest assessment of the WSA capacity and the consequential contracting of experts to fulfil the roles and responsibilities they cannot; political support for FBW policy; and accountability.



Receiving the IWA Award for Project Innovation in 2008 are Jay Bhagwan of the WRC, Mziwabantu Ramba of Emanti, Dr Rivka Kfir of the WRC and Grant Mackintosh of Emanti.

Translating policy into practice: Water and sanitation guidelines and tools

Improved water quality a click away

Innovation in water and wastewater treatment and supply has been a WRC focus since its establishment in 1971. In the years following South Africa's democracy, water service delivery became the responsibility of many newly formed municipalities, who faced severe challenges in water and wastewater treatment and supply. It became increasingly evident that more had to be done to relieve the plight of especially poor, rural communities.

This prompted the WRC to develop a growing number of guidelines and tools designed to assist municipalities to explore ways of addressing these challenges. The guides deal with topics ranging from selecting the right water or wastewater treatment technology to improved operation and maintenance.

One of the most popular of these is the international award-winning eWQMS *(electronic Water Quality Management System),* which many municipalities are now using successfully to help manage their water and wastewater treatment processes.

The efforts of the Department of Water to improve municipal drinking water quality have scooped national and international awards. The department, along with the Institute of Municipal Engineering and Emanti Management, was recognised internationally for the development of an electronic water quality management system (eWQMS) rolled out to all 166 municipal water services authorities in South Africa.

The eWQMS development team received the International Water Association's Global Project Innovation Award in the Operations/ Management category in Vienna, Austria in 2008, after winning the regional awards. The awards recognise excellence and innovation in water engineering projects throughout the world.

Rollout of the open source, Internet-based system started in 2006. Today, around 95% of WSAs provide drinking water data on a monthly basis. Water quality and other water service information is captured and stored on the central database. This information can then be easily retrieved via the Internet to generate reports, tables and graphs for management review and decision-making processes.

It is reported that the use of the system has contributed significantly to an improved level of awareness of drinking water quality matters, a growing improvement in effective drinking water quality management and a direct improvement in drinking water quality provision across South Africa. In one case, for example, a municipality's compliance to the national drinking water standard increased from 64% to 94% four months after it starting using the eWQMS.

In May 2008, Emanti Management also won the National Science and Technology Forum Award for Category E (Innovation developed through a small, medium or micro enterprise) for the eWQMS. Later that year the company received international recognition when it, together with the DWS and the Institute of Municipal Engineering of Southern Africa won the International Water Association's Project Innovation Award in the Operations and Management Category.

Help for small water treatment plants

Water infrastructure in South Africa is generally well developed in urban areas. However, rural water treatment plants often experience technical and management problems leading to the production of drinking water of an inferior quality with potential health consequences for affected communities. To address this problem, the WRC funded a study involving 181 such plants (mostly municipal owned) across seven provinces. The goal was to determine the nature and full extent of the problems in order to provide practical and user-friendly guidelines for intervention.

The study, led by Prof Maggie Momba from TUT, gathered information on the methods of disinfection applied, equipment employed, performance of the treatment plants, knowledge and skills of the operators as well as other technical and management issues, among others. The study shed significant light on the challenges hampering the performance of the country's small water treatment systems. The primary reasons for the failure of these plants included inappropriate technology, poor operation, lack of training, municipal financial constraints, lack of motivation of operators and lack of knowledge of basic water treatment operations.

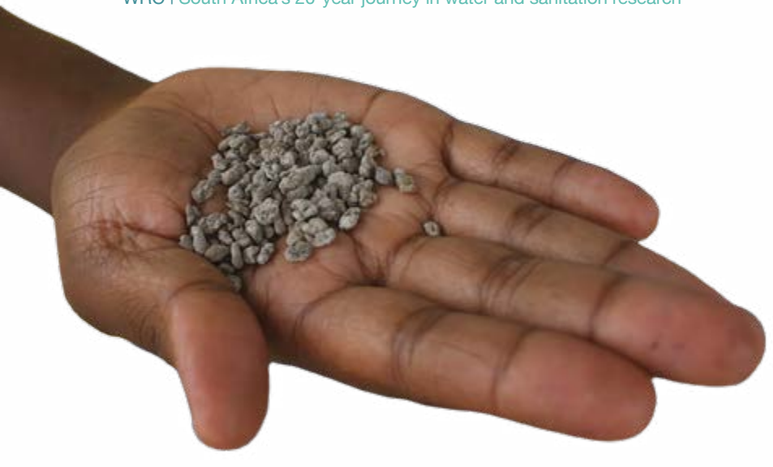
The resultant guidelines describe methods and processes for tackling some of these problems experienced at small water treatment plants. Practical solutions are offered, with emphasis on the multiple-barrier approach to optimising disinfection. In addition, the survey results have been shared with relevant stakeholders with an emphasis on the areas where water quality problems are being experienced. Nationwide workshops on the emergency disinfection of drinking water have also been held.

An illustrative training kit for rural water treatment plant operators is now available from the WRC, the end-product of a series of on-site mobile training of 26 operators from seven different small water treatment plants in the Eastern Cape. It emphasises why each step in water treatment is important for the sustainable production and delivery of safe drinking water and how to check the performance at each stage.

WRC research is aimed at improving access to safe water quality for communities.

"It is important that everyone in the water sector works together to assist municipalities to provide the best quality water to their communities."

– Prof Maggie Momba



Compost made from sanitised wastewater sludge.

"Much is already being done to improve drinking water quality in rural areas," notes Prof Momba. "It is important that everyone in the water sector works together to assist municipalities to provide the best quality water to their communities."

From waste to resource

Increasing population levels and high urbanisation rates, along with international trends to view sludge as a resource rather as a waste material, have underlined the importance of finding new, safer ways of managing wastewater sludge sustainably. Mismanaged wastewater sludge can have a considerable negative impact on the environment and human health.

Sludge management guidelines, developed with funding from the WRC in collaboration with the Department of Water, is playing a significant role in growing the status of wastewater sludge as a valuable resource. They provide guidance on the selection of appropriate disposal options, but also create an understanding of operational and legal requirements for different disposal options. The guidelines also recommend the beneficial use of the sludge where possible and sludge disposal is seen as a last resort.

The guidelines show great promise in improving the management of wastewater sludge. The City of Cape Town set a sterling example by using sludge for composting, land application, and palletisation, which has resulted in significant cost savings for the city.

A sludge drying bed.

The application of wastewater sludge to arable land is an effective method to dispose of wastewater sludge, and there are examples in South Africa where this is not only proving beneficial to the municipalities concerned, but also to end-users. In the Swartland in the Western Cape, the land application of wastewater sludge has significantly improved the nutrient and moisture content of the soils and farmers have been able to realise profitable yields from previously unprofitable areas.

The cost-benefits of using wastewater sludge for brick-making and fertiliser manufacture were also studied. The reuse of sludge in this way could not only have environmental and human health benefits, but could also assist in the creation of much needed jobs, specifically for semi-skilled people.

Conclusion

Today, the water and sanitation sector is undergoing substantive changes in its policy landscape. More recent policy developments include the amalgamation of the NWA and National Water Services Act, as well as a revision of the Water Research Act.

The National Water Amendment Bill was tabled in Parliament in February 2014 in order to clarify departmental roles relating to water use licences applicable to prospecting, exploration, mining or production activities. The Bill, which will amend the National Water Act (1998), is required to provide for an alignment and integration of the process for consideration of water use licences due to recent amendments to related legislation including the national environmental laws. In recent years, the WRC has coordinated a Policy Review, and has also engaged with many stakeholders to explore the implications of the National Water Amendment Bill for water R&D needs.

Similarly, the Water Research Act (No. 34 of 1971) has been amended to include textual improvements and name changes. The draft Amendment Bill is well considered and incorporates all of the comments that have been offered to date. The Bill, in the manner in which it sets out the compliance clauses, captures a good balance between creating an enabling environment and ensuring the correct legislative checks and balances.

Finally, the WRC has also been heavily involved in the implementation of NWRS II, which has made a significant shift to a knowledge-based paradigm, as reflected in the consultations as well as the gazetted NWRS II, and calls for a much larger contribution from R&D to empower the implementation of the strategy. In addition, the strategy also engages the further development of water sciences in South Africa. One of the key deliverables that the NWRS II emphasises is the Sector Research and Innovation (R&I) Strategy. In support of this, it is incumbent upon the WRC to coordinate the development of the National Water R&D Plan, the latter also emphasised in the Water Research Amendment Bill.

"We have, at last, achieved our political emancipation. We pledge ourselves to liberate our people from the continuing bondage of poverty, deprivation, suffering, gender and other discrimination."

- President Mandela, Inauguration Speech, 10 May 1994

Chapter 2

The water research journey of transformation

As well as supporting the transformation of the South African water sector, the WRC, as the country's premier water knowledge broker is continuously reviewing its effectiveness against government objectives.

Water Research Commission Chairpersons 1994-2014

- AJ Raubenheimer, 1994
- Colin Johnson, 1995-1998
- Prof Kingston Nyamapfene, 1999-2000
- Dr Hamanth Kasan, 2001-2005
- Dr Snowy Khoza, 2006-2008
- Prof Janine Adams, 2008-2011
- Barbara Schreiner, 2012-2014

The first democratic decade and its impact on research

Since 1971, water-related research and development on behalf of the government and water sector of South Africa has been vested in the Water Research Commission (WRC). Funded in terms of the Water Research Act of 1971 through a levy on water use, the WRC reports to Parliament through the Minister of Water. The WRC commissions research to address identified needs and disseminates resulting knowledge with a view to solving water-related problems. The WRC also plays a key role in capacity building in the water sector. The objectives of the WRC, as stated in the Act, are to co-ordinate, promote and encourage research in respect of a wide range of purposes and activities. The WRC has therefore been the key shaper of the national water and sanitation R&D agenda since its inception.

A WRC project conducted scientometric analyses of the water research landscape and concluded that South Africa has undergone significant changes in the output and structure of water research over the past few decades. There has been substantial growth

Former CEO of the WRC, Dr Rivka Kfir, with then Minister of Water, Ronnie Kasrils, in 2003.

in output with a total relevant sample publication record of 6007 articles and research reports and a current annual output of over 350 articles and reports per year. The number and sources of journal articles over this period have increased and diversified while WRC research report output has also increased.

This study also pointed out that two reasonably distinct research paradigms and two transition periods have emerged between 1977 and 2011. The first paradigm occurs in a period dominated by the quest to supply water, which is interrupted dramatically by changes in the political landscape. The Constitution, the NWA among others, and the shift in the national balance of power, introduce the next paradigm shift and an emphasis on integrated water resource management. This new paradigm is characterised by a research effort that is centred on new themes and concepts such as sustainability, community, governance and adaptation. The shift from the 1980s, once dominated by research efforts that focused on treatment, technical interventions, chemistry and so forth, now features research interests, themes and approaches such as integrated water resource management and multidisciplinary studies in water research.

In terms of the WRC journey, the period 1994 - 2000 brought with it a host of institutional transitions. In 2001, Executive Director Dr Piet Odendaal retired after a long and distinguished career in the national and international water field.

The year after Dr Odendaal's retirement, Dr Rivka Kfir was appointed as CEO in July 2001, with a clear mandate to transform the organisation. In December 2001, Dr HC Kasan was appointed as the new Chairperson of the Board.

From 2001 to 2002 the foundation for a strategic journey of organisational transformation was laid, a journey with a clear target of turning the organisation into a dynamic and innovative 'hub' for water-centred knowledge; a networking organisation linking the nation's stakeholders in water and working through partnerships. This was achieved via a process of 'business transformation'.

The new vision of the WRC was formulated: to be a globally recognised leader in providing innovative solutions for sustainable water management to meet the changing needs of society and of the environment. The key to this transformation was being relevant and effective, supporting both the creation of knowledge, by funding research and development, and the transfer and dissemination of the knowledge created. Dissemination of knowledge required an appropriate, sustainable knowledge base that would be effective in its ability to absorb new knowledge.

Under the leadership of the Board, the WRC revised its funding strategy and developed a new mode of operation, transforming its 17 research fields into five key strategic areas with an additional four crosscutting domains.

Four water-related KSAs were identified – water resource management; water-linked ecosystems; water use and waste management; and water use in agriculture. The fifth key strategic area, water-centred knowledge, focused on the widest possible dissemination of existing knowledge relating to water. The research thrusts of each key strategic area support, directly or indirectly, the country's water policy.

Between 2003 and 2010, the WRC supported various knowledge-centred activities aimed at improving South Africa's ability to appropriately address future water problems in the short to the long term. It addressed issues such as water for all, quality of life, and environmental sustainability, which are part and parcel of South Africa's national priorities and require considerable attention. The WRC also welcomed two Board Chairs in this period: Dr Snowy Khoza (2006-2008), the first black woman chairperson of the WRC, and Prof Janine Adams (2008-2011), a former WRC-funded postgraduate student that has walked two decades with the WRC through her research.

In addition, the WRC led numerous studies on strategic and implementation issues arising from recent water legislation, including the strategic approach to integrated water resource management, the recognition of water as a basic human right and the resultant free water policy, as well as the right of the aquatic environment to its sustaining share of water (the Ecological Reserve).

research focus areas

5

The WRC's five key strategic areas in 2000 were water resource management, water-linked ecosystems, water use and waste management, water use in agriculture and water-centred knowledge

WRC CEO, Dhesigen Naidoo (far right) with former Water Parliamentary Portfolio Committee Chair, Johnny de Lange and former Minister of Science & Technology, Derek Hanekom at the WRC Symposium in 2012.

The Second Democratic Decade: The Knowledge Tree era

The country is a remarkably different place than it was in 1994, characterised by the rollercoaster ride of divided experiences witnessed in the last 20 years. Additionally, the sector is in a state of flux. The legislative and policy environment is undergoing major changes, most notably the amalgamation of the sector's key pieces of legislation, the NWA and the Water Services Act, which could profoundly change the way the sector operates. In May 2014, we have seen the ushering in of a ministry unifying water and sanitation, and also the appointment of the Honourable Minister of Water and Sanitation, Ms Nomvula Mokonyane, and Honourable Deputy Minister, Ms Pamela Tshwete.

In a very similar vein, the WRC is a very different organisation to what it was 20 years ago, with a greater focus now on impactful research that informs policy, transforms the sector, capacitates a younger and more representative cohort of water and sanitation scientists, empower communities, and develops products and services for economic development.

The appointment of Dhesigen Naidoo as WRC CEO in 2011 was another turning point in the WRC's history and strategic orientation. In this period, the WRC adopted the concept of the water science and technology (S&T) Knowledge Tree and the Transformation Bridge as its main strategic planning objectives. This entails moving South Africa from a resource driven economy to a knowledge economy with a successful water industry; science driven policy, decisions and actions; and a larger more diverse water community. Additionally, these planning tools also signify the need to move from a focus on knowledge generation to impact.

Today, the South African water science sector is relatively strong, ranking 18th in the world in terms of research publications and the WRC has been a catalytic agent in this regard. We have also seen the positive impact of the WRC dialogues as a glue factor in bringing together diverse stakeholders on various issues related to water. The WRC's partnership record is also a high point.

Despite these achievements, South Africa continues to be burdened by significant market failures in the water innovation value chain. The WRC remains under-funded, and its impact and implementation visibility is limited to specific segments of the water sector. Additionally, the WRC's internal systems and knowledge management strategy are being strengthened to absorb a broader and deeper portfolio approach, and to ensure that the knowledge generated is accessible to all parts of society.

From 2011 to the present, the WRC has focused its attention on developing its impact narrative that provides a pathway from research to impact (What is our impact story? How are we relevant to everyone else?). This entails a review of current actions and activities as well as the identification of new actions that will ensure impact realisation.

But one thing that has not changed is the fact that South Africa is a water-scarce country. Even in the parts of the country where rainfall figures are more favourable, climate and weather variability has added to the availability challenges, with periods of intense flooding interspersed with long dry periods. This has made storage difficult and assurance of supply hard to attain.

Water and sanitation services remain core challenges of our time globally, and particularly for South Africa's growing political economy.

"Empirical evidence suggests that not only does the academic enterprise of science in the water sector not diminish through an increased focus on socio-economic development on the core issues of a developing country such as ours, but may even derive enhanced benefit from this orientation. It perhaps describes a pathway to South Africa eventually becoming a global hub of excellence in water development science."

– Dhesigen Naidoo, WRC CEO

Today, the South African water science sector is relatively strong, ranking 18th in the world in terms of research publications and the WRC has been a catalytic agent in this regard.

research budget
75%

75% of WRC's total annual budget goes towards supporting research

Yet while South Africa has met the MDG targets in these areas, our primary goals remain that of universal access to safe and sustainable water and sanitation services to all in South Africa as well as water infrastructure to support new entrants into the economy.

'MaDhlamini,' the iconic symbol of black, rural or peri-urban women that bear the highest burden with regards to water and sanitation delivery, remains unserviced. The change in fortune for MaDhlamini with the achievement of universal access to sustainable water and sanitation services in South Africa should be one of our main priorities.

Rather than be paralysed by these challenges, the WRC now regards these as opportunities for innovation. For the WRC, the challenge is to get useful information to MaDhlamini that can influence and aid service delivery interventions. Over the past few years, the WRC has worked to provide more information to MaDhlamini; provide more appropriate information to her; but also look at the solutions that she can use to help her. This requires an expanded knowledge dissemination strategy beyond the confines of the water and sanitation research and policy communities. It also requires a closer look at game-changers such as: 1) How RDI can strengthen the role of local government in service delivery; 2) How to enable the water and sanitation policy environment; 3) How to increase community involvement in RDI solutions; and 4) How to strengthen R&D partnerships with the private sector to unlock growth and development in the water and sanitation sector.

The WRC embraces this new paradigm in its current strategy. The project portfolio gives effect to the notion of water as a Strategic National Asset from the basic planning regimes of water sensitive design to the mining of freshwater and valuable minerals from acid mine water. The notion can be applied from developing sustainable low/no-water safe sanitation solutions to women-led small scale agriculture initiatives, and from research to empower the notion of ecological infrastructure as a key element of water infrastructure, to novel governance mechanisms to encourage wider empowered participation.

This, the WRC does this in partnership with South Africa's small but highly productive water and sanitation R&D community, the dedicated South African water practitioners, the prudent water users and our friends around the world in the quest to ensure the reality of universal access to water and sanitation services. Indeed, the expanded partnership model is key to ensuring that water and sanitation innovations succeed being pulled through the entirety of the innovation value chain.

The WRC recognises the need for the status of South Africa's water to be elevated to the core of the public agenda, and that advanced management practices should be applied and implemented to address the increasingly complex business of water resource

development and management. From 2012 onwards, the WRC has reinforced its efforts to fund appropriate research projects aimed at actively informing both policy development by government partners and decision-making by all parties in the water sector.

A shift in focus in the WRC's span of research

A notable development of the years between 1994 and 2000 was the shift in focus in resource allocation – from a bias in favour of the 'hard sciences' and engineering, to the 'softer' issues that have more immediate and direct benefits for communities. Research projects on softer issues permeated fields such as rural water supply and sanitation; water policy; water services (institutional and management issues); integrated water Resource Management; and Health Related Water Issues which, together, received 24% of the WCR research budget by the year 2000.

This figure reflected the WRC's serious commitment to South African citizens' right of access to sufficient (and clean) water, as enshrined in the Constitution and articulated in the Water Services Act.

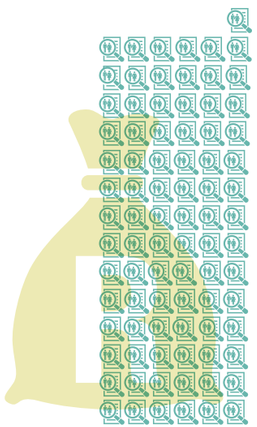
Compared to historical patterns, significantly larger amounts of funding (27%) were allocated to the closely linked cluster of research fields which aimed to protect the water environment and its associated water quality in order to promote sustainability.This cluster included the conservation of water ecosystems; water quality management; municipal wastewater treatment; and mine-water management.

The generous allocation of 8% to groundwater research reflected the Board's concern about this important, but at the time somewhat poorly understood and managed resource. In addition, 18% of the research budget was allocated to research activities targeted at addressing the perpetual quest for new ways of improving water-use efficiency across all areas of use.

The WRC's current investment in R&D from 2011 to the present is mainly through research projects and programmes in the directed (33%) and open (66%) categories. In accordance with the WRC's funding cycle, research proposals are invited on an annual basis, however, in more recent years, the WRC has expanded its portfolio as a result of increased leverage funding, which has necessitated the development of out-of-cycle Calls for Proposals.

Delegates Aidan Choles and Prof Tally Palmer at a WRC social science research workshop in 2013.

A notable development of the years between 1994 and 2000, was the shift in focus in resource allocation – from a bias in favour of the 'hard sciences' and engineering, to the 'softer' issues that have more immediate and direct benefits for communities. The more recent emphasis from 2011 to the present incorporates this focus and stretches it further to prioritise transdisciplinary research and the inclusion of social science and humanities research projects.



research portfolio

R160m

In 2013 the WRC supported 85 social research projects worth R160m.

AWARD

Following the WRC's transformation issues such as the inclusive governance of water resources have received increased attention.

New funding model demands an increase in international income

The WRC's 2002 funding model ensured a greater emphasis on internationalisation. Leveraging income for the creation, sharing and dissemination of water-centred knowledge meant that the WRC had to leverage income by striving to obtain funds from other sources to support water research. Leveraged income had to be obtained from both local and international sources, where the main source of income was due to support by various government departments for specific research and other knowledge-sharing projects. Other sources of income increased steadily from the transformation that began in 2001 and amounted to about 15% of total income by 2007, continuing to grow thereafter. By 2013, the leverage figure had increased to 10% of total income.

Noting the increasing demand for R&D funding and other WRC services in South Africa's water sector, the WRC needs to explore ways of increasing its funding streams. Some of the current realities for the WRC are:

- Limited R&D funding – The WRC can currently only fund 1 out of every 3 proposals that are recommended by the peer review process,

- A highly productive but very small community of practice - Limited support for emerging researchers (historically disadvantaged researchers),

- Limited support for capacity building (student support),

- Research currently limited to basic and applied research, limited scope for innovation support,

- Low levels of R&D participation by most players in the water sector,

- Low uptake/implementation of research outcomes (including technology development, piloting and demonstration).

Given these challenges, one of the WRC's special emphases post-2011 has been to substantially increase the resources available for water R&D in South Africa through a revised funding strategy. The following mechanisms are being engaged:

1. Exploring the feasibility of securing a dedicated Parliamentary Grant for the WRC as enabled by the Water Research Act.
2. Exploring the diversification of funding through new and increased resourced partnerships with the public and private sectors as well as foundations and donor agencies, including foreign direct investment. Public private partnerships will be explored through formal arrangements.
3. Providing directed support to the R&D community to better enable our collective ability to be more successful in gaining access to international competitive funds for water R&D.

research budget

44%

Currently about 44% of the WRC's current budget is focused on water resources and about 56% on projects that focus on water utilisation

Additionally, the WRC's strategy from 2011 to the present has been devoted to achieving a multiplier effect in WRC projects. As a guiding framework we have constructed for ourselves the 'WRC Knowledge Tree'. The tree metaphor reflects strength in foundation (i.e. roots firmly embedded in sound knowledge) and strong growth (i.e. branches and leaves growing vigorously). Every WRC project will strive to achieve as many of the WRC Knowledge Tree outcomes as reasonably possible. This applies within the project, to post-project actions, and to follow-on projects.

The core of our value proposition to the South African water sector, and, in particular, to the South African public, is that from the knowledge generated in the WRC project portfolio we are able to contribute to sustainable development, inform policy and decision-making, contribute new products, technologies and know-how to grow the economy, and build human capital and entrepreneurship with the aims of direct empowerment of communities and taking forward the national transformation agenda.

Another key pillar of the WRC's post-2011 strategy has been research concentration for accelerated knowledge and solution development. The construct of the WRC Lighthouse is a strategic tool that is used to direct research in key areas identified by the WRC. These Lighthouses are flagship programmes, and are trans-disciplinary, multi-KSA and inter-institutional mega-projects that examine priority water issues across the innovation value chain. The WRC actively seeks to direct key projects into these programmatic areas.

The five lighthouses include:

1. Water Sensitive Design
2. Climate Change
3. Water–Energy–Food Security
4. The Green Village
5. Freshwater Governance

The WRC's five Lighthouse programmes address climate change, water governance, water-sensitive urban design, the Green Village and the water-energy-food nexus.

Making water knowledge accessible

Management of knowledge within the WRC entails all the processes associated with the identification, sharing and creation of knowledge.

The WRC produces a number of publications aimed at realising this vision, and there is an increasing focus on offering these products in an electronic format. Completed research products are published in the form of WRC reports, which are available for free through the WRC website or publications department.

Water SA is an WRC's accredited scientific journal which contains original research articles and review articles on all aspects of water science, technology, engineering and policy. The journal has been in publication since 1975 and includes articles from both local and international authors. Issued quarterly, it is now published mainly as an e-journal with open, free access to the published information since April 2005. In 2009, access to *Water SA* was further enhanced with the completion of the process of digitising all back copies, creating an online archive of the entire *Water SA* collection, dating back to its very first edition in 1975.

Conveying water research in a popular scientific manner to different interest groups in the water field has always been a WRC priority. This role is fulfilled by *The Water Wheel*, a magazine aimed at improving general public understanding of science and technology.

Published six times a year, *The Water Wheel* had its origins in the transformation years of the WRC when the original newsletter, *SA Waterbulletin*, was revitalised to reflect a new image and a new beginning. The name symbolises the WRC as a dynamic hub for water-centred knowledge, and this is reflected in the fact that the magazine boasts more than 8 000 subscribers, making it the most widely read sanitation- and water-related publication in the country in terms of distribution, and one that is read as far afield as Kazakhstan!

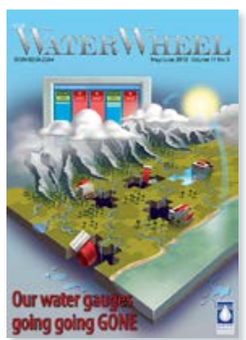
The younger generation has not been forgotten, with a special section dedicated to them in *The Water Wheel,* named *Water Kidz*, which deals with a variety of topics ranging from biodiversity to health and hygiene. The WRC also publishes special editions of *The Water Wheel* aimed specifically at children. The most recent publications aimed at a young audience include a cartoon-style water-related activity book published in 2013 in collaboration with the CSIR, and the *Water@Work Career Guide.*

The WRC's annual *Knowledge Review* is aimed at giving stakeholders a complete overview of its fund management, research portfolio, capacity-building initiatives, investment in the generation and transfer of knowledge, and operational activities of the preceding year. Specific examples are given where research has led to improved technology, decision-making and operational management in terms of the current five KSAs.

Conveying water research in a popular scientific manner to different interest groups in the water field has always been a WRC priority.

Student participation is an important element of WRC research.

The *Water Wheel* is widely read, counting school teachers, farmers, church environmental groups and members of the portfolio committee among its readers.



Members of Parliament engaging in the 'People's Parliament' (from left) MP Advocate Johnny de Lange, MP Ms J Manganye and MP Ms P Bhengu.

The WRC Knowledge Hub

Increasingly, the WRC is focusing on the electronic distribution of information and a strong Web presence. Today, this has developed to such an extent that a fully functional, content-based, searchable website is offered, containing all WRC documents including annual reports, knowledge reviews, *The Water Wheel, Water SA*, technology transfer reports and all other research reports. These are all searchable and contained in the knowledge hub. The website forms part of a larger drive to develop an electronic water knowledge hub, which will be a world-class digital water information centre. Additionally, through the WRC Knowledge Hub, we provide free access to over 6 000 resource material items.

Policy Briefs

Policy-makers often need to rapidly react to the public, the media, as well as various structures within government. At the same time they also need a solid basis to develop their own initiatives within their field of responsibility. Short written briefing notes help to improve the legislative assistance to policy-makers and strengthen their competence in this respect.

The WRC publishes policy, ministerial and technical briefs on various research findings, and topical issues of national relevance. Briefings can be requested on an ad-hoc basis from the WRC along with the more extensive reports that have been written on a particular subject.

Assessment and research capacity

Given the WRC's wealth of scientific research within the WRC funding portfolio, as well as the fact that the WRC employs technical experts in domains spanning the entire water and innovation value chain, the WRC is able to provide rapid regulatory impact assessments of policy proposals or examine the state of implementation of existing legislation.

Dialogues and events

One of the newer instruments that the WRC has launched to very favourable result has been the WRC Dialogues. The WRC Dialogues are discussion-based events on topical water issues affecting the South African public, the aim of which is to serve as a platform to exchange ideas and opinions related to water. In this regard, the WRC Dialogues are guided by the principles of transparency, openness and honesty; plurality of perspectives and inclusivity, mutual respect; a commitment to problem-solving and mutual accountability; and in the broader interest of knowledge sharing. The value of the WRC's role as convenor of these events lies in its ability to be a neutral knowledge broker as South Africa's premier water knowledge resource.

The WRC, in partnership with the then Parliamentary Portfolio Committee (PPC) on Water and the Environment, organised a public engagement dialogue with parliamentarians on the *Future of Water in South Africa and the Role of the Scientific Community of Practice* in September 2013.

The Dialogue provided a platform for open engagement between the scientific community and parliamentarians to better understand each others' roles in ensuring the sustainable management of water in South Africa. It also looked at the role of other key entities such as the WRC as a key knowledge broker between science and policy, and interrogated how the WRC can better facilitate communication.

The 'People's Parliament' as it fondly became known, surprised all expectations in attendance and the richness of the discussion due in large part to the informal nature of the dialogue and by providing a safe space for all to debate. Indeed the highlight of this session

MP Adv Johnny de Lange, and MP Ms J Manganye.

was the way in which the chair, Advocate Johnny De Lange, (Chairperson: PPC on Water and Environment, Parliament of the Republic of South Africa) encouraged the participation of a wide range of stakeholders on various issues.

One such issue pertained to equity in water and the fragmentation of the constitutional and legal framework in the water sector. This discussion focused on the need for a model to pull all mandates together, including the funding model of the water sector. The issue of governance was also addressed in terms of the need to draft regulations that align policies.

Additionally, a question was posed: "Do we need more scientists in Parliament or more parliamentarians interested in science?" Here, the discussion centred on the need for water science to be more focused, and able demonstrate how it benefits society and the vast majority of South African people. This discussion also alluded to the need for improved communication between scientists and members of Parliament. The WRC was encouraged and challenged to be the information-sharing tool of R&D to parliament.

Apart from this being the first type of interaction between legislators and water scientists outside the hallowed halls of Parliament, it gave resonance to the very important notion of creating a sustainable dialogue between the science community and political decision-makers. Much has been said and written about the knowledge chasm, where on the one side you have scientists claiming that they have many of the scientific solutions needed to address South Africa's water challenges, and on the other side the decision-makers and water users feeling insufficiently supported by science to enable better and smarter management of our precious water resources. This has led to the knowledge chasm being described as the void between scientists, who feel that they are not heard, and a society and economy that says that they are not adequately served by science.

The People's Parliament was a cornerstone in the bridge across the chasm. Both parliamentarians and scientists very quickly converged on the core issues defining the national water challenge, and with amazing efficiency, to the surprise of the many who expressed reservations on the potential success of the exercise, found resonance on many of the positions.

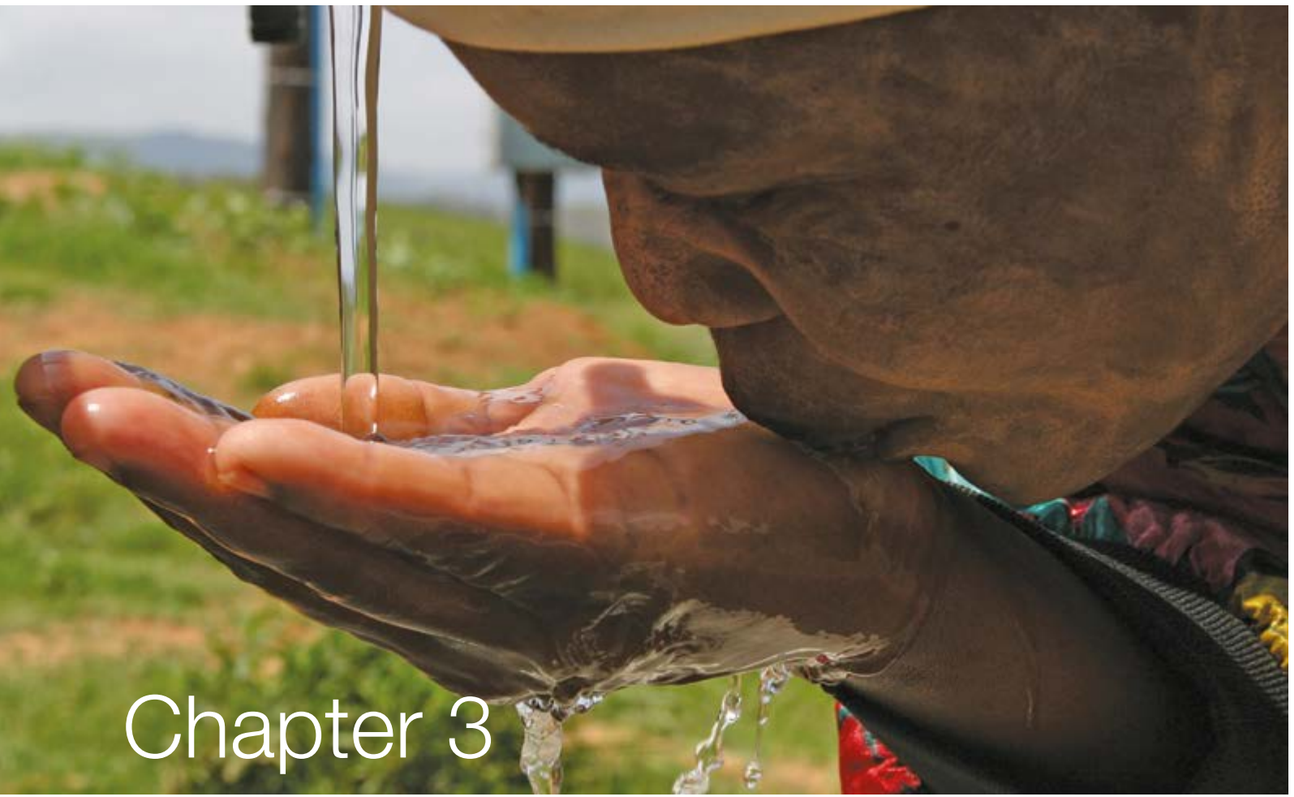
We should take our hats off to both to the MPs and the truly remarkable candour in which they approached the dialogue, and the remarkably constructive nature in which the scientists unpacked the challenges and the scientific solutions. The PPC also expressed their pleasure at the great progress this water science community has made to ensure that the pursuit of science is increasingly resulting in positive socio-economic outcomes and impacts, as enunciated in the WRC Knowledge Tree.

WRC continues to spread its wings 2004-2014

The organisation has spent the last ten years consolidating its position as a strategic, dynamic, water-centred knowledge hub, to serve South Africa in the first instance. Increasingly, it is proving to be a credible role-player in Africa as well as globally, thereby enhancing South Africa's position internationally. The WRC recognises that it is just one entity in the water innovation value chain in South Africa. We therefore recognise the importance of partnerships and actively build our partnership profile for informing priorities, leveraging funds, developing research products and services and transferring knowledge.

It is through co-ordination, co-operation and communication in water R&D that the WRC has been able to punch above its weight and make inroads to global solutions. Understanding that achieving full implementation of research outputs requires specialist inputs and resources beyond those available to the WRC, we actively pursue mutually-beneficial partnerships that will improve our overall effectiveness. Collaborative partnerships have been established with private and public entities, as well as governmental departments and international institutions.

WRC CEO, Mr. Dhesigen Naidoo providing the contextual background for the 'Peoples Parliament'.



Chapter 3

Transforming South African society

The WRC continues to focus on research that helps to promote development through the reduction of poverty and inequality in South Africa. Of special interest is the role that water may play in achieving social transformation and justice in the context of deepening democratic practices, the extension of water services and redressing the wrongs of the past.

This is complicated by the country's commitment to ecological sustainability, and addressing the effects of climate change, HIV/AIDS and the daily realities of households living in poverty. Where appropriate, the WRC includes a social perspective in aspects of water research. This includes issues of gender, class, disability, urban and rural location, culture and religion.

WRC research integrates a variety of methodologies to provide a holistic view while emphasising respect for people's rights, and encourages participation in monitoring and decision-making as entrenched in South Africa's Constitution. Research projects in this domain are aimed at developing a greater understanding of social dynamics in the water sector and people's needs for and views on water; encouraging people's participation in water management and decisions about water; and searching for ways to use water for transformation and social justice.

The NWA makes provision for a number of water entitlements.

Water Allocation: A human rights issue and a development challenge

Inequalities in access to land and water in South Africa arose as a result of prevalent laws initially under European Colonial rule and later under apartheid. Combined, these resulted in black people being denied access to water for productive use.

Reforms, based on the principles of equity and fairness under the democratic government have seen a number of programmes and policies aimed at redressing the imbalances of the past. Among these are the Reconstruction and Development Programme, Land Reform Programme as well as reforms in the water sector. The NWA is the main instrument that governs access to water for productive use. The NWA seeks to ensure that the country's water resources are protected, used, developed, conserved and managed in accordance with the principles of efficiency, sustainability as well as equity.

The NWA removes the notion of private ownership of water and instead recognises water as a national resource, owned by all the South Africans held in trust by the state. The NWA provides the legislative framework for water allocation reform (WAR).

The struggle for access to sufficient water in semi-arid South Africa is both a human rights issue and a development challenge, impacting on health, agricultural and economic productivity, the education opportunities of women and children, as well as social stability and well-being.

As custodians of the national water resource, the Department of Water must promote the beneficial use of water in the best interests of all South Africans.

The allocation of water should, therefore promote equity, address poverty, generate economic growth and create jobs. The water allocation process must also recognise that redressing the effects of previous discriminatory legislation also provides social stability, which in turn promotes economic growth. Moreover, the water allocation process must allow for the sustainable use of water resources and promote the efficient and non-wasteful use of water.

All spheres of government, water agencies and research agencies need to work together to promote the productive and responsible use of water.

Water is also required for productive uses.

The NWA makes provision for a number of water entitlements:

1. **The Reserve:** Water required to meet basic human needs as well as for carrying out ecosystem functions.
2. **Schedule 1 Use:** Limited quantities of water required for household use, watering of stock, etc. with low potential for negative impacts on water resources.
3. **General Authorisations:** Larger quantities of water with potential for negative impacts. Authorisation can be granted for a specific type of water use, and/or any category of user.
4. **Licensed Water Use:** Larger volumes of water for commercial use.

Compulsory licensing may eventually be used everywhere to license water use, but the priority areas for compulsory licensing will be areas of water shortages (where current or future demand exceeds supply) or where pollution is severe (stressed catchments). The compulsory licensing process may also be used where it is required to assist historically excluded people to gain access to the resource as well as to:

- achieve a fair allocation of water from stressed water resources,
- improve the efficient use of water in the public interest, and
- ensure efficient management of the water resource, and
- to protect water quality.

Another important document is the Strategic Framework on Water for Sustainable Growth and Development which is based on a vision of "a robust, accountable and people-centred water sector, which ensures that water security, supports social transformation and economic growth without compromising environmental integrity". In this regard, WAR is recognised as having a potential to contribute towards growth and development thus raising the need for accelerated reallocation of water for productive use in order to enhance diversification of livelihoods among the rural poor.

Water allocation reform process kicks off

In 2005 the Department of Water announced the start of the water allocation reform process. The department recognised that allocating water without ensuring that all users have the capacity to use this water productively will limit the benefits. Consequently, water allocation should not only aim at realising the goals outlined in the framework, but must work closely with all spheres of government to promote the productive and responsible use of water. Likewise, water allocations should try to minimise the impacts on existing lawful users of water who are already contributing to our development. As such, water allocations should promote shifts in water use patterns that are equitable but also gradual and carefully considered.

This goes well beyond the Department of Water mandate and requires the active pursuit of those cooperative governance arrangements required to support the productive use of water. In many instances, this is a difficult and costly process. Accordingly, approaches to water allocation are initially being rolled out in areas experiencing water stress. However, in order to address the short-term need for equity in other areas, the approaches will include options that promote the beneficial and equitable use of water in all catchments.

Striking a gender balance

Gender is a central organising principle in all societies, northern and southern, urban and rural, agrarian and industrial alike. Yet efforts to address gender-based inequities have not levelled the playing field as expected.

Women and girls are responsible for collecting water for household use, often having to walk long distances carrying heavy loads of water. Having access to water not only for domestic purposes, but for productive purposes, can be a critical part of rising out of poverty.

But there are significant gender differences in the use, access to and management of water. Women often have little or no water rights, and form the highest proportion of people without access to safe drinking water.

The consequences of this are well documented as the burden of collecting water detracts from productivity, access to education and makes women and girls the most vulnerable to water borne diseases that thrive in unsafe water sources.

But while some progress has been made, the decisions pertaining to water use and allocation continue to be dominated by men. Unless these traditional roles and decision making patterns are shifted, women will continue to have their efforts to achieve economic growth and independence, undermined.

As in many spheres water research struggles to reach beyond the rhetoric of gender equality and translate understanding into action and change. As such, WRC projects, programmes and partners must understand, acknowledge and mainstream gender in order to sustainably reduce poverty and improve food security. Gender issues in development go beyond gender *per se*, and relate to citizen engagement and social justice, where the real war on poverty is fought.

The WRC aims to bridge the gap between rhetoric and practice. It looks at gender as the different roles and responsibilities that societies ascribe to people based on sex, age and other social constructs. Gender is reflected in differential power relationships, of particular importance to any development initiative concerned with access to and control of natural resources.

"The struggle for equal rights for women and men is not unique to South Africa and is not a recent phenomenon. It can be traced in all societies and over a period of many years and even centuries. The issue of women's rights and women's position in society has also come to be part of the post-World War II discourse on development, even for this, a number of approaches exist."

– Eiman Karar,
WRC, Executive Manager:
Water Resources Management

Having access to water not only for domestic purposes, but for productive purposes, can be a critical part of rising out of poverty.

"When I was appointed as a WRC research manager for water and sanitation for developing communities, I was surprised by the lack of researchers from the target communities. I grew up in a rural area with no water or sanitation services; therefore, I had a better understanding of the problems faced by these communities. I started a research programme on gender and water to highlight the role of women in addressing the problem of lack of water and sanitation services."

– Dr Nozi Mjoli, Hlathi Development Services

WRC takes leading role at Water Advisory Council

In 1996 WRC research manager Dr Nozi Mjoli was appointed Deputy Chairperson for the National Water Advisory Council for a period of two years. The Council advised the Minister on matters relating to the development and management of water resources, including subterranean and private water, environmentally and ecologically sensitive issues related to the development of water resources, also the provision of water supply and sanitation services, pollution and disposal of effluents, and any other water-related matter referred to the Council by the Minister.

Dr Mjoli was the first black woman to be appointed in a managerial position at the WRC. Although the environment was not enabling at the time, Dr Mjoli took the decision that she was going to make a success of her career in the water sector. As the research manager responsible for research projects relating to the provision of water and sanitation for unserved communities she was committed to improving the lives of all those millions of South Africans who lacked access to water and sanitation services prior to the country's democratisation.

Among others, she introduced a theme on gender and water and sanitation as she believes that women have an important role to play in sustainable water management as mothers, managers of their households and citizens.

Thankfully she met up with the late Hugo Maaren, then also a research manager at the WRC. "Hugo made it his business to mentor me and exposed me to opportunities to participate in sector conferences and workshops. In recognition of my interest in gender and water issues, he nominated me to be the organiser of a UNESCO gender workshop for eastern and southern Africa, which was held in Pretoria in 1997. I consider this to be one of my career highlights in the water sector."

Boosting women's participation in water management

The objectives of the regional Unesco workshop included the development of strategies for improving women's participation, to create conditions and regulations favouring women's empowerment in water resources development programmes and to stimulate international and regional cooperation for the exchange of information and experiences.

Dr Nozi Mjoli.

Dr Mjoli, has a passion for finding solutions to the water supply and sanitation challenges facing the people of South Africa. She has been instrumental in incubating and catalysing research and development in the subject area of water supply and sanitation for marginalised communities. She is a role model for the younger generation of black women.

The international recognition of Dr Mjoli's contribution to the water sector has seen her contribute to water allocation issues, represent women – and the country – on a number of bodies and fora, such as the Water Supply and Sanitation Collaborative Council, the United National Development Programme, and the Global Water Partnership.

She was instrumental in incubating and catalysing research and development in the subject area of water supply and sanitation for marginalised and poor communities. This was achieved in a very difficult environment dominated by years of First World science. Her research output resulted in policy change in this area. Dr Mjoli was later appointed Director of Water Resource Management at the WRC.

In 2003, she formed her own consultancy, Hlathi Development Services. As a consultant she has developed several research strategies for the WRC, for example, the sanitation research strategy, water services research strategy and *Strategic Framework for Water and Health Research.*

Analysis of water allocation under South African law

A report by Advocate Maritza Uys in late 1997 tackled the issue of water allocation under South African law. She concluded that water legislation pre-democracy had not provided protection for the ecobiotic water requirements, nor had it contained sufficient measures for the sustainable conservation of water as a scarce resource.

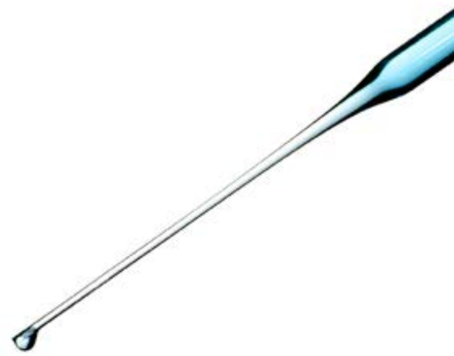
This critical evaluation of water allocation in South Africa proposed fundamental principles whereby ecobiotic water requirements would be included among the water user sectors that enjoy statutory protection.

Many water sources were already in state of over-utilisation and applying environmental considerations may have been seen to deprive the holders of existing lawful water rights the use thereof. The report proposed a revision of the allocation system to increase water availability to all users. One way would be to reconsider the distinction between public and private water which had been the cornerstone of the water allocation mechanism and which had justified the exclusion of various water sources from the statutory allocation system.

The subsequent review of the Water Law made provision for the protection of river ecosystems by allocating water rights to the reserve which provides for instream water requirements and basic human needs.

"The study proposed principles for the revision of South African water law in order to create a system of water allocation that will accommodate the water requirements of all user sectors in a balanced and equitable way."

– Adv. Maritza Uys, Advocate of the Supreme Court of South Africa



For smallholder revitalisation to be successful, significant resources need to be poured into human capital development.

Revitalising rural communities

There are more than 300 smallholder irrigation schemes in South Africa, covering about 50 000 ha. Most of these are located in the former homelands. The schemes continue to draw substantial funding from government for social and economic upliftment, often with limited success.

Typically, poor performance has been associated with a range of factors, including poor maintenance of infrastructure and equipment; high energy costs where pumping was involved; lack of institutional support in terms of credit; marketing and draught power; lack of extension and farmer training; conflict; and weak local organisation.

Guidelines for the revitalisation of small-scale irrigation schemes

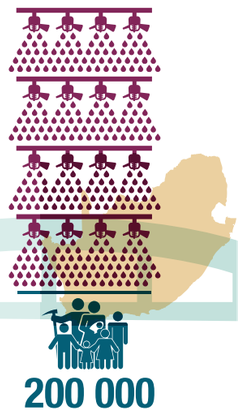
A set of WRC guidelines aimed at providing a map to the rocky road of smallholder irrigation scheme recovery was published in 2006. As part of the three-year project to develop guidelines for the revitalisation of small-scale irrigation schemes in South Africa, a national database of 317 schemes covering approximately 50 000 ha was compiled.

The guidelines, presented in two volumes, are based on extensive case-study research, multi-stakeholder workshops and reviews of major South African and East African smallholder irrigation programmes and are intended for decision makers, technical and extension staff, consultants, development practitioners and scheme leadership.

As the authors of the WRC Irrigation Revitalisation guidelines, Jonathan Denison and Siyabu Manona, point out, there is no simplified answer. "Hard experience of programmes across the country since 1994 shows clearly that unlocking potential through revitalisation initiatives is far more difficult, time consuming and costly than many professionals and politicians have realised."

The central theme of the guidelines is the critical need to appreciate and address the complexity of these schemes. Development principles, specific fieldwork approaches, planning tools and inspiring case studies are presented. Exciting new ways of addressing the challenge are put forward, for example the categorisation of farming styles that allow interventions to respond to the fundamentally different needs of distinct groups on any schemes. The four typical groups reflect the reality of different plot sizes, livelihood strategies, investment capability, skills level, risk appetite, cropping interest and marketing interest.

The guidelines are based on meaningful involvement and information exchange between farmers, plot holders and technical experts, ensuring co-constructed plans for land-tenure, agricultural, technical, institutional, marketing and financial aspects. Plot holders



200 000

irrigation

302

In 2011, there were 302 smallholder irrigation schemes in South Africa, supporting around 200 000 farmers and their families

need to be at the centre of the planning and implementation process, which demands substantial two-way information transfer so that the implications of their decisions can be fully appreciated.

Irrigated food plot production

Prof Wim van Averbeke of the Tshwane University of Technology (TUT) was approached by the WRC to investigate irrigated food plot production on smallholder irrigation schemes in the central Eastern Cape. The project explored the circumstances in which irrigated food plot production occurred on a selection of irrigation schemes using a factor approach. The study also quantified the benefits participants derived from irrigated food plot production.

From 2003 to 2007, Prof Van Averbeke led another key project titled 'Best management practices for small-scale subsistence farming on selected irrigation schemes and surrounding areas through participatory adaptive research in Limpopo Province'. The project centred mainly on Dzindi, Rabali and Khumbe irrigation schemes.

Prof Van Averbeke also served as project leader on another WRC-funded research project aimed at identifying practical ways to improve the performance of smallholder canal irrigation schemes in the Vhembe district of Limpopo at both scheme and plot level. Limpopo is the heartland of smallholder irrigation schemes in South Africa, more specifically canal schemes, which were the first type of irrigation schemes to be constructed. The findings confirmed the continued relevance of canal irrigation and showed that gravity-fed canal schemes were more likely to be operational and to last longer than pumped schemes.

The final output of this WRC-funded research was a comprehensive report that documents the holistic approach followed in addressing the challenges confronting smallholder irrigation farmers and lessons learnt, as well as practical crop and animal production manuals for smallholder farmers and their advisers.

"The findings of this project have brought us a step closer to full understanding of how farmer-managed smallholder irrigation schemes function, what their impact on livelihoods of rural people is, and how this impact can be further enhanced," says Prof Van Averbeke.

In-field rainwater harvesting and conservation

Since the WRC launched its first IRWH research project in the Free State in 2001, this technique has been successfully applied in backyard food gardens by more than 1000 households in 42 villages at Thaba 'Nchu and Botshabela. The IRWH technique that succeeded in breathing new life into village land which has been lying fallow for ages, providing food and income, was developed by a team of Free State researchers from Glen College of Agriculture.

"The project demonstrated that in areas where farming is still important to people, smallholder irrigation schemes constitute a viable rural development option."

– Prof Wim Van Averbeke, TUT

"Critical to the success of the technique is that it sold fast among villagers," says Cobus Botha, project leader of the water harvesting research projects. A major advantage is that IRWH costs very little, apart from manual labour, in an area where jobs and wage money are almost as scarce as food.

During the WRC studies, basic principles like the grading of soils as well as how different mulch combinations can reduce evaporation from the soil surface were investigated. Intensive field experiments on clay and duplex soils in the Free State, conducted over six seasons, showed that IRWH increases maize and sunflower yields by as much as 50% compared to conventional production techniques.

Further research has proven infield rainwater harvesting technology to be sustainable, not only in terms of increased agronomic productivity, but also in terms of containment of risk, conservation of the natural resources base, social acceptability and economic feasibility. Furthermore, the technique frees farmers from unaffordable mechanical dependence to produce crops.

The villagers in the Thaba 'Nchu and Botshabelo area had been neglecting their cropland due to a lack of finance and agricultural equipment, as well as continuous crop failures on account of the low and erratic rainfall and marginal soil quality. Nowadays, rainwater harvesting initiatives are helping to feed thousands of villagers in the area. The new technique also provides additional financial income. Various community-based bodies in the area have formed the Tswelelopele Small Farmers cooperative, a municipal-based water-harvesting group that includes 42 communities.

Building vital capacity

The success of this project is attributed to the various capacity-building initiatives as well as communication methods used to ensure the growth and sustainability of the technology. The technology has been successfully transferred to the small-scale farmers in 'Thaba 'Nchu and Botshabelo on whose plots the experiments were carried out and also to the Department of Agriculture. Technicians from previously disadvantaged communities have been fully equipped to provide further guidance in the application of the IRWH system.

Communication methods used to disseminate knowledge of the IRWH technology include the development of simple and practical training guides in collaboration with researchers, technical assistants, farmers and technical officers, as well as materials incorporating indigenous farming knowledge in efforts to improve present farming practices and systems. In addition, demonstration plots presented the opportunity to involve farmers in activities throughout the growing season and fallow period. Active participation rather than passive observation was encouraged, both to assist farmers in taking ownership of the IRWH technology and mastering the various related activities.

Villagers from Thaba 'Nchu celebrate following a successful harvest using rainwater harvesting.

Rainwater harvesting is successfully applied in 42 villages in Thaba Nchu and Botshabela, allowing households to grow food for their families.

Rhodes University

An emerging aquaculture farmer with fish from a dam in the Eastern Cape.

Amplifying the benefits

WRC funding is continually geared towards finding new rainwater harvesting techniques. One such technique combined the advantages of water harvesting, no-till, basin tillage and mulching on high-drought-risk clay soils. This practice reduces run-off to zero. Additional research has also been undertaken into the types of soils that are suitable for IRWH. The report sets a benchmark for soil scientists and also benefits subsistence farmers by assisting them to identify soil types suitable for IRWH in different farming areas in South Africa.

Although this research work was completed in the semi-arid region of central South Africa, the principles are applicable in different regions of all provinces. The technique is currently being upscaled to communal croplands. Work is also continuing to assess the social and economic acceptability of rainwater harvesting and conservation practices in selected peri-urban and rural communities.

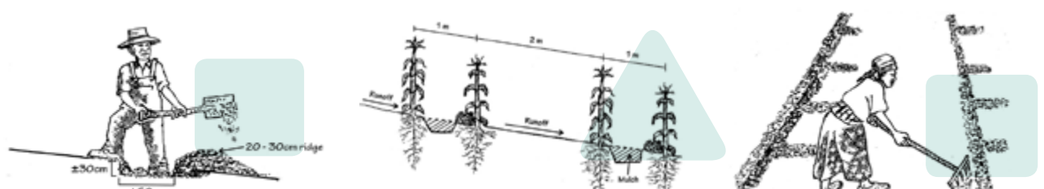
Aquaculture in South Africa – relieving hunger and improving livelihoods

Over the past two decades, the WRC initiated and invested in a number of research projects on aquaculture, particularly focused on alleviating hunger and improving rural livelihoods. The first was a baseline study on the contribution of aquaculture to rural livelihoods in South Africa. In this report, published in 2004, a number of priorities for further research were identified.

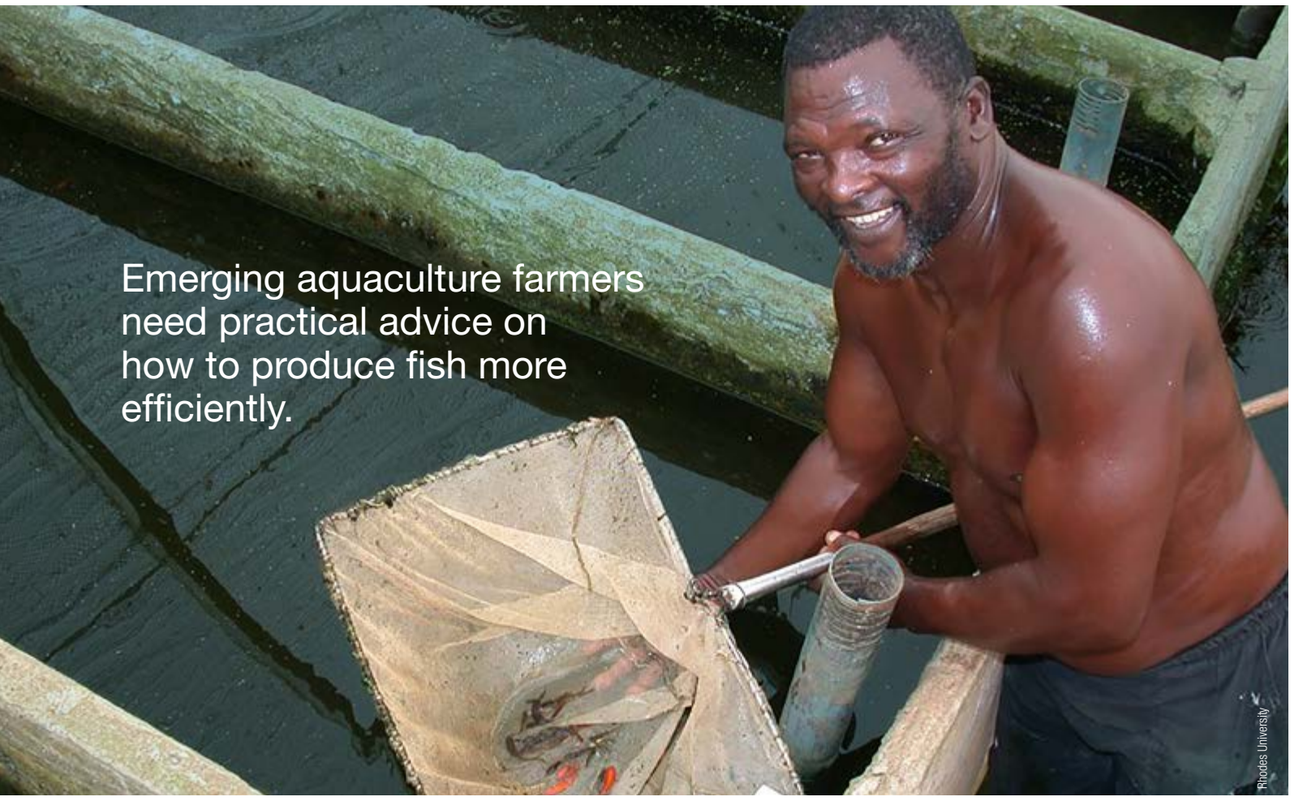
In cooperation with Rhodes University, widely-based consultation with provincial departments of agriculture followed. This culminated in a report by Qurban Rouhani, WRC project leader and director of the Rural Fisheries Programme at Rhodes University and his colleague, Prof Peter Britz of the Department of Ichthyology and Fisheries Science. The report, *Participatory Development of Provincial Aquaculture Programmes for Improved Rural Food Security and Fisheries Science*, was published in 2011.

"Through the project's constant communication and interaction with various agriculture department personnel and stakeholders, aquaculture has been placed firmly on the agenda."

- Prof Trevor Britz, Rhodes



The WRC guidelines for rainwater harvesting use simple illustrations to explain techniques.



A successful ornamental fish farmer KwaZulu-Natal.

This research coincided with the evolvement of a national policy on aquaculture driven by the then Department of Agriculture, Forestry and Fisheries (DAFF), who co-funded the WRC-solicited research projects. An important first step in the development of rural aquaculture was the development of draft provincial aquaculture strategies in participative workshops for six provinces – Limpopo, Mpumalanga, KwaZulu-Natal, Free State, Northern Cape and North West provinces. The strategies provide a valuable 'road map' for the provincial agriculture departments to plan and develop aquaculture in the provinces.

This project set out to revitalise selected provincial hatcheries to act as development hubs for emerging farmers, and from which to provide services such as advice, training and fingerlings. The hatcheries were found to be in a general state of disrepair, operating on low budgets and with few skilled staff, and were not performing. A critical aspect was that these provincial facilities had no guiding operational policy and their existence seemed to be disassociated from the needs of the province.

The project team provided technical support not only in the training of staff at the various provincial hatcheries, but also in developing strategic plans for the revitalisation and operation of these hatcheries, in close cooperation with the provincial agriculture departments.

One of the hatcheries to receive a makeover was Turfloop near Polokwane in Limpopo, originally established in 1982 as a catfish production and research facility in the former Lebowa homeland. The facility, which ceased operation in the early 1990s, began operating again following investment from the provincial agriculture department and support by the WRC project team. In 2008, the hatchery spawned catfish for the first time in ten years following intervention by the WRC-funded project team. By 2009, Turfloop was producing its first male tilapia with technical assistance from Limpopo University's aquaculture unit.

Another highlight has been the publication of a manual for rural freshwater aquaculture, which was guided through the various stages of testing by the Rural Fisheries Programme. The manual covers topics ranging from basic fish biology, setting up ponds, production and shipping, to feeding, health and disease issues.

Fish is sold along the roadside in Limpopo. Farmers can establish a considerable number of customers by selling fish informally.

Aquaculture is not just about producing food. Here a farmer in KwaZulu-Natal sorts fish for the ornamental fish trade.

Extension officers have a crucial role to play in the SA agricultural sector.

Training a new generation of extension officers

The advancement and expansion of South Africa's agricultural base – particularly small-scale agriculture – remains an important objective of national Government. It is an aim that requires improving and extending skills development and training in the agricultural sector, including entrepreneurship training. This includes the training of a new corps of extension officers that will respond effectively to the needs of smallholder farmers and contribute to their successful integration into the food value chain.

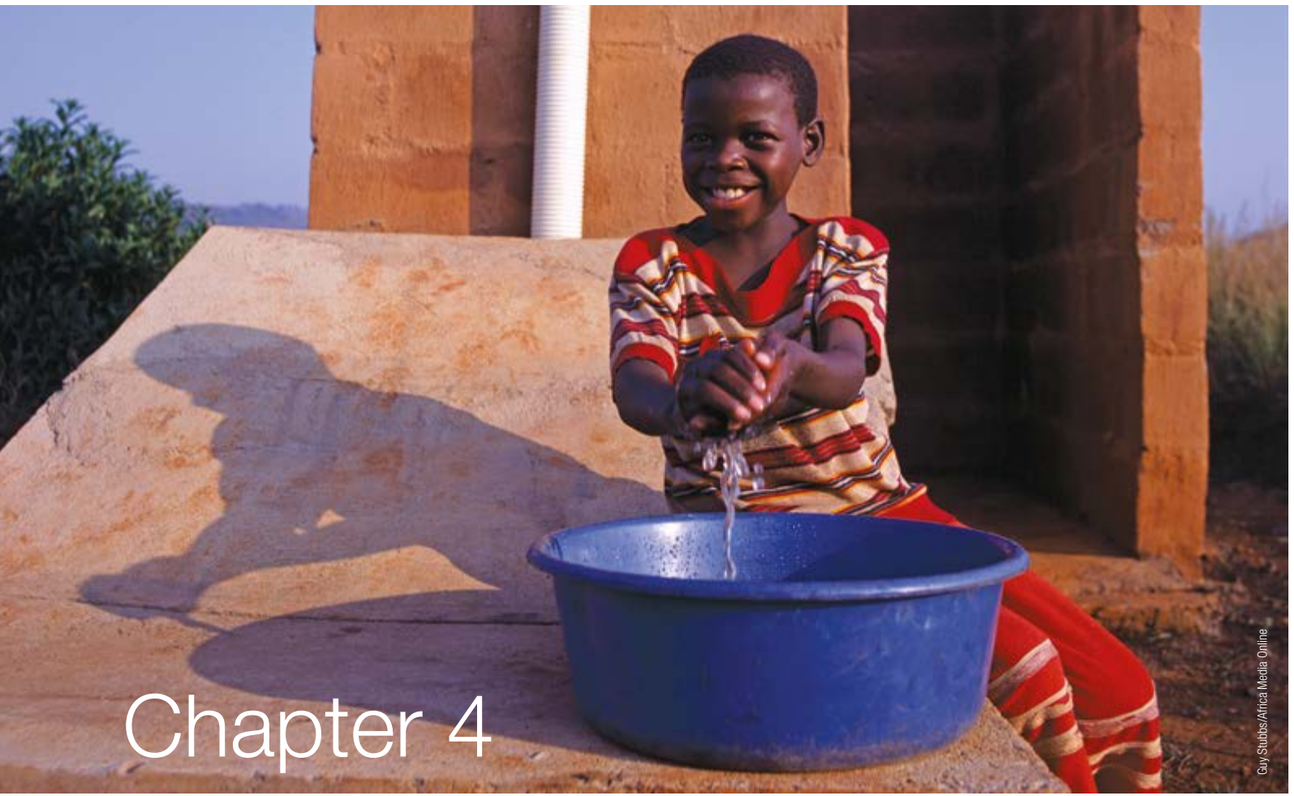
There are around 390 extension officers currently serving small-scale and commercial irrigation farmers. The extension services offered include advisory services for sustainable income generation; providing and facilitating access to agricultural information for improved planning and decision-making; facilitating access to technology; providing and facilitating access to advice on sustainable agricultural production and skills development; and strengthening institutional arrangements.

Functional irrigation equipment is but one requirement of successful irrigation farming. The science of irrigation management is complex and comprehensive, and therefore the irrigation extension officer requires comprehensive technical knowledge and skills in irrigation management, as well as appropriate knowledge and understanding regarding human behaviour, in order to serve his farming community effectively.

To strengthen and improve the current level of training presented to extension workers for the tasks they have to perform on irrigation schemes, the WRC funded the development of learning material for eight learning areas identified to form the 'knowledge profile' of the extension officer. This training material covers the main elements which directly or indirectly inform irrigation water management.

The aim of the learning material is to support tertiary training organisations, such as agricultural colleges and universities of technology, offering agricultural programmes on a NQF Level 5, as well as to support training providers offering short courses in irrigation management. The project was co-funded by the DAFF. A total of 93 learning modules were included in the material, which have been divided into technical- and extension-related modules.

The learning package covers the entire spectrum of irrigation water management, starting with a brief overview of the soil-plant-atmosphere continuum, then moving on to agri-climatology, irrigation water management, irrigation engineering, and the irrigation legislative context and irrigation economics. The package also covers irrigation crop and fodder production as well as general skills required for productive agricultural extension. This research output fills a major knowledge gap by making comprehensive training modules available for in-service training of extension officers.



Guy Stubbs/Africa Media Online

Chapter 4

Empowering communities

Poverty and inequality remain significant challenges in South Africa's development. The WRC recognises that the role of water is pivotal in guiding communities onto the path towards economic and social prosperity. WRC research is not only aimed at improving the lives of South African communities and helping them to thrive in the South African economy, but also at equipping them with the necessary water-related knowledge to adapt to future challenges, such as those brought on by climate change.

"The high cost of providing services and infrastructure in rural areas, and especially places that are remote and have low population densities requires innovative solutions."

NDP 2030

While WRC developed technologies, such as desalination of brackish groundwater, had aided in the provision of clean water to rural communities for decades, it was not until 1990 that the WRC really started to contemplate the potential impact of scientific innovation on the lives of particularly underprivileged South Africans. While WRC research had rapidly started to increase towards the end of the previous decade, it was only once a meaningful research programme had been put in place that the Commission's focus in this regard started to gain real momentum. This programme was aimed at not only addressing technological aspects, but also the socio-economic problems associated with water supply and sanitation in developing communities.

"The provision of adequate water supplies and sanitation services to the total population is a major objective of the RDP. Since 1990 the WRC has been stepping up its research in this field when a strategic planning workshop afforded the development of affordable and acceptable sanitation technology for developing communities a highest priority."

– WRC Annual Report, 1994

Providing low-cost, sustainable sanitation options remains a priority for South Africa.

Sanitation: vital for people's health, well-being and dignity

In 1994, the Reconstruction and Development Programme (RDP) mandated the government to ensure that all South Africans would obtain equitable access to water services. This required a new policy and strategy in order to respond to the water services challenge and threw a new spotlight on basic sanitation.

The pre-1994 work of the Standing Committee on Water Supply and Sanitation (which brought together various water sector stakeholders, such as municipalities, the WRC, organised labour, various non-government organisations, the water boards government departments, and various extra-parliamentary organisations) fed into the Department of Water's efforts to draw up that new strategy.

A significant milestone in the development of the new policy was a national stakeholder conference held at Kempton Park at which sector role players agreed on the key recommendations for inclusion in the future *White Paper on Water Supply and Sanitation.*

The WRC was simultaneously stepping up its research funding in this field when a strategic planning workshop afforded the development of affordable and acceptable sanitation technology for developing communities a highest priority. The strategic research plan was announced to the water research community at large in order to stimulate relevant research submissions to the WRC.

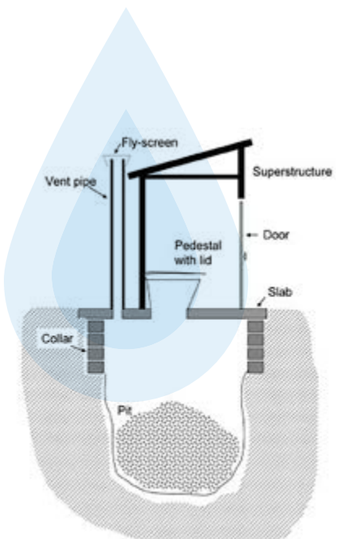
A lot of the information emerging from WRC studies during the 1992 to 1996 period contributed to many of the policy and legislative initiatives in the early years of democracy. So the RDP planning, the new water legislation, the planning around water and sanitation were all beneficiaries of the new direction in WRC research.

After that, in terms of sanitation, a lot of the focus went into the implementation side and meeting the backlogs that South Africa was dealing with. In its funding of sanitation-related research the WRC was increasingly becoming involved in projects on 'non-technological' issues. Furthermore, it became clear that with the many 'non-technological' issues which were common to sanitation, there was a need for a strategic research plan and for a research coordinating committee to focus on these issues.

access to sanitation

78%

Percentage of population who has access to basic sanitation: 48% in 1994; 73% in 2008 and 78% in 2013



A typical VIP system.

What is a VIP?

For a pit latrine to qualify as a ventilated improved pit, it must comply with certain requirements, it must:

- Provide hygienic separation of human waste from contact with people;
- Have a vent pipe fitted with a flyscreen to minimise odour and flies;
- Be built on a secure slab that will resist collapse of the superstructure; and
- Provide privacy and dignity for the user.

A municipal worker cleaning a VIP toilet.

Ventilated improved pit toilets

Ventilated improved pit (VIP) toilets continue to be considered the minimum level of sanitation of choice for many municipalities responsible for improving access to services in their rural and peri-urban communities, and millions of these units have been constructed all over the country during the past 20 years.

While they remain and offer a good basic sanitation delivery option, their long-term sustainability poses a number of challenges when the pits fill up. This is compounded by the fact that, generally, the contents of the pits and/or their characteristics are historically not well known or understood.

Once pits are full they can no longer fulfil their function of providing safe, hygiene and dignified sanitation. As a first step in improving this situation, the WRC has lead VIP-related research through partner organisations such as the Pollution Research Group at the University of KwaZulu-Natal.

Research into VIPs has focused on, among others, understanding the contents of VIP sludge, finding innovative and safe ways of pit emptying as well as sustainable ways in disposing of VIP sludge. It has been made clear through these studies that management of pit latrine sludge is not a one-dimensional problem, but may require different approaches that are dependent on the nature of the pit contents.

Sanitation research fund for Africa

An exciting recent development has been the establishment of the Sanitation Research Fund for Africa (SRFA) by the WRC and the Bill & Melinda Gates Foundation. The purpose of the fund is to provide impetus for scientific-based knowledge and practical solutions for faecal sludge management. The development of local capacity and solutions is a key project objective.

The two key areas which have impact on the sustainability of VIP technologies are being investigated namely establishing a sound understanding of the scientific processes occurring in pit latrine sanitation systems and the development of innovative solutions for the safe extraction, disposal and beneficial use of faecal sludges from pit toilets.

This information will allow designers and practitioners to impact the most appropriate solutions and technologies to deal with these aspects of faecal sludge management. A total of 12 research teams from eight African countries were selected for the SFRA project. This project provides a unique opportunity for a locally driven initiative to generate local solutions.

Sanitation innovations

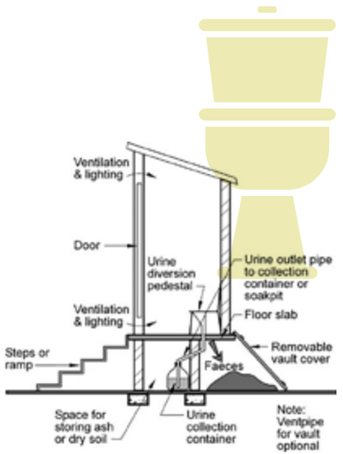
Over the last 20 years WRC research has not only focused on improving known sanitation technologies but also at introducing innovative, alternative sanitation solutions. One of the most successful of these technologies has been urine diversion toilets, which has become an accepted basic sanitation solution in areas such as eThekwini (Durban).

The eThekwini Municipality, which is considered as one of the leading municipalities in South Africa in the provision of basic sanitation services and has won a Stockholm Industry Water Award, has selected urine diversion, ventilated improved double pit (UD/VIDP) toilets as the preferred delivery mechanism for certain communities in their area of responsibility.

The first units were installed in 2003, with some 10 500 new units being installed per year.

A urine diversion toilet outside Durban.

More recently WRC research has adapted pour flush sanitation – a popular on-site sanitation option in Asian countries, for use in South Africa. Similar to a full flush toilet, with pour flush sanitation water is poured in by the user rather than coming from a cistern. The system uses significantly less water – only one or two litres as opposed to the five to seven litres needed for conventional flush toilets. Since it is an on-site sanitation system, there is no complex sewerage and wastewater treatment network required making it much cheaper to install, operate and maintain.



A typical urine diversion toilet.

The prototype pour flush toilet being tested.

The first project, initiated in 2009, investigated the possibility of adapting pour flush sanitation for use by South Africans. This research was led by Partners in Development. Some changes had to be made to the pour flush toilets usually used in Asia – for one, South Africans prefer to sit rather than squat, so a pedestal had to be provided. The toilets also had to be able to handle anal cleansing material, such as toilet paper or newspaper.

The new pour flush toilet is designed to be as simple as possible to avoid parts which can break or block. While looking very similar to a full flush toilet, there is no water tank, cistern, flusher or 'liquefier' (a problematic feature of certain low flush systems which were introduced to South Africa in the last 20 years). Since there is no plumbing no leaks are possible. The toilet is flushed by pouring one or two litres of water into the pan. The pan funnels steeply to a 70 mm-diameter outlet. Greywater can be used for flushing.

Rather than a conventional sewerage system, the pour flush toilet block is attached to two leach pits. When one leach pit becomes full, then a switch is made to the alternative pit.

After extensive testing, the first two toilets were installed in Pietermaritzburg in September 2010. They have been in operation since then without problems or blockages. Consequently, a further 20 household demonstration units were built as well as three toilets at a crèche.

Further units have been constructed in pilot studies in the Western Cape to test the efficacy of these systems in dense settlements. Toilets have been successfully installed in three areas, namely in Klipheuwel informal settlement, Cape Town; the Klein Begin community, Grabouw; and Enkanini informal settlement, Stellenbosch.

In order for the technology to work in an institutional setting, such as a school, the pour flush was converted to low flush technology – i.e. a small cistern was added so that users would not need to fill a bucket in order to flush. This prototype was successfully piloted in two schools in the Durban area in partnership with eThekwini Municipality, namely Sizimesele Primary School and Thandaza High School.

Maluti Water

Resident with pour flush toilet, Western Cape.

Advantages of pour flush technology

- Unlike a pit latrine pour flush toilets can be built onto a house.
- Unlike conventional waterborne systems, pour and low flush sanitation use only a litre or two for flushing.
- Cheaper to build than full flush toilets with septic tank and soak pit.
- Greywater can be used for flushing without the need for a piped recycling system.
- The water seal prevents smells and flies, as well as trash and solid waste entering the pits.
- Users cannot use the pit as a receptacle for domestic waste (unless they access the pit separately).
- Pits are smaller, so there is no need for deep excavations. This also allows for easier access and emptying.

Low flush system installed in a school setting.

Following the successful piloting of the low flush technology in the Durban schools a WRC project started in 2014 whereby the possibility of providing timber frame pour flush sanitation blocks for use in schools is being tested. Constructing sanitation structures from timber opens up the possibility of a rapid response to the needs of schools facing a sanitation crisis.

Social franchising – the business approach to removal and disposal of faecal sludge

Studies undertaken by the CSIR and WRC have found that social franchising partnerships for the routine maintenance of infrastructure could alleviate and address many challenges in the management of water services. The research started in 2005 when Dr Kevin Wall formerly of the CSIR, Built Environment wondered about the possibility of applying franchising principles, usually associated with fast food outlets, to water and sanitation.

A pilot project, started in the Eastern Cape since 2009, provided selected infrastructure maintenance services to approximately 400 schools in the Butterworth education district. Half a dozen franchisee microbusinesses were created, and of the order of three dozen previously unemployed people were taught workplace skills. Irish Aid funded the concept development, but the franchisees were paid from the normal Department of Education schools operation and maintenance budgets.

The report boasts some significant numbers. The learners at the 400 schools have benefited tremendously, especially the girl learners, who now have access to private, clean and hygienic toilets. The sanitation improvements have seen an increase in attendance rates at schools which are being serviced.

Furthermore, six emergent franchisee micro-entrepreneurs have been established and supported. Furthermore, a training programme has been developed, consisting of formal training, on-site mentoring, regular get-togethers, report backs and sharing of experience, and ad hoc training. Operational methodologies for school and household situations have been developed.

More than 20 sustainable jobs and more than 50 part-time informal employment opportunities have been created (mostly taken up by rural women). A public-private partnership, supporting job creation and the establishment and nurturing of emergent micro-entrepreneurs, has been created.

Introducing franchising to the South African water and sanitation sector has not ended with the pilot project. In January 2014, a significant milestone was reached when Impilo Yabantu (the franchisor) signed up its first franchisee, Nocawe Lupuwana, who will trade under her own dedicated franchise company, IY East London, trading as Impilo Yabantu East London.

Trainee franchisees and their employees during the pilot in 2010.

"The WRC is particularly proud of driving the social franchising concept in the water sector. In striving for job creation and finding better techniques within the sanitation and water services environment we decided to examine the whole concept of franchising at a very local level: operation and maintenance."

– Jay Baghwan, WRC Executive Manager: Water Use and Waste Management

Improving dietary variety is crucial to improving malnutrition in South Africa.

Improving food security with less water

As the foremost funder of water-related agricultural research in South Africa, the WRC is playing a vital role in ensuring the sustainability of the country's farming activities, from household through to commercial scale. The overall objectives are to assist farmers to utilise scarce water resources efficiently, beneficially and sustainably to increase household food security and farming profitability, thereby increasing social and economic welfare. Key issues currently being addressed are the productivity of water use for crops and livestock, poverty reduction and wealth creation in rural areas, as well as the prevention of resource degradation. These efforts are aligned with government aims to reduce poverty and ensure sustainable socio-economic growth and development.

Over the last 20 years the WRC has made a strategic shift to achieve a balance between research projects in irrigated and rain-fed agriculture, agro-forestry and aquaculture; to promote farmer involvement in poor rural communities and through participatory action research; and to take research projects further toward practical application of results with technology transfer projects. Agriculture and water-related projects include the evaluation of water use and nutritional productivity of food crops in the diet of poverty-stricken rural people.

Food security remains a priority issue for South Africa despite the country's national 'food secure' status. An estimated 14 million people, or about 35% of the country's population, are estimated to be vulnerable to food insecurity, while the development of as many as 1,5 million children under the age of six is reckoned to have been stunted by malnutrition.

It has been recognised that the home-production of specific foods among rural communities should be based on scientific evidence, taking not only current best practice in agricultural and human nutrition into account, but also the socio-cultural context within which the interventions are to take place. Internationally, it is accepted that better understanding of the links between agriculture, nutrition and health is a priority. Thus, before researching water use and nutritional productivity of crops, it is essential to know what food is consumed by poor people, what the nutrient content is of these food products, and which of these foods can be produced by household members, either in homestead gardens or communal croplands.

These arguments motivated the initiation of a WRC-funded scoping study to investigate present-day knowledge about the current food intake of rural communities in South Africa. The project also investigated the nutritional water productivity of several food crops. From the findings it does appear that poor, rural households lack dietary variety. Diets have generally been found to be monotonous and cereal-based, with a low intake of fruit, vegetables and food of animal origin.

food security

53%

Food security in SA: 53% of households experience regular hunger, 10% have access to agricultural land and 18% can potentially grow food in homestead backyard gardens in rural villages

Nutritional water productivity combines knowledge of the composition of food products in terms of nutrients with knowledge of the water productivity of that food product.

While this study has identified many challenges to food security and nutrition in South Africa, it has also identified opportunities. The WRC has commissioned a follow-up study focusing on rain-fed and irrigated production of food crops and their potential to meet the all-year nutritional requirements of rural poor people in South Africa. The provinces of North West, Limpopo, KwaZulu-Natal and the Eastern Cape have been prioritised, as this is where the majority of South Africa's rural poor live and produce crops under rain-fed and irrigated conditions.

Water as a route to nutritional security

Water and nutritional health of people are intricately linked. In water-limiting environments, such as most parts of rural South Africa, it is of utmost importance to focus the promotion of home production of foods not only on those crops and livestock that have the potential to address nutritional deficiencies, but also on food products that are simultaneously water productive. Combining human nutrition needs with water productivity has resulted in a new concept among researchers, namely 'nutritional water productivity'.

Nutritional water productivity combines knowledge of the composition of food products in terms of nutrients (for example the protein or vitamin A content of a food) with knowledge of the water productivity of that food product.

This was the focus of a scoping study initiated, managed and funded by the WRC. The project was led by the Department of Human Nutrition at UP, supported by the UP Department of Plant Production and Soil Sciences and the Nutritional Intervention Research Unit of the South African Medical Research Council.

The result is an index for a given food product which includes nutrient-based output per unit water use, for example micrograms of β-carotene in 100 g raw spinach per cubic metre of water used to produce the food. This knowledge can be used to promote the production of those food products that may contribute to closing the nutrient gaps in vulnerable communities while, simultaneously, leaving a sustainable water footprint.

Proving the value of indigenous crops

Over the last 20 years, WRC research aimed at improving agricultural water use has become increasingly embedded in South African realities. One of the important focus areas of research was the harvesting and use of water for food production in homestead gardens for improved family diets and the possibility of generating additional income. Recognising homestead farming (and especially food gardening) as a coping strategy for poor households to overcome vulnerabilities caused by poverty, the WRC generated comprehensive training packages for use by development facilitators engaged in supporting poor households in their efforts to grow food.

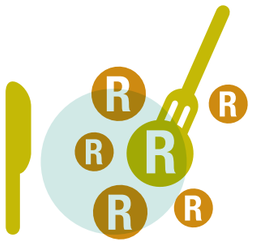
Micronutrient under-nutrition, also called 'hidden hunger', affects many South Africans, particularly the poor. It often goes unnoticed, but it curtails both the physical and mental development and health of those affected. It prevents children from reaching their full potential, thus placing a burden on the future of South Africa.

The potential value for food security and rural development of gathering wild foods, growing locally adapted species and eating from the local ecosystem is recognised internationally.

Traditional South African leafy vegetables have important advantages over exotic vegetable species. These 'wild vegetables', locally referred to as *morogo* or *imifino*, are excellent sources of several important micronutrients, including beta-carotene (Vitamin A), folate, Vitamin C, and iron. Regular consumption of African leafy vegetables can assist in balancing the common, largely starch-based diets of many South Africans by adding these essential micronutrients, particularly beta-carotene and iron. They are generally easier to produce and usually require fewer resources such as water.

A WRC project has generated valuable knowledge about the nutritional status of South Africans and its links to agriculture and water. It has also developed science-based information that enables optimisation of important agronomic practices used in the production of traditional South African leafy vegetables, particularly with regard to water use, plant nutrient requirements, germination and emergence, as well as the response to drought and heat stress. Furthermore, the project has generated comprehensive new knowledge regarding the highly beneficial aspects of African leafy vegetables in addressing important micronutrient deficiencies in poor rural communities.

Laboratory, on-station and action research was undertaken to develop best practices aimed at improving food security and the well-being of households. One of the products of this project has been South Africa's first comprehensive guide on the production of African leafy vegetables. The guidelines focus on amaranth, Jew's mallow, Chinese cabbage, nightshade, spider flower, pumpkin, tsamma melon and cowpea.



food expenditure

R8 485

Poor households spend on average R8 485 a year on food, which accounts for 34% of their total household expenditure. Maize meal is the most common purchase.

Wim van Averbeke

A group of youths harvesting nightshade.

The study preceding the development of the production guidelines confirmed that African leafy vegetables can be grown in home gardens using local resources. The indigenous vegetables selected were shown to be more drought- and heat-tolerant than introduced exotic vegetables, such as Swiss chard. This could prove significant in the context of projected climate change.

The guidelines not only provide previously unrecorded information on production practices, such as seed selection, fertilisation, pest control and water use in relation to environmental variables at localities where these crops are growing, but also aim to raise the status of these traditional food plants in South Africa by pointing out the valuable contribution these plants could make to the food security and, hence, nutrition security of South African households.

They also offer considerable opportunities for commercialisation and, through this, the creation of new livelihood opportunities. The guidelines are already being actively used by non-profit organisations focusing on food security and home gardens.

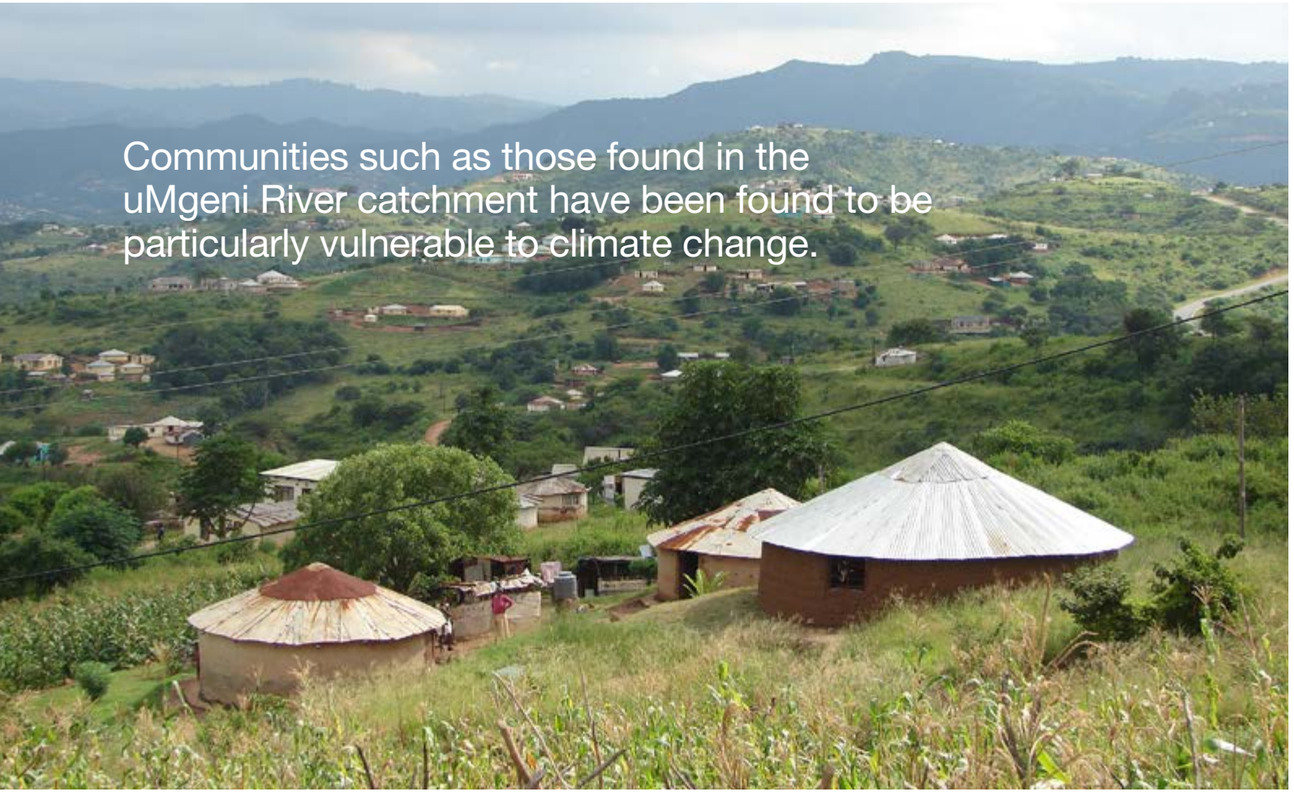
The WRC is continuing its investment in these traditional food plants, with research being undertaken on water requirements, fertilisation and nutritional productivity of African leafy vegetables and yellow-fleshed sweet potatoes, including the modelling of water use of these crops.

"While water wise indigenous crops will not in the short term offer the solution to bring 850 million people out of chronic hunger, it certainly holds promise for several million people, particularly in Sub-Saharan Africa to not only ensure an end to hunger, but also offers the possibility of sustainable livelihood to very small scale, largely subsistence farmers and their communities"

– Dhesigen Naidoo, WRC CEO

Harvested nightshade is loaded into a truck for delivery to a supermarket in Thohoyandou.

In Vhembe, Limpopo, the flowers, leaves and young fruit of pumpkins are used in the preparation of a delicious side dish.



Improving communities' resilience to climate change

South Africa's climate is subject to high inter-annual variability and presents significant vulnerabilities in the face of probable global climate change. Regional impacts from global changes are most likely to be manifest in the hydrological aspects which will impact water resources and water dependent infrastructures most strongly.

The WRC first recognised the potential impacts of climate change on the water resources of South Africa as a priority area for research area in the mid-1980s. At the time it was impossible even to begin to address the topic in a meaningful way because of the lack of scientific capacity and (especially computational) resources.

In the face of the long lead times required for planning and policy development, it was decided that an accurate understanding be developed for the probable regional consequences of global environmental change for future decades. The WRC funded various research projects in the 1990s in this regard to create more robust climate change scenarios for use by South African climate change impact researchers.

Partners in the WRC's climate change research have included various departments at the universities of Cape Town, KwaZulu-Natal and Pretoria, Witwatersrand and Zululand, as well as the South African Weather Service, and the Department of Water and Sanitation (DWS). Besides the knowledge gained, significant contributions were made to the development of local climate-related research capacity in climate science and its linkages to water resources.

Later the WRC also started focusing on determining the impact of potential climate change on water resources. The first major study focusing explicitly on climate change impacts on South Africa's water resources started in 2002, with a comprehensive report being published in 2005. *Climate Change and Water Resources in South Africa: Potential Impacts of Climate Change and Mitigation Strategies* provided valuable insight into the magnitude of the potential impacts and the consequential adaptation needs in the sector. The WRC report followed hot on the heels of South Africa's National Climate Change Response Strategy, approved by Cabinet in September 2004.

The WRC report confirmed that global climate change is a threat to sustainable development, that it can undermine poverty alleviation efforts, and have severe implications for food security, clean water, energy supply, environmental health and human settlements. The report produced credible regional projections using the latest general circulation models, as well as regional climate models and empirical downscaling techniques.

But climate change is not only about changes in the earth system, it is also about the impact of these changes on vulnerable communities. The impacts on both rural and urban communities, particularly in the absence of effective risk reduction strategies, are expected to be significant in a changing climate scenario and require an effective response. In communities where access to clean water is already a problem, a slight decrease in rainfall has an amplified effect, for example. So climate change will become another stress that cities have to deal with, along with growing informal settlements, pollution, poverty, and health issues, to name but a few.

"Model projections show that changes in temperature and rainfall are most likely to have significant impact on water resources in southern Africa. Climate models projections show a likely increase in the number of people who could experience water stress by 2055 in northern and southern Africa".

– Dr Chris Moseki, former WRC Research Manager

"The impact of climate change on the water sector might be felt sooner than we think. We could see a significant reduction in runoff in certain areas in the west of the country by as early as 2015."

– Prof Roland Schulze, UKZN

research projects
R30m

Between 1988 and 2008 the WRC invested around R30-m in 30 research projects aimed at climate change.

In 2009 The WRC contributed to the South African position paper in preparation for the United Nations Framework Convention on Climate Change. Input was made to the United Nations Climate Change Conference (COP15) and negotiations in Copenhagen in December 2009 by providing support on strategic water issues as and when required by the Ministry and the Department.

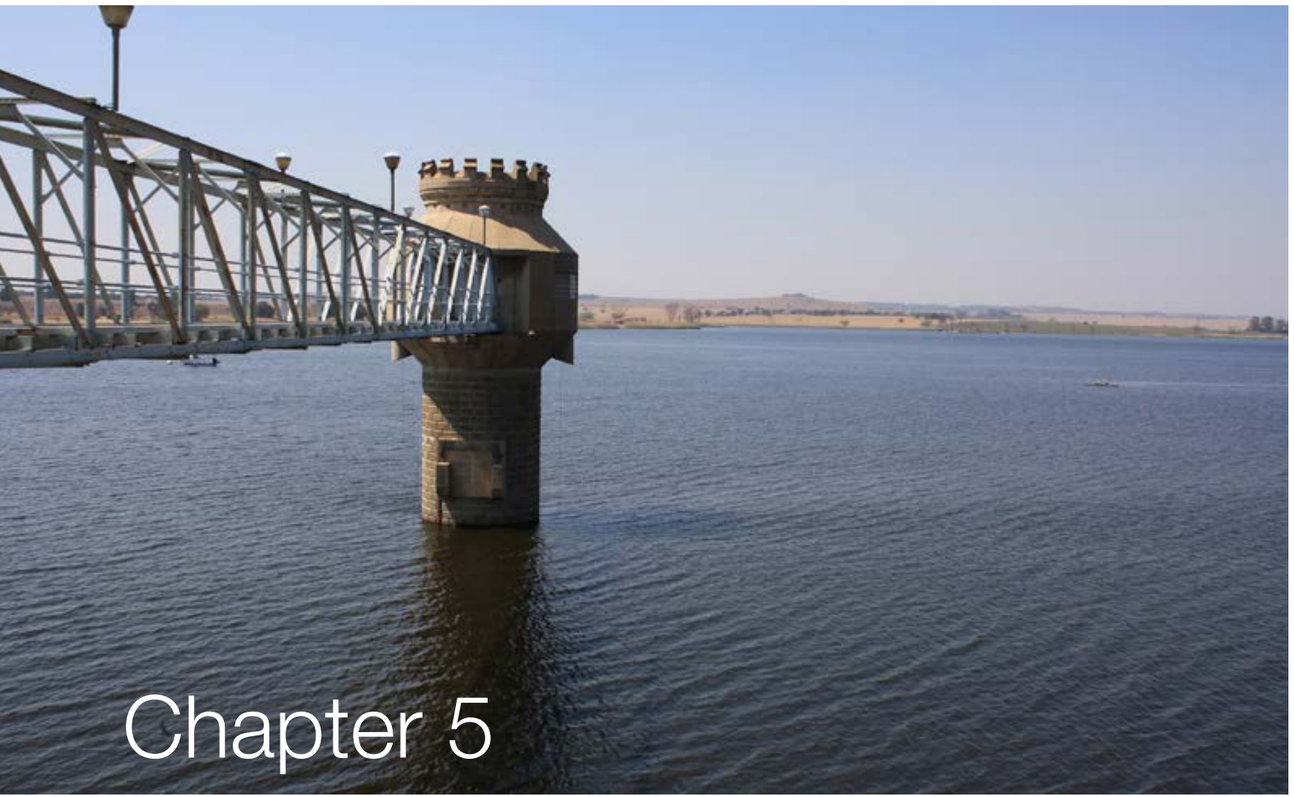
More recent climate-change related projects by the WRC include research on predicting the secondary impacts on water resources due to primary changes in precipitation and temperature associated with climate change; applications of rainfall forecasts for agriculturally-related decision making in selected catchments; using enhanced knowledge of climate variability for the benefit of water resource management; and multidisciplinary analysis of hydroclimatic variability at the catchment scale.

Newer climate change-related projects include identification, quantification and incorporation of risk and uncertainty in water resource management tools; an evaluation of the sensitivity of socio-economic activities to climate change in climatically divergent South African catchments; and integrating water resources and water services management tools.

Climate change research at the WRC now focuses on developing a better understanding of global climate change and hydro-climatic variability impacts, crafting methodologies for vulnerability assessments and development of appropriate adaptation options and solutions at various scales.

Research under this portfolio also includes developing appropriate quantitative understanding, tools and strategies for managing the impacts of climate variability and change as well as for managing risks associated with extreme events. These aim to support the development of policy responses, at regional, national or catchment scale, to existing and emerging problems.

At the climate change dialogue held in March 2013 were Imraan Patel (Department of Science & Technology); Dr Sylvester Mpandeli (Department of Environmental Affairs); Prof Roland Schulze (University of KwaZulu-Natal); Chris Moseki (formerly of WRC); Dr Sabine Stuart-Hill (UKZN) and Dhesigen Naidoo (WRC).



Chapter 5

New products and services for economic development

Science and technology continue to revolutionise the way goods and services are produced and traded. Government's National Development Plan recognises that South Africa needs to sharpen its innovative edge and persistently contribute to global scientific and technological advancement.

At the same time, given the limited availability of freshwater resources in South Africa, innovative new approaches are required to reconcile demand and supply, particularly in the most water-stressed catchments and areas of development, so as to ensure that South Africa's growth is not negatively impacted. The WRC has recognised that in order to meet these objectives, greater investment in research and development to facilitate innovation is required.

During the past two decades, several innovative developments – some with commercial properties – have been funded by the WRC. The Commission also continues work with partner organisations to facilitate the transfer of WRC innovation along the water knowledge value chain to further stages of technology development, commercialisation and uptake.

Olifants River, Mpumalanga

Enhancing knowledge on SA's water resources

Water is South Africa's scarcest resource. It is therefore crucial that we ensure that the water we do have is developed and managed optimally for the country's citizens, for economic development and for the aquatic environment. This makes quantifying how much water we have, one of the most important tasks to be undertaken in the local water sector.

Over the last 30 years the WRC has commissioned and funded four major national surveys of South Africa's national water resources i.e. the *Surface Water Resources of South Africa in 1980* and in 1990 and the *Water Resources of South Africa in 2005* and the *Water Resources 2012* study (WR2012).

These studies play an important part in legislation and policies. They provide the cornerstone of baseline national water resources assessment and planning for South Africa, as required in the NWRS.

A new study is been roughly conducted every tenth year, but this 10-year gap between assessments was proving to be too long in a water stressed country with accelerated demands in which rainfall is highly variable with real threats of climate change impacts.

To bridge this gap the WRC commissioned a four-year integrated Water Resources of South Africa study (also known as WR2012 Study) in April 2012. The main purpose of the study is to create a Web-based, interactive reporting system to continually quantify both surface and groundwater resources as well as the general water quality of South Africa. Such a system will be essential in the continuous updating of the NWRS and the country's water resources planning.

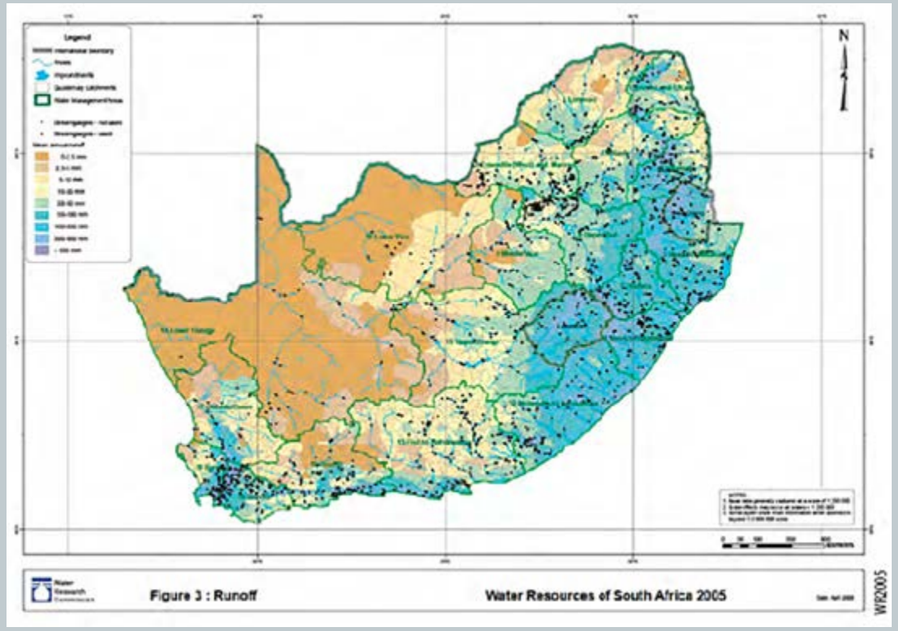
WR2012 is due for completion in April 2016. It will, for the first time, include a publicly accessible, Web-based, interactive surface and groundwater resources reporting system.

annual mean runoff

49 210m

49 210 million m^3/year – South Africa's mean annual runoff

The WR2012 study was officially launched in March 2012. Present at the launch were study project leader Allan Bailey, WRC CEO, Dhesigen Naidoo, Mbangisani Nepfumbada from the Department of Water and WRC Research Manager, Wandile Nomquphu.



South Africa's mean annual runoff.

"South Africa's climate is characterised by complex hydrological features. Not only is it highly variable in space and time, it is not unusual to experience extreme climatic conditions in different parts of the country at the same time, for example drought in one part and floods in another."

– Wandile Nomquphu, WRC Research Manager

Striving for excellence in wastewater management

Waste minimisation clubs

The past two decades have seen an increasing awareness of the footprint of organisations in the area of wastewater management. The water footprint of a business refers to the total volume of freshwater that is used to produce its goods and services. Waste minimisation clubs (WasteMin clubs) have been found to be an effective way of improving local industries' environmental performance by promoting cleaner production.

WRC research led to the establishment of two WasteMin clubs. The first of these clubs was in the metal-finishing sector in the greater eThekwini Metropolitan area, and the second one, a cross-sectoral club in the Hammarsdale region, both in KwaZulu-Natal. These clubs proved to be a great success, with open sharing of information and ideas among club members, financial benefits to the companies and a reduction in their environmental impact.

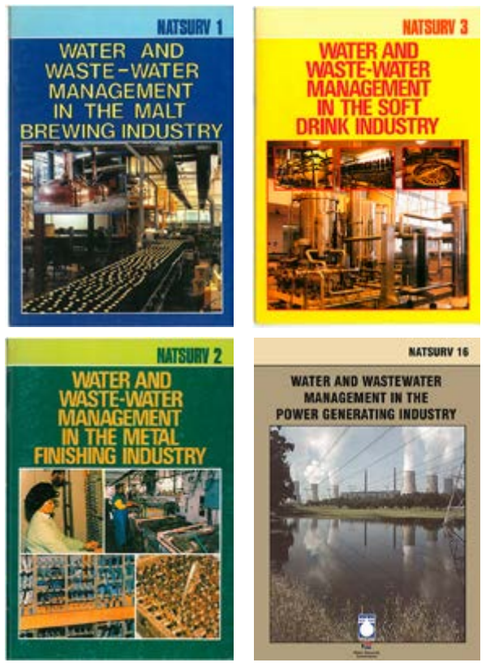
The two pilot WasteMin clubs have since evolved into two spin-off initiatives. The first, a Metal Finishing Association was initially formed in the KwaZulu-Natal region and subsequently became a national organisation, promoting waste minimisation as one of its core activities. The second, the Hammarsdale Industrial Conservancy, has adopted waste minimisation as a key activity to promote environmental improvement in the area. Furthermore the two initial clubs have spawned 30 other WasteMin clubs nationally in various sectors, including the mining industry.

National survey (Natsurv) of water and wastewater in industry

In 1985 the WRC, in collaboration with the Department of Water commissioned a national industrial water and wastewater survey of all classes of industry in order to ascertain the minimum water requirements (specific water intake) of particular industries, as a blanket restriction in times of drought would be grossly unfair. Furthermore, the study surveyed the wastewater and typical pollutant loads generated which allows regulators to manage discharge to sewers.

A guide for establishing waste minimisation clubs in South Africa has been translated into Chinese, with permission from the WRC. The guide was originally compiled for the WRC by Susan Barclay of the University of KwaZulu-Natal's Pollution Research Group. The translation and free distribution of the guide was sponsored by the EU-China Environmental Management Cooperation Programme.

WasteMin clubs are a group of industries working together to reduce their environmental impact, and improve the efficiency of their businesses.



The Natsurv guides have been among the most widely sought and applied publications of the WRC and have made a huge impact managing pollution and water usage in industry. The guides have had wide usage by industry, academics, regulators and consultants.

The survey resulted in the publication of the Natsurv series of guidelines on water and wastewater management for the following industrial categories: sugar production, poultry abattoirs, red meat abattoirs, soft drinks, dairy products, metal finishing, sorghum beer, malt brewing, laundry, edible oil, pulp and paper, textiles, wine-making, leather tanning, fruit and vegetable processing, pelagic fishing, fish processing and most recently, the oil refining and re-refining and power-generation industry. Altogether 19 different guides were published by the WRC from 1987 onwards until 2005. Most of the guides have been incorporated in courses presented by universities and universities of technology.

The Natsurv reports for different industries have been well used since they were developed by the sector. However, South Africa and its industrial sectors have either 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 therefore certain information contained in the national surveys can be regarded as obsolete.

Furthermore, initiatives like the UN CEO mandate, water stewardship, water allocation and equity dialogues, among others, suggest growing awareness related to water use, water security and waste production. It is therefore considered an opportune time to review the water and wastewater management practices of the different industrial sectors and make firm recommendations.

The WRC is currently revising all 19 Natsurvs. This is a process that commenced in 2013 with four studies supported per year and the aim is to complete all current revisions by 2019. In addition, the Department of Water is supporting this process and has commissioned a survey on a new industry – the steel industry. This will result in the 20th Natsurv being made available to the sector inclusive of best practice approaches.

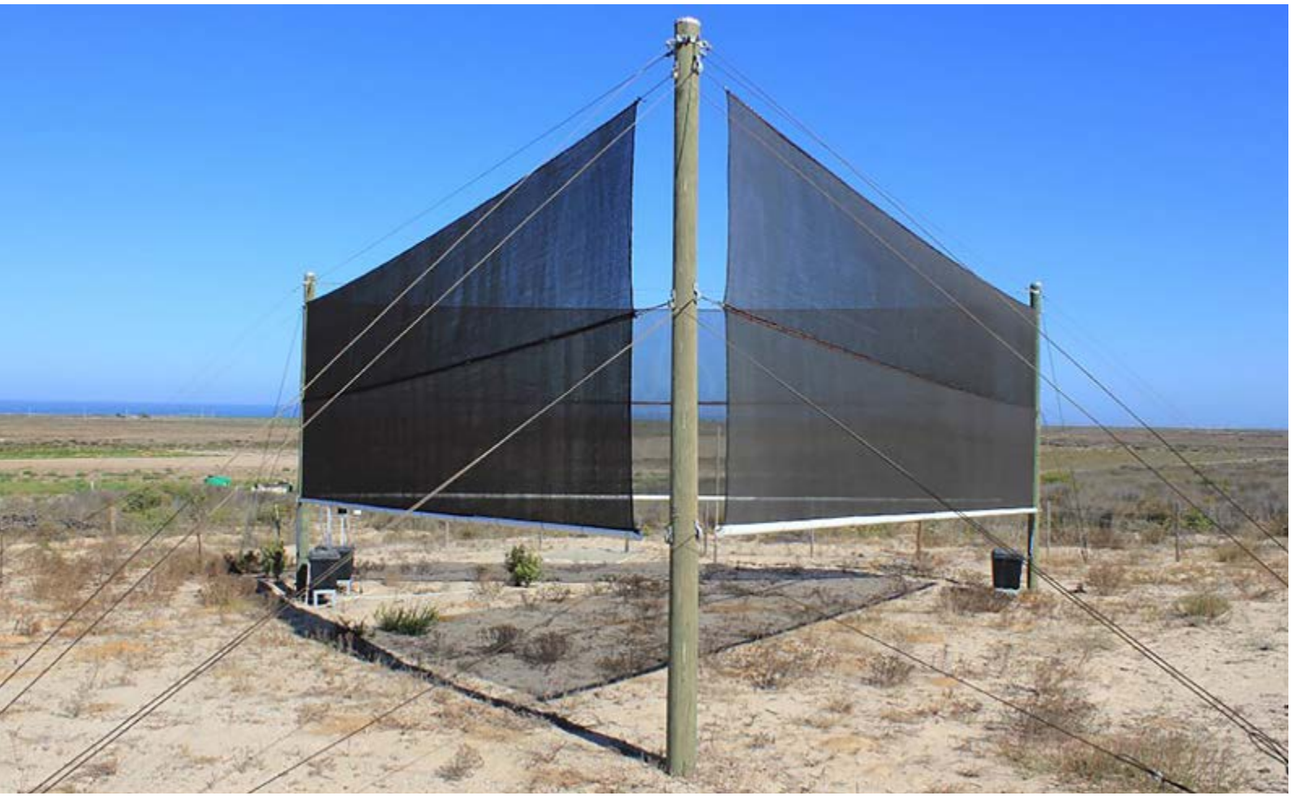
The dual-stage membrane bioreactor (MBR)

As the national driver of innovation in the water sector, the WRC is involved in projects that promote on-site treatment of industrial wastewater for reuse, thus promoting the concept of zero liquid effluent discharge. Dr Wade Edwards came up with such an innovation – the Dual-stage MRB Process Technology licensed exclusively to ATL-Hydro.

"While innovative and considered as Best Available Technology, the membrane bioreactor process comprises a relatively simple flow configuration and is therefore ideally suited to industries characterised by effluents which are difficult to treat; footprint constraints; and requirements for high-quality treated water," says Dr Edwards.

The MBR technology is a unique operations strategy employing membrane bioreactors for the treatment of high-strength industrial effluents containing recalcitrant pollutants. The significant advantage is that this process design can be retrofitted to existing infrastructure with relatively low capital expenditure. Because the reticulation and process flow control of this system is relatively simple insofar as hardware requirements are concerned, automated control of the process would be significantly less complex and relatively inexpensive compared with the current systems presently considered when new activated sludge processes and associated infrastructure are designed.

The technology, which proved to be successful for the treatment of a variety of industrial process wastewaters generated by diverse industries, has been patented.



Fog harvesting screens on the West Coast.

Harvesting fog

The idea of harnessing fog as a source of drinking water has been studied for decades. The first experiments were conducted in 1901, on Table Mountain.

Fog harvesting in low rainfall areas could enhance water security in water-scarce parts of South Africa, particularly in rural communities. To this end, studies undertaken by the WRC since 1995 have established the feasibility of using fog to supplement existing water supplies. The studies are aimed to design, erect and operate a fog water collection system in rural communities.

Profs Jana Olivier and Johan van Heerden from the Department of Geography, Geoinformatics and Meteorology at UP have been involved in fog harvesting research for the WRC since 1995, together with Prof Hannes Rautenbach, Director of the UP Water Institute.

In 1999, a prototype system under leadership of Prof Olivier was set up at Tshanowa Junior Primary School, on the Soutpansberg in Limpopo. The only water sources the children had before the erection of the fog nets were a non-perennial spring 2 km away, and a dam, 5 km away.

Permission was obtained from the relevant local and tribal leaders to erect a fog water collection system on vacant land adjacent to the school. Construction commenced in 1999 and local inhabitants were employed to assist. An automatic weather station was also installed to record rainfall, wind speed and wind direction. Within four days of completion, learners and members of the local community were drinking water collected by the fog screen.

The same system was later also set up by Prof Van Heerden at Lepelfontein, a small missionary station about 400 km from Cape Town. Although groundwater here is abundant, it is of such poor quality that it is considered a health risk.

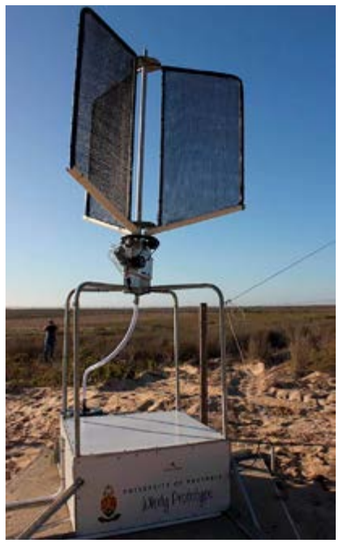
The fog screens were installed in 1999, and the overflow from one of the 10 kl tanks is now being used to supplement the water from the desalination plant. At least 80 per cent of the water collected at this site is from fog alone, as the region receives very little rain. While Lepelfontein's water initially showed high levels of sodium – possibly due to the proximity of the ocean and wind-blown spray – Prof Olivier says that water quality at both sites is good, with no disease-forming organisms present in samples.

"In fact, at Tshanowa, water was rated as Class 0 – ideal quality," she says. "Since the water is used for drinking purposes, quality is tested regularly." She adds that experiments conducted at other high elevation sites around the country have yielded more than 10 ℓ per square meter of collecting surface per day. "This shows that in terms of quality and magnitude of yield, fog harvesting could go a long way to alleviating water shortage problems in the fog-prone mountainous regions of the

"The joy on people's faces when we first succeeded in harvesting water from the fog nets was priceless."

– Prof Hannes Rautenbach, UP

Prof Hannes Rautenbach of UP (right) with Regent Mpapatla Bakhoma Modjadji of the Rain Queen Dynasty during his WRC-funded research project on fog harvesting in Limpopo.



The 'whirly', an innovative WRC design, is aimed at increasing water yield from fog in windless conditions, as is often the case along the West Coast. The rotation of the three screens has resulted in an increase in water volumes captured during fog events.

country. "The costs are low, the technology is simple and the source is sustainable for hundreds, even thousands of years."

As a direct result of these projects, the UP Meteorology Group has introduced a 'community project' module that forms part of its BSc Meteorology curriculum, where students go to rural schools on an annual basis to teach and perform maintenance on fog harvesting structures. In 2010, the WRC approved a new project worth R2,4 million under leadership of Prof Olivier to expand fog harvesting in areas where applicable.

Two nine-panel systems have been erected at Cabazana near Kokstad in the mountains of the Eastern Cape, and one nine-panel system at Lamberts Bay and Doringbaai on the West Coast. These systems are robust and have withstood numerous storms.

Additional research has resulted in a method to grade different fog water system sites, while research dealing with a wide range of features relevant to fog water extraction, including design features and water yield, is ongoing.

Researchers from UP have developed two WRC innovations on fog harvesting. The first innovation is a measuring instrument for low and intermittent water flow. The volume of fog varies considerably – from hundreds of litres per day to less than one. Water collection is also intermittent, with a lot of water collected during wet conditions to none during sunny periods. Conventional water flow meters invariably fail during these conditions.

Prof Johan van Heerden has built a low-flow meter (LFM) that can measure such flows. It is based on a tipping bucket principle, but can measure 1 to 1.5 ℓ per tip. The LFM is made from perspex to enable easy identification of blockages. The system has been tested under field conditions over the last two years and has been found to be robust and accurate.

The second innovation, the Whirly, can be used to harvest fog water during near-windless conditions. Previous systems – and those used world-wide – are static nets that rely on fog-bearing winds to blow through the system, depositing tiny fog droplets of water on the screen. These droplets then coalesce, become heavier and trickle downwards. They drip into a gutter attached to the bottom of the screen. From there it is channelled to storage tanks.

The new invention consists of a vertical shaft with three nets attached. An electronic system has been attached that cause a rotor to turn - thereby rotating the nets when the relative humidity reaches 98% (as it does during foggy conditions). The system switches off when the fog ceases. The batteries that drive the system are charged by means of solar power. This system allows the capture of water during near windless conditions – a situation that often occurs on the West Coast.

It is estimated that in 20 years more than half the population will live within 10 km of the shore.

WEROP – Generating clean energy and water for communities

The southern African coastline has been identified as one of only six wave power rich areas in the world by the US Department of Energy (DoE). The estimate of wave power potential is very high, with the US DoE calculating that in the Pacific North West coastline alone wave energy could produce some 40-70 kW per metre of coastline.

The WRC-funded wave energy reverse osmosis pump (WEROP) is such a wave energy solution. In WEROP, wave power is harvested to provide the energy for desalinating sea water in order to supply high-quality freshwater for local community use just off Simonstown in the Western Cape. "The elegance of the solution lies in WEROP's ability to generate electricity while at the same time providing water fit for drinking," says WRC Research Manager Dr Jo Burgess.

The system is potentially unique in the world, while the know-how around operating it is totally novel. Primary research was carried out on-site, around the Cape Peninsula, where the WEROP was assembled, launched and tested in order to improve its operation and design. Once scaled up, it will be among the world's first off-grid drinking water systems.

The WEROP system was designed and developed by freelance oceanographer Simon Wijnberg, who originally conceived the idea while surveying the coast around southern Africa. The plight of remote coastal communities in northern Mozambique who had no access to fresh water inspired him to find a solution to their problem. WEROP has since become his full-time occupation and has led to the establishment of a wave energy conversion R&D company, Impact-Free Water (Pty) Ltd, of which Wijnberg is the CEO.

Anchored to the sea floor, with a buoy that rides the surface waves, the WEROP uses both the rise and the fall of the passing waves to generate energy. Seawater is pumped through a flexible pipeline to a reverse osmosis desalination unit on the beach. Theoretically, the present size WEROP can pump an average of 45m^3 of filtered seawater per day.

"WEROP provides an alternative water supply technology that works *with* nature rather than *against* it," notes Dr Burgess. "It mitigates climate change by using only wave energy to desalinate seawater, with carbon credit awards as a valuable by-product."

The data have been gathered and the WEROP initiative has been channelled to the Technology Innovation Agency (TIA) for development funding.

Just off Simonstown in the Western Cape, wave power is harvested to provide the energy for desalinating sea water. This results in high-quality freshwater for use by the local community.

Acid mine drainage, especially from abandoned mines is a huge challenge in many areas of South Africa.

Mine-water – from pollutant to resource

Mining was and still is one of the primary driving forces behind the development of South Africa. The areas in which development and progress are currently centred were mainly determined by the relative paucity and disproportionate distribution of our water sources on the one hand, and by the relative abundance and location of our mineral resources on the other hand. Mining remains the single, most important industry in our country.

Since the main part of the impact of mining on the aquatic environment is diffuse in nature and therefore difficult to quantify and to control, it was only in recent decades that the regulatory authorities started paying attention to the problem of how to regulate this impact.

Mines are expected to present the authorities with an environmental management programme in which it should be indicated among others, what the background environmental conditions were before the commencement of mining activities and how these activities will influence the environment during and after completion of the activities. It also needs to be shown how the environmental impact will be managed.

In prioritising research needs, it was found that the most pressing need was for research on the identification, evaluation and development of cost-effective strategies and technology for the management of the impact of mining activities. The secondary research needs were identified as being the quantification of the current use and contamination of water sources by mining activities, determination of economic, socio-political and regulatory issues relating to water sources, and formulation of the best available technology which would not incur excessive costs.

Prior to 1990 most South African mine water related research was conducted by the now disbanded Chamber of Mines Research Organisation. The WRC's involvement in mine water research was limited to determining the water requirements and pollution potential of gold and uranium mines.

Two aspects of research related to improved predictive ability have received special attention: firstly, the ability to predict the generation of acid drainage, and secondly, the ability to predict the rise in water levels and/or time and point of decant when pumping associated with active mining stops.

Non-point sources of pollution are of major importance in certain catchments. This realisation came to the fore particularly in 1992 in the light of the new approach of the then Department of Water to integrated catchment management. Mining, in particular, was identified as a potential, important non-point source of pollution about which more information was needed.

Against this background, in collaboration with the Chamber of Mines of South Africa, the establishment of guidelines and procedures to determine and counteract the impact of gold mine activities on the water environment was initiated during the year.

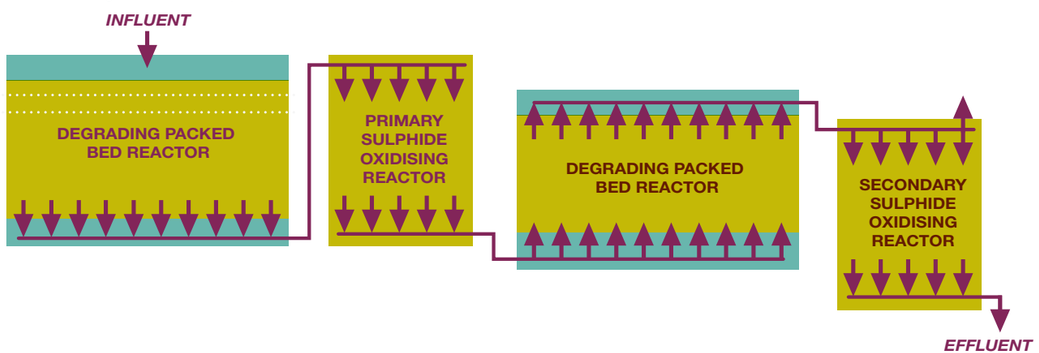
A project to study the occurrence of bacteria causing acid mine drainage in the outer layers of coal waste dumps was also initiated. It was at this time that the WRC foresaw that the significance and extent of mining-related water research both inside and outside the Commission will increase to such an extent that it decided to establish a Coordinating Committee for Mining Related Water Research (CCMRWR).

Mining provides crucial jobs to thousands of people in South Africa.

"Between 1990 and 2000, research focused on the impact mining has on the surface environment, on treatment options for mine effluents and on the rehabilitation of mining spoils. Since 2000 the emphasis has shifted to the development of predictive tools and modelling techniques, with the focus on treatment options shifting to implementation and passive systems."

- Dr Jo Burgess, WRC Research Manager

Schematic diagram of the IMPI process



The development of passive treatment systems, capable of ameliorating the various forms of mine effluent on a long-term self-sustaining basis, was identified as a high priority research need. One of the early responses was a project by the CSIR to assess the full extent of the problem and the depth of knowledge worldwide.

Another study funded by the WRC in 1997 demonstrated that underground mine water can be neutralised effectively with limestone in a fluidised bed reactor. Limestone neutralisation of acid water in this manner offers advantages over conventional neutralisation processes and it can be implemented on a full scale after site-specific tests have been conducted to obtain design criteria for specific waters.

Acid water is neutralised with a discharge or recycle in mind. Acid water contributes to corrosion of pipelines and contributes to surface water mineralisation. It is generally detrimental to aquatic life and has a negative aesthetic impact on rivers and streams.

Lime neutralisation is largely applied to meet legislative requirements regarding discharge of effluent into receiving rivers.

In 2002 a WRC-funded research consortium announced that after eight years of development, they had made a dramatic breakthrough in the field of mine water treatment.

The Integrated Managed Passive Treatment Process technology (IMPI) was a world first. Using naturally available energy sources such as topographical gradient, microbial metabolic energy, photosynthesis and chemical energy the system requires nothing more than regular, but infrequent maintenance to operate successfully over its design life. The minimum design life of an IMPI treatment plant is 15 years.

This research programme succeeded in improving the efficiency of existing technology by a factor of 20 over conventional anaerobic passive reactors, thereby making it commercially viable.

The South African mining industry faces major problems relating to the management and treatment of contaminated mine water. These problems exist with regard to operational mines and, importantly, they also exist for mines which have ceased operations and which have long-term water quality problems.

That is where IMPI came into its own. Effluent treatment technology for dealing with water quality problems was previously of a chemical or physical nature. Although this technology is generally effective, it typically has very high capital and operating costs and intensive, ongoing, long-term maintenance requirements. This is a particular problem for those mines that have ceased operations and where it is not practical or cost-effective to construct an active treatment plant that requires constant supervision and maintenance.

An urgent need was, therefore, identified to develop low-cost, self-sustaining, low maintenance passive treatment systems to address the problems of acidification and salinisation (in terms of sulphate) at operating, defunct and closed mines in South Africa.

The integrated passive treatment technology was designed in three primary configurations as follows: Impisure – applications where reduction of sulphates, metals and acidity is required; Impimare – applications where reduction of metals and acidity is required and Impiplume – applications where *in-situ* remediation of contaminant plumes is required.

The final phase in this successful development programme is the design and implementation of full-scale systems within the mining industry.

The IMPI process involves the subdivision of the overall mine-water treatment process into individual units, each designed and optimised to perform a key function. If required, a final aerobic polishing stage can be added, primarily to remove residual levels of volatile fatty acids and nutrients.

Full scale versions of the IMPI system are being implemented at various sites, based on the knowledge gained over seven years from the pilot plant at Vryheid Coronation Colliery in KwaZulu Natal.

The full scale implementation of the technology needs to take into account various site-specific factors. In order to address these uncertainties,

"The IMPI process was a breakthrough, because it could treat mine wastewater at less than half the capital cost required for an active system, which would use, among other capital-intensive elements, electricity and chemical dosing. Indeed, the operational costs of running IMPI are less than one-tenth that of an alternative system."

– Dr Ralph Heath, Golder Associates

"During the past 20 years, South Africa has made valuable contributions towards finding solutions for AMD and the local research fraternity has a range of world-class solutions on offer."

– Dr Jo Burgess, WRC Research Manager

a standardised four-phase implementation procedure was developed to ensure an optimised site-specific plant design when rolling out full scale versions of the system.

Additional evaluations and research are still continuing. The researchers have seen progressive improvement in the performance of the system as the research has gone through the different phases.

The technology developed during this research project is firmly based on two major South African biological sulphate reduction research initiatives. The first initiative has been ongoing for a period of around 15 years by Pulles Howard & de Lange and subsequently Golder Associates Africa and has focused on passive sulphate removal technology. The second initiative has been ongoing for a period of around 15 years by the Environmental Biotechnology Research Unit at Rhodes University.

These two initiatives started off operating independently but have been cooperating with true synergy for the last 10 years. The collective manpower investment in these two initiatives is believed to be of the order of 120 man years and the collective budget in 2009 value would exceed R100 million. The leading position occupied by South African researchers in the field of passive sulphate removal technology is therefore not accidental, but is rather the product of a sustained and concerted research effort and a sustained support from the South African research funding agencies and South African mining industry.

The monitoring programme at the Vryheid Coronation Colliery pilot plant continued for a ten-year period from 1996 to 2006. With more than 1 million data points, this pilot plant is undoubtedly the world's best monitored passive sulphate removal plant and has revealed very valuable information about the long-term performance of these reactors.

Quantifying the acid mine drainage problem

Between 1990 and 2000, WRC mining research focused on the impact of this sector on the surface environment, on treatment options for mine effluents and on the rehabilitation of mining spoils. From 2000 to 2010, the emphasis shifted to the development of predictive tools and modelling techniques, with a focus on treatment options shifting to implementation and passive systems.

Discharge of acid rock drainage (ARD) or acid mine drainage (AMD) wastewaters following the closure of gold and coal mines, has played a major role in driving much of the WRC's mining research agenda since 2000. Acidic effluents arise in the mining industry mainly from discarded overburden, slimes dams, sand dumps, underground workings and metallurgical plants.

Two aspects of research related to improved predictive ability have received special attention: firstly, the ability to predict the generation of acid rock drainage (ARD) or acid mine drainage (AMD), and secondly, the ability to predict the rise in water levels and/or time and point of decant when pumping associated with active mining stops.

In view of the plethora of techniques used to predict the likelihood of AMD, research targeted at opencast coal mining led by the Institute for Groundwater Studies at the University of the Free State (UFS) started in 1999 to standardise the methods used to quantify the potential and magnitude of AMD. Based on extensive testing of existing static methods, standardised methods of measuring initial pH, neutralisation potential and acid potential of water have been recommended.

Prediction of AMD is done by lab methods such as Acid-Base Accounting (ABA); however it is still difficult to predict the rate and quantity of AMD. ABA is a procedure performed in the laboratory to determine the potential of AMD generation, confirm if there will be potential for acid generation and salt load.

The WRC undertook to investigate the standardisation of methodologies to be followed to quantify the potential and magnitude of AMD under South African opencast mining conditions. The UFS project, undertook to:

- Investigate the applicability of existing global ABA technologies to South African opencast coal mines.
- Refine ABA methodologies for local conditions through experimentation.
- Establish a creditable database, detailing results from this investigation for future reference.
- Select and recommend ABA methodologies to be used in South African opencast coal mines.

WRC research targeted at opencast coal mining started in 1999 to standardise the methods used to quantify the potential and magnitude of AMD. Based on an extensive testing of existing static methods, the researchers recommended standardised methods for measuring initial pH, neutralisation potential and acid potential of water. They described and justified the advantages of the recommended methods.

They also developed an easy to use spreadsheet tool, ABACUS, to standardise the interpretation of static ABA data and, where the suggested sampling methodology has been followed, to provide a method for extrapolation to the field through volume-weighted techniques.

"The WRC played an integral role in the development of the IMPI process. Without the WRC, we would not have been able to run the pilot plants, let alone role out the full scale implementation that followed."

– Dr Ralph Heath, Golder Associates

There are around 270 gold mine tailings in South Africa.

Defining a suite of acid-drainage prediction tools

Although the project focused on ABA, it strived to define a suite of acid-drainage prediction tools. The researchers coined a new acronym, ABATE (derived from Acid-Base: Accounting, Techniques and Evaluation), for the approach that integrates a range of tools to predict the potential for acid generation. This also helps to prevent confusion from arising in the use of the term ABA, since most people associate ABA with the static test component of drainage chemistry prediction, rather than the entire suite of tools. Research is in progress regarding the use of geochemical modelling techniques to predict the evolution of ARD over time.

There are about 270 gold mine tailings covering 180 km^2. Continued efforts to remine and consolidate the tailings into mega-dumps, the contamination and reclamation of the footprint beneath them and the degree to which tailing properties and time affect the depth and rate of weathering of typical tailings dams, have been investigated.

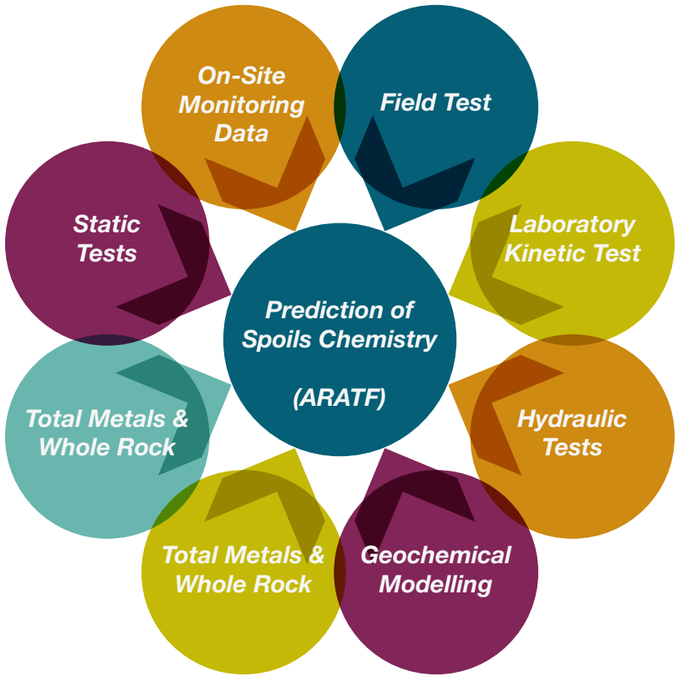
An empirical model was developed to predict the likely period over which tailings dams will produce acidic drainage. Efforts are currently underway to develop a coherent process to facilitate transparent and effective regulatory decision-making regarding the sustainable design, operation and closure of residue disposal facilities. A preliminary Decision Support System to facilitate decision-making was completed in 2008.

The ability to predict the rise in water levels, and hence when and where decant to surface would take place after the cessation of mining, has received considerable attention. This ability is particularly important in view of the recovery of water levels in deep gold mines and the seepage of ARD from old shafts. Pioneering research in this regard was undertaken in a 1995 investigation into the flooding of Central and East Rand gold mines which have become largely interconnected through mining activities.

A series of collaborative research projects between the WRC and Coaltech (a non-profit research organisation funded by coal mining companies) captured the mine plans and coal seams in a three dimensional GIS, enabling the mines to determine decant points and the extent of intermine flow within the Mpumalanga coal fields. This ability is used to determine the position and capacity of plants to treat the ARD emanating from the coal fields.

In 2006 the WRC joined the global alliance of research organisations, which support the activities of the International Network for Acid Prevention (INAP).

In the late 2000s, concerns around the present and predicted decanting of AMD from gold mines on the Witwatersrand again thrust this complex pollution issue into the limelight.



The Prediction Wheel for Mine Drainage Chemistry and ABA's part therein (after Morin and Hutt, 1999).

"The difficulties pertaining to the treatment of AMD are mostly not scientific or technical, but rather involve institutional arrangements and funding. More than 20 different models for treating all the types of mine water have been developed worldwide, so the issue is not that people do not know how to treat the water."

– Dr Shafick Adams, WRC Research Manager

The Rhodes Biosure process makes use of wastewater sludge to neutralise acid mine-water.

Sustainable treatment of acid mine drainage wastewaters

One of the indigenous AMD treatment technology developments, the Rhodes University's BioSURE Process, developed through the WRC, focused on the specific process development objectives of large volume treatment linked to long-term process sustainability.

Following observations by students at Rhodes some years ago, on the enhanced breakdown of complex organic substrates in sulphate-reducing environments, it was shown that sewage sludge (and other organic wastes) could be used to fuel a microbially-driven process in which acidity in AMD was neutralised, and sulphate salts and heavy metals could be removed. Apart from the low-cost advantages of biological processing, the opportunity costs in the co-disposal of waste and recovery of treated water as a value-added product offered additional possibilities.

The development of the Rhodes BioSURE Process has followed a more or less textbook case of technology R&D, with a lead time of about 15 years from initial observations in the early 1990s and fundamental descriptive studies to full-scale process demonstration and implementation in 2005.

Initial observations of complex organic substrate utilisation in fueling sulphate-reducing microbial processes were made in tannery ponds. Enhanced sulphate reduction was achieved in follow-up fundamental enzymology and kinetic studies. The team at Rhodes started to look at different reactor configurations and the use of primary sewage sludge as the electron donor. These observations were transferable across a range of complex organic carbon wastes and were shown to be particularly effective where sewage sludges were used.

Following laboratory bench-scale studies in which the various features of the process were characterised, a programme of process development scale-up commenced.

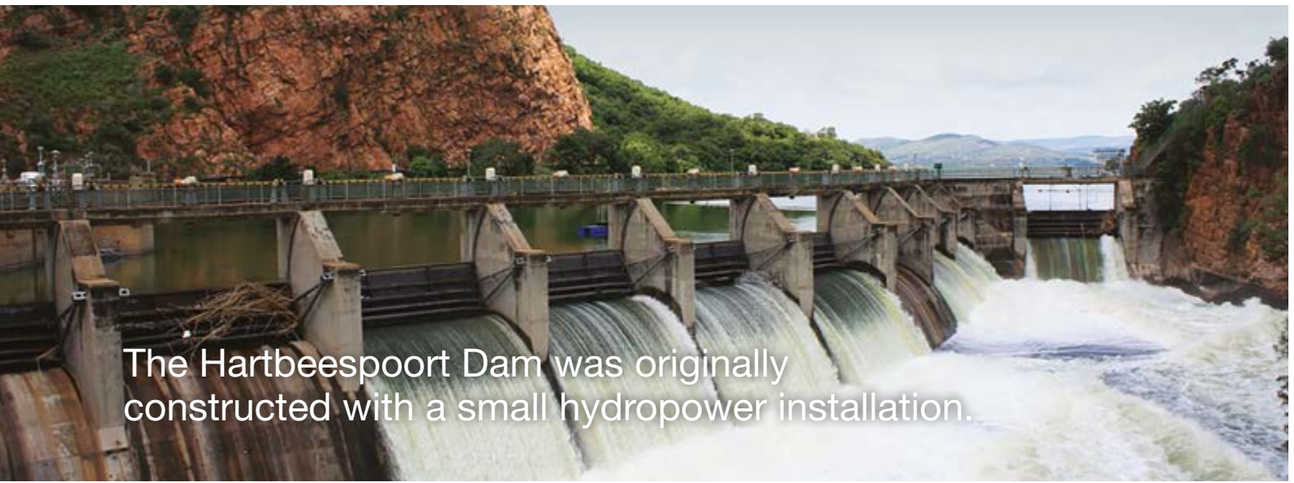
This led to the construction in 2005 of a 40 m^3/day pilot plant at Grootvlei Gold Mine in Springs, where AMD was being actively pumped from the mine to the Blesbokspruit Ramsar site wetland. Primary sewage sludge as the carbon source for the process was supplied by ERWAT's Ancor Sewage Treatment Works close by.

This pilot plant was operated over an 18 month period and the operational and design criteria derived provided the basis for a decision to proceed to the construction of a technical-scale plant at the Ancor Works. This required the installation a 2.4 km pipeline to pump AMD from the Grootvlei Mine to the Ancor Works and Dortmund tanks available at the site were converted to function as process reactor vessels. The technical-scale plant was sized to treat 1.6 mℓ a day AMD and over the study period it was shown that sulphate levels could be reduced to less than 100 mg/ℓ at hydraulic retention times of around 12 hours.

Following detailed process kinetic modelling studies which included the development of a computational process simulation programme in collaboration with engineers at the University of Cape Town and the University of KwaZulu-Natal, design work commenced on the construction of a full-scale BioSURE process plant to treat ten megalitres a day. The process was designed to remove sulphate to levels below 250 mg/ℓ and long-term operation has resulted in the removal of more than 12 t a day of sulphate.

One of the main outcomes of this development has been the demonstration that the utility company provides a feasible operational environment for dealing with the long-term management of the AMD problem. These organisations have the infrastructure, technology and expertise required to manage large volumes of wastewaters on a daily basis and at as low a cost as possible. Their business investment model focuses over the long-range (50 to >100 years) and the cost recovery potential in waste co-disposal and water recovery present income opportunity incentives.

Untreated AMD could possibly be used by municipal sewerage works to aid nitrate digestion, thus eliminating water treatment costs, while also saving clean water. The BioSURE treatment process is built on this principle and is being considered by the Department as part of the long-term solution.



The Hartbeespoort Dam was originally constructed with a small hydropower installation.

Tapping untapped renewable energy

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 the growing energy consumption, it is clear that there is a need to change the way energy is generated and used. The renewable energy technologies are without a doubt the means how the future economic development will be supported and energy demands satisfied.

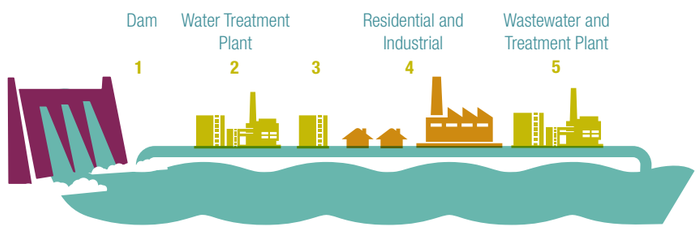
UP, supported by the WRC and collaborating organisations such as the City of Tshwane Metropolitan Municipality, Bloemwater and the eThekwini Municipality, undertook a research project to investigate and demonstrate the potential of extracting the available energy from existing and newly installed water supply and distribution systems.

The aim of the project was to enable the owners and administrators of the bulk water supply and distribution systems to install small-scale hydropower systems to generate hydroelectricity for on-site use and, in some cases, to supply energy to isolated electricity demand clusters or even to the national electricity grid, depending on the location, type and size of installation. It taps into an unutilised source of hydropower by using excess pressure in conduits to produce clean and renewable hydroelectric power.

This type of energy generation, referred to as conduit hydropower, is different to conventional hydropower generation where large dams are used to store river water in a reservoir. Its simplicity is what makes this solution so elegant: harnessing energy that is already present within the existing infrastructure and that would usually be lost through the use of a pressure valve.

The hydroelectric energy generation technology has been successfully demonstrated at the first closed-conduit hydropower pilot plant in South Africa, which was constructed at the Pierre van Ryneveld reservoir situated in the Country Lane Estate, south of Pretoria. This ±15 kW installation utilises a cross-flow turbine discharging through the roof into the reservoir. A controlled flow is supplied to the turbine from the main supply line into the reservoir.

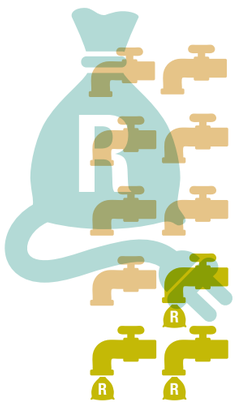
The generated power is used on site for lighting, as well as for alarm and communication systems. The Homeowners' Association of the estate have also indicated that they would like to utilise the power for street lighting. Annually, approximately 131 000 kWh could be generated with this unit, which is enough to supply 10 households.



Potential energy-generation locations in the water supply and distribution system

The current status of global energy shortages requires new thinking due to the emphasis to reduce CO_2 emissions, development of alternative energy generation methods and growing energy consumption.

WRC Executive Manager, Jay Bhagwan, Marco van Dijk and Prof Fanie van Vuuren, both of the University of Pretoria, with the Community Renewable Energy Award scooped by the WRC conduit hydropower project in the 2014 *Mail & Guardian* Greening the Future awards.



cost of energy

30%

The average percentage of water utilities' operational cost represented by the cost of energy.

The technology has also proven to be a huge success in converting the main supply of energy for operating the Bloemwater head office in Pellisier to a sustainable energy source. The Bloemwater facility can produce 96 kW/h of energy from a bulkwater supply pressurised conduit.

For the Brandkop hydropower installation, a 96 kW crossflow turbine and synchronous generator was installed. At this site this is about 30% of the full potential of the pipeline. The turbine is housed in a turbine room located next to the Brandkop Reservoir. The Bloemwater head office is directly connected to this hydropower plant, says Mokutu Kgwale, Director for Infrastructure Development, Operations and Maintenance at Bloemwater.

Approximately 30% of the water supplied via the Caledon–Bloemfontein pipeline is diverted through the turbine. Sufficient renewable energy is generated to supply the peak demand of Bloemwater's head office as well as meeting the electricity requirements of the reservoir terrain. Annually ±800 MWh could be generated with this micro-hydropower installation.

Numerous municipalities and water utilities, including Rand Water, are now investigating whether there is potential for conduit hydropower in their water infrastructure as well as being open for other alternative low-head options.

For the WRC the success of the pilot projects heralded the start of a journey that would potentially result in the provision of renewable and low-cost energy to all areas of the country. Conduit hydropower requires a small capital investment and has a short return on investment period. As long as people use water, renewable electricity can be generated.

Crossflow turbine and generator installed for the Bloem Water project.

The turbine room located next to the Brandkop Reservoir.

Ensuring more crop per drop

The commercial irrigation sector is responsible for over 62% of South Africa's total water use. If the challenging objectives set by the NWA, which calls for water to be used in an equitable, efficient and sustainable manner, are to be adequately met, appropriate decision support is required for the agricultural industry. Over the years, the WRC has attempted to do just this, and a number of models catering for specific aspects of water resource management have been developed with funding from the WRC.

WRC Executive Manager of Agriculture, Dr Gerhard Backeberg, explains that the roots of many of the benefits being reaped today were already laid down decades ago. These include landmark work in the field of irrigation. Smart solutions with high impact include the water administration system (WAS), which is now being rolled out under the auspices of the Strategic Water Partnership Network (SWPN).

Additional boons include the possibility of developing whole new market mechanisms for indigenous crops. This may mean that economic access may be improved, as indigenous crops are shielded from the commodity trading mechanisms which are the current key price drivers and in many instances, together with the sophisticated distribution chains, the mainstay reason for food price inflation.

Use of rainwater in agriculture

WRC first when it comes to agricultural water research

According to an investigation into project data for all water-related agriculture in the country conducted in 2010, the WRC is the foremost funder of water-related agricultural research in South Africa.

The study considered all projects related to irrigated and rain-fed agriculture, woodlands and agroforestry, grassland and livestock watering as well as freshwater aquaculture and inland fisheries. A total of 65 water-related agricultural research projects were identified valued at a total of R208-million. Of this, the WRC contributed around R130 million. The Commission is also funding the highest number of projects.

The high number of projects in the irrigation agriculture category reflects the maturity of South Africa's irrigated commercial sector, and shows big investments being made into the sector, which not only uses most of the country's water, but contributes significantly to food production and employment. Many research projects also address water utilisation for poverty reduction.

Increasing irrigation efficiency

Irrigation technology has improved significantly over the past two decades, and a number of WRC research projects have led to models that are contributing to increased efficiency in water use and planning.

PUTU: The PUTU irrigation models, conceptualised by the Department of Agrometeorology at the UFS, effectively simulate irrigation scheduling, crop growth and yield potential. The validity of the models, which employ weather data among other inputs, has been demonstrated. The models result in increased crop yields and savings in pumping costs.

SAPWAT: This model's primary function is to estimate crop evapotranspiration, from which irrigation requirements for application in planning, design and management can be derived. A supporting database allows it to be used to estimate the crop water use requirements of different crops under different irrigation management regimes throughout South Africa and neighbouring countries. Models like *ACRU* and *BEWAB*, developed by the Universities of Natal and the Free State are incorporated. The most recent version, SAPWAT 3, includes comprehensive long-term weather data and provides for the introduction of enterprise budgets as part of the planning process (more on this innovation below).

SIMCOM: A dynamic model called SIMCOM was developed to successfully link irrigation, economic and crop growth simulation models. It is the result of a research project aimed at developing a decision-support system for increasing the economic efficiency of using water and energy for irrigation at whole-farm level and was undertaken by researchers at UFS. The research also took into account the risk irrigation farmers are willing to take.

BEWAB: This irrigation water management program calculates the total crop-water requirement and is the result of WRC-funded research by soil scientists of the UFS.

SWB: Researchers of the Department of Plant Production and Soil Science at UP developed the Soil Water Balance (SWB) computer program to assist irrigation farmers and specialists with irrigation scheduling. It stimulates water dynamics in the soil-plant-atmosphere water continuum, making use of weather, soil and crop management data.

Gravity irrigation systems: In 1989, the Department of Agricultural Engineering at UP set out to develop a computer program for the design of gravity irrigation systems and consequently Rehab Consultation did the research and developed the *OPTIVLOED 2.2*. Six *OPTIVLOED 2.2* design courses in South Africa were funded by the WRC. The user is able to see how modifications of design options will affect the system performance.

The WRC provided financial support for a number of research projects concerning the optimal management of irrigation systems.

Irrigation remains the biggest user of water in South Africa.

The internationally acclaimed WAS system is currently used by all major irrigation schemes in South Africa, totalling about 167 000 ha.

The University of Johannesburg (UJ) was responsible for the development of **PROCAN,** which simulates unsteady flow of water in any canal or river. A second, the award-winning WAS, handles all water requests by farmers and is running on all major irrigation schemes throughout South Africa (more on this innovation below).

RISKMAN: The Risk Management simulation model is a model of net cash flow for water use and crop combinations at specified risk levels, generally applied at farm scale.

GIS: The development of an integrated information system for irrigation farming using WAS, SWB and RiskMan computer models represents the culmination of research and development previously done under three different WRC research projects. The result is a tool that can be used on irrigation schemes to minimise water distribution losses, maximise efficiency of water use through effective irrigation scheduling and incorporate risk analysis into crop and cash-flow planning. Prior to integration, all three models made extensive use of separate databases, which have now been integrated and linked to a geographical information system (GIS). Each model in the integrated information system can be used alone, or information can be transferred directly between constituent models.

Wetting front detectors: These provide the means for irrigation farmers, whether they be small-scale, emerging farmers or established, commercial farmers, to achieve a higher degree of irrigation efficiency at relatively low cost. The award-winning technology, based on an Australian invention, has been extensively tested in South Africa, with outstanding results.

The WAS Program - saving water throughout South Africa

Productivity of water use in irrigated agriculture remains a contentious issue, and pressure is increasingly being placed on irrigation farmers to reduce their water use in the wake of limited water resources and competing demands from domestic and industrial uses. To provide irrigation schemes with decision support for efficient water management, the Water Administration System (WAS) was developed with funding from the WRC.

WAS is a uniquely a South African, integrated management tool for irrigation schemes that delivers water on demand through rivers, canal networks and pipelines. It is used for water distribution management and for the calculation of dam and canal operating procedures for a given downstream water demand.

Twelve years of research went into the development of the WAS program, with its main aim to minimise water losses on irrigation schemes. By implementing the water release module of the WAS program alone, field measurements have indicated water savings of between 10% and 20%.

This internationally acclaimed system was developed in 1985 by civil engineer and programmer Dr Nico Benadé, with funding mainly from the WRC. The initial research project involved the development of a computer model to simulate water flow in irrigation canals. "This is where my career as a water researcher started, and I have been involved in water research ever since," says Dr Benadé.

The idea was to use this model to minimise water losses on irrigation schemes that deliver water on demand through canal networks. "We had great success with this model, which received international recognition," he explains. "The only problem was that it was not the solution to the problem of saving water. It did, however, trigger an array of research projects which led to the development and successful implementation of WAS."

WAS is a decision-support program for use by water user associations on irrigation schemes in managing water accounts and their water supply to clients through rivers, canal networks and pipelines. It makes use of eight modules: the administration, water order, measured data, water release, crop water use, water report, bulk SMS and water account modules. These modules are fully integrated, making it possible to cross-reference relevant data and information. The system can be installed on a single computer or on a server for use over a network.

Largely as a result of Dr Benadé's efforts, and with assistance from the WRC, irrigation schemes which have implemented WAS have reduced their water losses by up to 20% through improved water releases in canals and rivers. The program is currently used by all major irrigation schemes in South Africa, totalling about 167 000 ha, which is almost 28% of the irrigated area of South Africa serviced by water user associations. This includes 9 991 abstraction points, with a total water allocation of 1 206.5 million m^3.

In September 2006, Dr Benadé scooped the International Commission on Irrigation and Drainage's (ICID's) Innovative Water Management Award for WAS at a ceremony held in Kuala Lumpur, Malaysia; a significant recognition for two decades of hard work and dedication and the first time a South African scooped the award in this category.

Dr Benadé is actively involved in further research, development, training, support and implementation of WAS. He has turned the outcome of the research into a sustainable business. When asked about the impact and value of the WRC in the WAS innovation cycle, he says: "The impact has been enormous and really difficult to quantify. The WAS program makes a huge difference on all our major irrigation schemes in terms of water savings and productivity. If you ask any of the big irrigation schemes whether they can do without WAS, the answer is a definite no."

In 2010, three years after Dr Benadé won South Africa's first WatSave Award from the International Committee on Irrigation and Drainage (ICID), the Head Water Control Officer of Vaalharts Water, Kobus Harbron, scooped the country's third WatSave Award for the use of WAS at the Vaalharts scheme. The award, in the 'Innovative Management' category, was presented at ICID's 61st International Executive Council Meeting held in Jogyakarta, Indonesia.

A total of 1 120 km of main canal, feeder, community and drainage canals criss-cross the Vaalharts area, delivering water to hundreds of commercial and emerging farmers according to a set allocation.

SAPWAT – SA does it again

In 2011, ICID awarded the country another WatSave Award during the 21st International Congress on Irrigation and Drainage held in Iran. The accolade, in the 'Innovative Management' category, was awarded to Pieter van Heerden and Charles Crosby for their outstanding contribution to water saving and water conservation in agriculture through the development and support of irrigation planning and management tool SAPWAT3.

The original SAPWAT program was developed by agricultural engineer Charles Crosby and released in 1999. SAPWAT is not a crop growth model, but rather a planning and management tool relying on an extensive South African climate and crop database. It is general in applicability in that the same procedure is used for vegetables and field crops, annual and perennial crops, as well as pasture and tree crops. With this program it is possible to simulate wide-bed planting, intercropping and different irrigation methods.

"SAPWAT 'imitates' irrigation and, to do this realistically, must take into account all the inputs that influence irrigation as well as the interactions between them," says SAPWAT co-developer Pieter van Heerden, an agricultural consultant specialising in agricultural extension and irrigation practice, with the emphasis on water needs planning. "SAPWAT can pin-point the factors that are critical in the management of irrigation," he notes.

SAPWAT uses data from a countrywide network of weather stations. It serves as a training aid and planning tool for crop water needs, production systems and the use of river systems, for comparing irrigation strategies and for irrigation scheduling, taking into account such aspects as evaporation at different stages of plant development.

Correctly applied, it can help a producer achieve optimal production in relation to his outlay on irrigation. Designed as a 'calculating shell', it gives the user full control of data used in irrigation water estimation. Existing data can be added to, edited or reviewed by the user.

At the Loskop, Oranje Riet and Lower Olifants irrigation schemes the water-supply losses in the canal system have been reduced to 20% per year.

Computers were installed at the Vaalharts Water office to assist in the capturing of water orders. Water control officers visit the water office once a week to capture their own water orders, which are used for the release calculation.

In addition, the effect of soil water management options, such as deficit irrigation, can be evaluated. Irrigation strategies can be varied to demonstrate the effect of different strategies on irrigation requirement. This allows the user to devise irrigation strategies aimed at maximising rainfall use efficiency and thus reducing irrigation water requirement. In addition, salinity stress and water stress situations can be imitated. All irrigation requirement estimates can be stored and revisited to determine what effect changes in irrigation water management, irrigation system and planting dates could possibly have.

Since its introduction, SAPWAT has been applied by users in 15 countries, including Angola, Mali, Mozambique, Swaziland, Niger, Namibia and Uzbekistan. Through the years the program has been continuously upgraded and improved, mainly with funding from the WRC.

The latest version, SAPWAT3, essentially an enhanced and improved version of SAPWAT, was released in 2008. The program was developed for estimating irrigation water requirements of crops, farms and drainage or administrative regions for planning purposes. Today, SAPWAT3 is used by all irrigation designers in South Africa to optimise water use to its fullest extent.

In addition to the WatSave award, Van Heerden has received the SABI (South African Irrigation Institute) silver medal for exceptional contribution to irrigation technology in 2011.

Since its introduction, SAPWAT has been applied by more than 300 users in 13 countries, including Angola, Mali, Mozambique, Swaziland, Niger, Namibia and Uzbekistan.

Pieter van Heerden (right), pictured here with Prof Giel Viljoen of the University of the Free State, who developed the SAPWAT irrigation planning and management tool.

Vice-President Honoraire of ICID, Felix Reinders hands over the WatSave Innovative Water Management Award 2010 to Kobus Harbron from Vaalharts Water.

Chapter 6

Sustainable development solutions

Water underpins all socio-economic development in South Africa. A reliable supply of water in sufficient quantities at the desired quality is critical for economic growth, social development and job creation.

Sustainable development remains a core principle of all WRC projects and activities. Consistent with the WRC's vision, there is specific focus on sustainable development solutions. This is undertaken by addressing enabling principles of sustainable development, namely, protection of water resources, optimal water use, equity between generations, current equitable access, environmental integration and good governance.

Looking after South Africa freshwater resources

Protecting SA's freshwater biodiversity

The WRC was ahead of its time, embarking on environmental research long before it became fashionable.

The year 1990 saw the entrance of the WRC into the sphere of aquatic ecosystem research. In total, five projects commenced in January 1990 ranging from the freshwater requirements of estuaries through to the legal aspects of water for the environment to the assessment of instream flow requirements, both biotic and abiotic, of rivers.

Aquatic ecosystem research in 1990, expressed as a percentage of total WRC research expenditure at the time comprised only 3,49% of the funding, but many of the projects were set to make waves internationally in coming decades.

By 1995, the research being funded in the WRC's *Conservation of Water Ecosystems* programme was aimed at alleviating the effects of human interference in natural ecosystems. The research looked at the effects of inter-basin transfers on both donor and recipient rivers.

The South African Scoring System (SASS), a rapid method for the bioassessment of river health using the invertebrate fauna, had by the mid-1990s reached a point where it was giving predictably consistent results, and was being applied routinely in different areas by government departments, statutory organisations and private bodies.

wetlands

65%

Around 65% of wetland ecosystems are threatened in South Africa

river ecosystems

57%

Around 57% of river ecosystems are threatened in South Africa

The WRC has been supporting environmental research since the 1990s.

The KNP's rivers are a welcome haven for many creatures.

Studying the Kruger's arteries of life

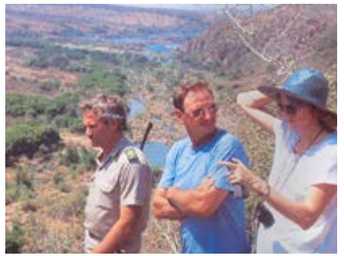
The Kruger National Park Rivers Research Programme (KNPRRP) was a highly successful multi-disciplinary, multi-organisational programme aimed at addressing major concerns about the quantity and quality of the waters of the perennial rivers flowing through the Kruger national Park (KNP).

Initiated in the late 1980s to further river conservation efforts, a major thrust was the development of capacity to predict impacts of upstream influences on the biophysical condition of the rivers, for mitigation purposes. This approximately 10-year multidisciplinary research programme, ultimately led to the adoption of a strategic adaptive management system for KNP river management. The major challenges to scientists during the KNPRRP era included a need to develop and describe a common understanding of the heterogeneity and dynamics of the river systems and then to articulate this understanding to management within a strategic framework.

The WRC was one of the key organisations that conceived of and initiated this programme. During the 1990s the WRC provided the lion's share of financial support for the programme.

The first (1988–1993) and second (1994–1996) phases of the KNPRRP provided a multi-disciplinary, scaled understanding and predictive base for better decision-making involving the KNP's river systems. This was important because causal links between catchment processes (land-use, water abstractions and sediment production) and downstream biotic responses were previously fraught with problems of scale and inter-disciplinarity.

One of the outstanding achievements of the KNPRRP was the development of a multi-disciplinary, multi-institutional research management team that contributed substantially to the understanding of fundamental environmental processes in rivers. Furthermore, a decision support system was developed which can provide users with an information pathway to assist in management decisions, or to explain and motivate environmental water use.



Australian visiting researcher, Dr Angela Arthington visited the KNPRRP during 1992. Here she is with Andrew Deacon (then of SanParks) and Dr Peter Reid, formerly of the WRC.

The Sabie River is filmed from the air as part of the KNPRRP.

A KNP tigerfish with a WRC biotelemetry transmitter.

Researchers and officials from DWS on a field visit to the dry Sabie River in the Kruger National Park during the early 1990s.

Colin Reed

Students from the Freshwater Research Unit at the University of Cape Town undertaking river monitoring.

Co-ordinating the national rivers research effort

A conference in 1998 was organised specifically to formulate a National Rivers Initiative (NRI) to address research needs in rivers nationally. The conference was held under the auspices of the Southern African Society of Aquatic Scientists (SASAQS) and was supported by the WRC and other stakeholders.

The conference aimed to describe all aspects of river research and management in the country identifying strengths and weaknesses and outlining a way forward. The delegates made recommendations for improved management of rivers; identification of glaring deficiencies in knowledge; determining priorities for the future; and for an umbrella structure to oversee and coordinate all river research in South Africa. A task group was mandated to develop the proposals made at the conference.

The management of the NRI process built on the experience gained during the KNPRRP, but the issues addressed went wider. The NRI was made up of a number of separate research programmes, each addressing identified strategic needs for the management of water resources. Some of the research programmes already running at the WRC, such as the research programme on the Surface Water Ecological Reserve, were included within the NRI.

Timing is of the essence. As a result of WRC funding, the Zoology Department at the University of Cape Town (UCT), had by 1997 already developed a method to estimate the flow volume and pattern of flow required to maintain a viable ecosystem in a river for which little or no data exist. The existence of a methodology to quantify environmental flow requirements came just in time to allow the concept of an Environmental Reserve to be included in the water law review that was being undertaken in South Africa at that time.

The method, known as the Building Block Methodology (BBM) for instream flow assessment, may be made in a relatively short time (six to nine months).

Developed to enable managers to balance the abstraction and impoundment of water to the requirements of the riverine ecosystem, it was used initially in the pre-feasibility studies for proposed impoundments.

The method was included in the new Water Act of 1998 as a requirement for all significant catchments and the methodology was subsequently exported to other countries around the world.

SanParks

The deaths of hundreds of crocodiles in the KNP in 2008 due to pansteatitis turned the attention again to the state of the country's rivers.

"The WRC, over the last 20 years has been at the forefront of funding and supporting work relating to environmental flows. Simply put, this is water for the environment. Even our Constitution talks about water that should first be given to people, then to the environment and then water for other purposes. The Reserve is comprised of human needs and environmental needs."

– Dr Stanley Mbofho Liphadzi, Executive Manager: Water-Linked Ecosystems

Dr Jackie King.

Publication of the Manual for the Building Block Methodology

While there are a number of methods worldwide for the estimation of instream flow requirements, none were found to be adequate for South African conditions. Many of the existing methods relied on specific indicators. South Africa needed an approach which would give estimates with an acceptable level of confidence for data-poor systems.

Through a decade of extraordinary cooperation and willingness to contribute, the national body of aquatic scientists, water managers and engineers developed the BBM to the point where it became one of only a few advanced environmental flow methodologies in the world with a formal manual.

The lead author of the manual, Dr Jackie King, had been with the Freshwater Research Unit at UCT and subsequently worked on flow assessments in various capacities. She recalls the build-up to what became the *Manual for the Building Block Methodology to Determine the Flow Requirement of the Ecological Reserve.* The manual was published in 2000.

South Africa's work in this field was – and still is – at the forefront of global practice and we have developed a wide international reputation.

Dr King learnt her way across the multidisciplinary nature of what came to be called environmental flow assessments, helping to bring together specialists in hydrology, hydraulic modelling, sedimentology, fluvial geomorphology, water chemistry, riverine vegetation, aquatic invertebrates, fish, amphibian, reptiles, riverine mammals, sociology, anthropology, resource economics, water law, macro-economics, water management and politics.

"In the early days we worked much in isolation from the rest of the world because of apartheid, and independently developed methods for assessing environmental water needs that influenced our new post-apartheid National Water Act (particularly the policy of the Environmental Reserve).

While she has entered private practice, Dr King still teaches at the UCT Summer School – all about water issues learnt from her WRC research years. Dr King, along with her colleagues, she has since also developed the DRIFT (Downstream Response to Imposed Flow Transformation) methodology to catalogue, analyse and assess the multi-variate effects of changing flow patterns in rivers.

Dr King has received many accolades, including a *Women in Water Award* for her efforts. The WRC was (and remains) a significant funder of these developments.

According to Dr King, South Africa's work in this field was – and still is – at the forefront of global practice and the country has developed a wide international reputation. "In my opinion, the funding and intellectual support, and just plain good and kind project management of the WRC has been the crucial factor in our success.

Among the funding bodies she has worked with, Dr King says the WRC stands head and shoulders above the others in terms of good working relationships, trust, belief in what the scientists are doing and pride in their results. "Given that the WRC has equally good working relations with the national water ministry and has successfully brought together water scientists, water engineers and water managers, there is no doubt in my mind that the WRC is a great force for good in water management in South Africa," she adds.

The BBM advanced the field of environmental flow assessment in an entirely new direction, being a holistic methodology that addresses the health (structure and functioning) of all components of the riverine ecosystem, rather than focusing on selected species as do many similarly resource-intensive international methodologies. This kind of approach has been spearheaded in South Africa and Australia, in close collaboration, and because of its pragmatic and all-encompassing nature, has triggered exceptional growth in communication between many scientific disciplines, and between scientists and water managers.

An updated version of the manual was published in 2008.

Environmental or instream flows are flows that are left in, or released into, a river system with the specific purpose of managing some aspect of its condition. Their purpose could be as general as maintenance of a 'healthy' riverine ecosystem, or as specific as enhancing the survival chances of a threatened fish species. They could be targeting the river channel and its surface waters, groundwater, the estuary, linked wetlands or floodplains, the riparian zone, and/or any of the plant and animal species associated with any of these system components.

"In my opinion the funding and intellectual support, and just plain good and kind project management, of the WRC has been the crucial factor in our success. From the initial foresight to fund this field of research, through the years of uncertainty of turning a 'grey' science into an internationally accepted one, to the growing international exposure of the decade from 2000 to 2010, the WRC has stood fast in support."

– Dr Jackie King, Architect of BBM methodology

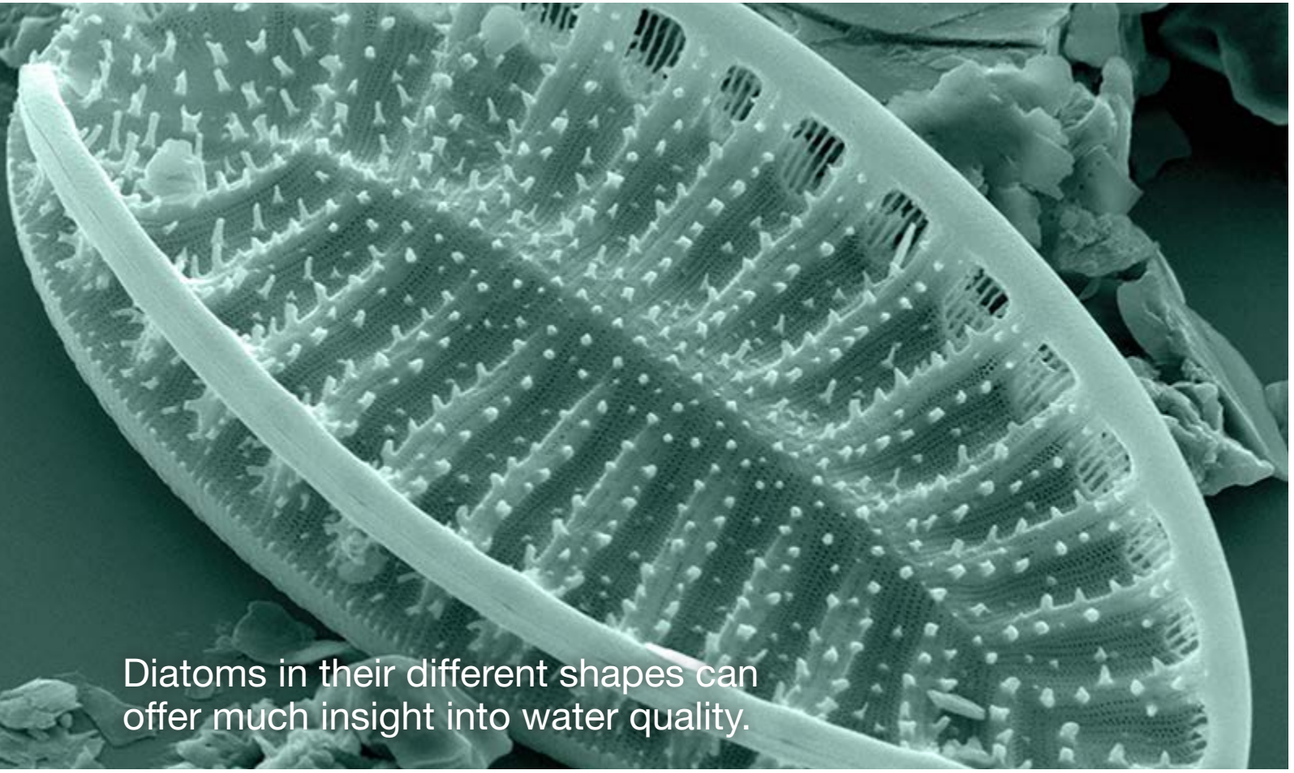
Landmark series of guides on invertebrates

Between 2000 and 2007, the WRC published a nine-volume series of guides that include keys to most of the fresh- and brackish-water invertebrates in southern Africa. Today this series is still regarded as the definitive work on the identification of Southern African freshwater invertebrates.

The aim of the series was, firstly, to improve understanding of biodiversity in the region. The geographical coverage, while focusing principally on southern Africa, also includes distribution records from elsewhere in Africa. Secondly, the guides drew together all previous definitive works (some dating back to the 18th and 19th centuries) and all recent literature of the time.

The volumes were the culmination of years of effort by a large number of people and organisations. In 1998 Prof Jenny Day of the Freshwater Research Unit at the University of Cape Town took on the role of senior scientific editor, and writer Irene de Moor was contracted to take on the job of managing editor to ensure an easy-to-use format for the guides.

"The guides are still extensively used, particularly by postgraduate students, but what is encouraging is that they are used by other groups as well, such as educators," says Prof Day. They are also of great value to people involved in assessing river health and for a WRC-funded research project currently underway to investigate aquatic invertebrates as indicators of thermal change.



Diatoms in their different shapes can offer much insight into water quality.

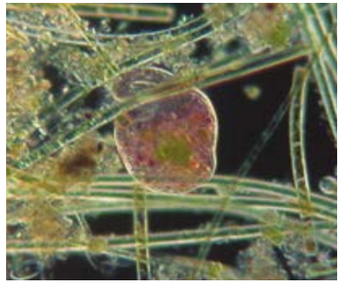
Diatoms as water quality assessment tool

Diatoms are microscopic algae found in almost all aquatic and semi-aquatic habitats. They are one of the most common types of phytoplankton. Within the last two decades diatom indices have gained considerable popularity throughout the world as a tool to provide an integrated reflection of water quality. Water quality assessment protocols based on the use of diatoms are well developed.

In many cases it has been shown that the use of diatoms for predictive or forensic assessments provides a more sensitive, robust and seasonally-durable methodology when compared with similar approaches based on invertebrate populations. The value of diatom material retained in sediment layers provides an historical perspective that can be retrieved through the expedient of careful sediment coring. Such analyses provide a fingerprint of change that can extend back over centuries. While sediment coring is commonly applied to pollen studies, its use for studying diatoms and molluscs is virtually unknown in South Africa.

The use of diatoms in particular, and phytoplankton in general, in South African water quality studies has, until recently, been virtually non-existent. The results emanating from WRC research in the early 2000s awakened a wider recognition of the value of this technique such that today it is applied across entire river systems, in urban environments and in wetland assessments.

Among others, a diatom assessment protocol (DAP) was developed for South Africa. Use of the application was successfully employed in the State of the Rivers assessment for the Crocodile-Marico West river system.



"Up to 70% of what happens in the water quality can be reflected in diatom assemblages."

- Dr Bill Harding, DH Consulting

Contributing towards river health

The assessment of aquatic life in rivers is a widely recognised means of determining the condition or health of rivers. Macroinvertebrates, in particular, are recognised as valuable organisms for biological assessments, due largely to their visibility to the naked eye, ease of identification, rapid life cycle often based on the seasons and their largely sedentary habits.

Numerous bioassessment techniques have been developed over the last three decades, varying in complexity and region of implementation.

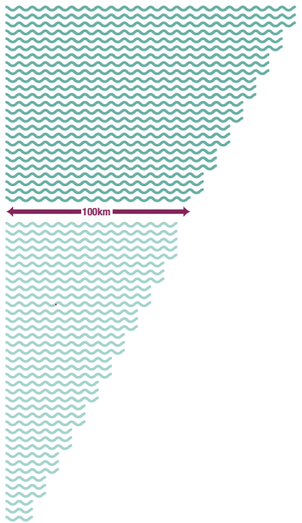
Through strategic partnerships, the WRC has ensured that South Africa has an exemplary history in this field, culminating in the refinement of invertebrate and other techniques and their application in a National River Health Programme. The highly successful SASS method forms the backbone of this programme.

The SASS index offers a cost-effective method for assessing the health of the macro-invertebrate community in a river. During the development of the SASS, the methodology was widely discussed, and it is now routinely being used as part of the biological monitoring of river health. It is also one of the indices which form the basis of the National River Health Programme.

Scientist sampling invertebrates in the Buffalo River.

"The mini-version reduces the taxonomic complexity of SASS to a few aquatic invertebrate groupings (13 instead of 90) and forms a useful educational tool for school learners and non-specialists. It also allows communities to play an active role in the monitoring of water quality of the rivers in their area."

– Bonani Madikizela, WRC Research Manager



free flowing rivers
25

South Africa has only 62 free flowing rivers remaining. Only 25 of these are longer than 100 km.

Encouraging citizen science

In 2012, the WRC in collaboration with local partners, launched the latest South African Scoring System version 5 (SASS 5) and its simplified version, MiniSASS, at a special event in Pietermaritzburg, KwaZulu-Natal. A key tool in the assessment of the health of the country's rivers for a number of years, the system still uses the composition of invertebrates living in rivers, and is based on the sensitivity of various animals to water quality.

The revision to version five was conducted by GroundTruth, an environmental consultancy in Hilton, KwaZulu-Natal. The consultancy is run by Dr Mark Graham, who was one of the original developers of miniSASS.

About 6 000 records have been taken from full environmental assessments using the SASS methodology and the data has been analysed showing a very good correlation between the SASS data and the miniSASS data. The tool itself consists of a simple net and a site information sheet to record samples found in the river and give ecological information about the site. High scores indicate high sensitivity to pollution and low scores indicate high tolerance of pollution. A quantitative score of the system is translated into health categories ranging from Natural to Seriously Modified. Support tools, such as field guides, assist identification and understanding of the bugs and worms found in the water and form part of the miniSASS tool kit.

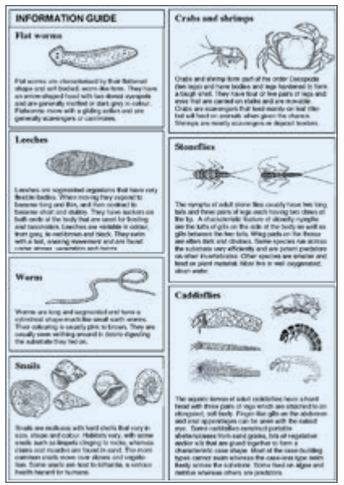
This cheap, effective set of tools is easy to use and has the potential to make a real change at the community level. MiniSASS provides 'eyes and ears on the ground' in terms of identifying water quality problems and raising red flags. Community involvement and understanding of water quality issues would ensure that connections are made between broader catchment activities and water quality. MiniSASS is an effective way of ensuring that the next generation of consumers, river health monitors and potential polluters, as well as the next generation of leaders have a greater appreciation and understanding of aquatic ecosystems.

The new version underwent testing at the WESSA Environmental Centre in nearby Howick by river health practitioners and environmental educators. Subsequently, a new website, www.minisass.org, has been developed by GroundTruth and WESSA, and this incorporates an interactive Google Earth map and database that allows miniSASS users to upload their results and view those submitted by others.

The miniSASS project team recently developed the miniSASS website, the most important feature of which is the interactive Google Earth map and database. The interactive map allows miniSASS users of all ages to explore their catchment, find their river and then upload their own miniSASS results. In this way it is anticipated that a public-access, interactive map of river health across Southern Africa will develop, with results continuously contributed by users as citizen science. Users can explore all results, compare and contrast river health across catchments and in relation to land use activities, while connecting with others who are sampling rivers in their community.

Dr Mark Graham of Groundtruth explains the miniSASS concept to a group of learners at an information session during the WRC Symposium in 2013.

Learners get closer to river critters during the MiniSASS information session at the WRC Symposium in 2013.



An example of the MiniSASS information guide.

WRC CEO, Dhesigen Naidoo (left) with the former Deputy Minister for Water and Environmental Affairs, Rejoice Mabudafhasi (centre) and SANBI CEO Tanya Abrahamse at the launch of the Freshwater ecosystems atlas in 2011.

Freshwater ecosystems atlas

Freshwater ecosystems provide a valuable natural resource, with economic, aesthetic, spiritual, cultural and recreational value. Yet the integrity of freshwater ecosystems in South Africa is declining at an alarming rate, largely as a consequence of a variety of challenges that are practical (managing vast areas to maintain connectivity between land and freshwater ecosystems), socio-economic (competition between stakeholders for utilisation of ecosystem services) and institutional (building appropriate governance and co-management mechanisms).

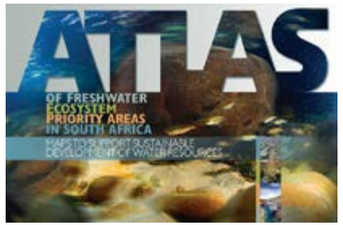
An atlas that maps river, wetland and estuary priorities for South Africa was launched in November 2011. The *Atlas of Freshwater Ecosystem Priority Areas* is one of the products of South Africa's first comprehensive assessment of the country's freshwater ecosystem priority areas, or those areas of the country that are most important for ensuring the integrity and continued functioning of our freshwater ecosystems.

Partners of the WRC in the project included the South African National Biodiversity Institute (SANBI), the Council for Scientific and Industrial Research (CSIR), the World Wide Fund for Nature South Africa (WWF-SA), the Department of Water, the Department of Environmental Affairs, the South African Institute for Aquatic Biodiversity (SAIAB) and South African National Parks (SANParks). In addition to the project team and reference group, the project also relied on the participation of some 150 stakeholders.

The criteria for identifying freshwater priority areas were based on earlier work in which government departments agreed on a vision for managing and conserving freshwater ecosystems. These criteria included areas where populations of threatened or near-threatened freshwater fish occur; areas that are considered high water yield or high groundwater recharge areas; and free-flowing rivers and connected ecosystems which are most likely to support biodiversity.

The project used data from the national river health programme as well as from a multitude of river surveys and assessments, some of which were coordinated by the Department of Water Affairs. The research team also sourced data from the different provincial structures in the various water management areas. These data sets were then put into a spatial format and were taken to freshwater ecologists and biodiversity experts at regional review workshops.

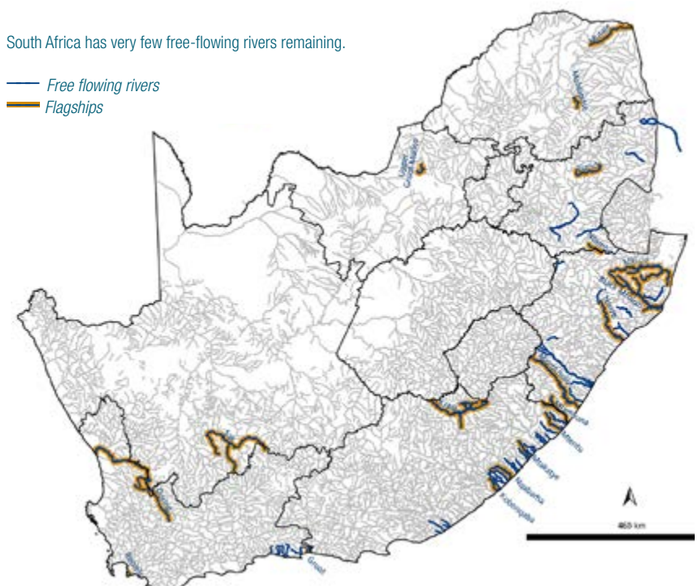
The atlas contains 19 priority area maps – one for each water management area in South Africa. The maps show river priority areas and the associated land that drains into that particular river reach, called the sub-catchment. It also shows wetlands, or clusters of wetlands that are priorities. It has different colour fish symbols to indicate the presence of



The results of the freshwater atlas were extensively workshopped among stakeholders.

Signatories to the National Freshwater Ecosystem Priority Areas.

South Africa has very few free-flowing rivers remaining.



a fish sanctuary for critically endangered and endangered and other threatened indigenous freshwater fish. Upstream management areas are also indicated – in these areas development can go ahead, but must not impact on the condition of the downstream priority areas.

The atlas is available as a hardcopy format as well as on a DVD with a GIS viewer. The project team compiled an implementation manual to provide guidance on how the freshwater ecosystem priority areas should be implemented. A technical report explaining the science behind the maps is also available.

Groundwater – SA's hidden treasure

Groundwater is the sole or main source of potable water for some urban and many rural communities in South Africa. Although only 15% of the country's total water consumption is obtained from groundwater sources, very often those communities dependent upon groundwater have no other viable sources of supply.

Over the past two decades, initiatives to accelerate the provision of potable water to rural communities have focused on local groundwater resources. The results of many years of research, particularly in terms of the portrayal of groundwater resource potential in the form of hydrogeological maps, have made an increasingly important contribution to these efforts.

It is estimated that over 90% of the surface area of South Africa's groundwater occurs in secondary hard rock aquifers, consisting primarily of zones of weathering and fracturing. Location, development and management of these supplies are considerably more difficult than supplies located in primary sedimentary aquifers. Consequently groundwater research in South Africa has largely focused on groundwater exploration in hard rock aquifers, groundwater resource evaluation and groundwater management, in particular the protection of groundwater from the adverse effects of pollution.

About 9% of the WRC's total research investment over the last two decades has been in groundwater research.

'Banking' water for dry spells

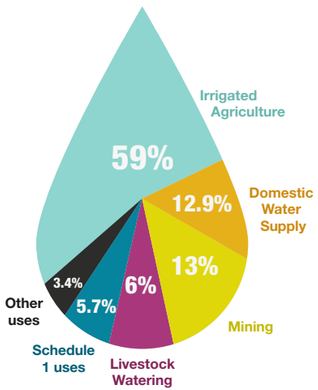
Artificial recharge and the principles of conjunctive use offer a valuable tool for augmenting the rather limited natural recharge. Water can frequently be stored more effectively in suitable aquifers than on the surface, where losses through evaporation may be considerable. This conservation technique is of special significance in semi-arid and arid areas.

It was the prospect of storing treated sewage water in the sand beds of the Cape Flats that initially led to the WRC funding groundwater research nearly 40 years ago, the first work of its kind to be undertaken in South Africa. A significant milestone was attained in 1995 with the publication of a manual on quantitative estimation of groundwater recharge and aquiver storativity, based on a collaborative project between the WRC and DWA.

One of the first WRC-funded studies into artificial recharge, undertaken by Drs Ricky Murray and Gideon Tredoux, who worked for the CSIR in Stellenbosch at the time, led to four WRC-funded pilot case studies being implemented at Windhoek in Namibia, Calvinia and Kharkams in the Northern Cape, and Polokwane in Limpopo. All the pilot projects were focused on artificial recharge to hard-rock aquifers, which make up 90% of South Africa's aquifers.

Based on the encouraging results of the CSIR-supervised pilot study, and an economic feasibility study indicating that artificial recharge was the most viable option available to them, the Windhoek Municipality decided to go ahead with full-scale implementation – the first ever major scheme in fractured rocks. Ultimately the full-scale scheme – with an initial planned injection rate of 200 ℓ/s – secured 25-30 Mm^3 in Windhoek's 'water bank', representing a couple of years' supply for the burgeoning city.

The success in piloting several artificial groundwater recharge schemes in fractured rock aquifers in southern Africa culminated in the production of a booklet titled *Water Banking – A Practical Guide to Using Artificial Groundwater Recharge.*



groundwater use

100%

Who is using groundwater in South Africa?
59% Irrigated agriculture, 12.9% Domestic water supply, 13% Mining, 6% Livestock watering, 5.7% Schedule 1 uses, 3.4% Other uses (industry, recreation, aquaculture, power generation)

The WRC with the Department of Water then published a national artificical recharge strategy. This is an excellent example of where research led to a national strategy and policy. The strategy was published in 2008.

The roll-out focused on increasing awareness of artificial recharge; incorporating artificial recharge into relevant planning documents such as the National Water Resource Strategy and Groundwater Strategy; and developing successful demonstration sites. These elements were vital in getting artificial recharge accepted as a tool of choice.

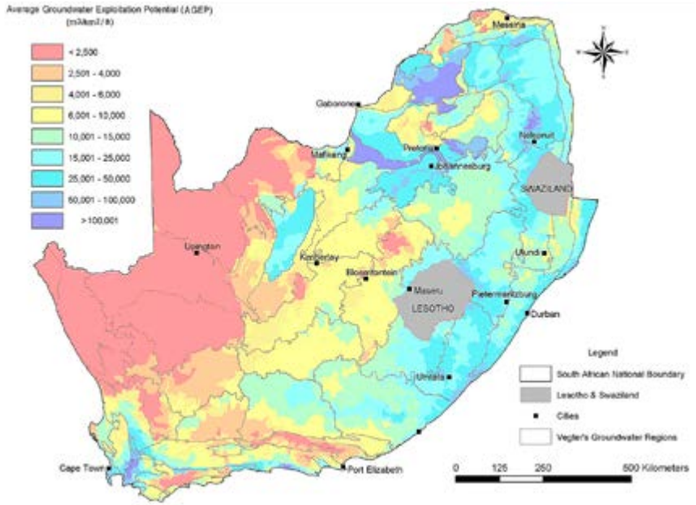
The strategy and roll-out led to widespread awareness and further studies at Sedgefield, Hermanus and in the Vermaaks River Valley near Oudtshoorn, as well as borehole injection tests carried out on the Langebaan Road Aquifer. Feasibility studies were undertaken for a number of other areas where artificial recharge had been proposed, like the sand dams of Limpopo and Mpumalanga, the Lephalale artificial recharge assessment, and the Kenhardt and Kathu proposals.

Recent projects include conducting feasibility studies for the towns of Plettenberg Bay and Prince Albert; transferring groundwater from one aquifer to another in Williston (western Karoo); conducting trial borehole injection tests in Langebaan (Cape west coast); and substantially increasing the artificial recharge and abstraction capacity in Windhoek by drilling new injection and deep abstraction boreholes.

"The Groundwater Strategy fed directly into the NWRS II," says Dr Shafick Adams, Research Manager at the WRC, "which has undoubtedly served to raise the profile of this valuable resource. The investments from the WRC in these areas over the years have led to a greater understanding of South Africa's complex aquifer systems, and finding ways to manage them effectively."

Artificial groundwater recharge presents a practical, cost effective and environmentally acceptable water management alternative for water supply authorities, rural communities and farmers.

South Africa's exploitable groundwater resources.



What is artificial recharge?

Artificial recharge describes the practice of taking excess surface water when it is available and redirecting it so that it fills up groundwater aquifers at a higher rate than would happen naturally. Artificial recharge can be done in different ways. For example, water can be diverted to recharge basins where it the naturally infiltrates into aquifers. Alternatively, water can actually be pumped down boreholes to fill up aquifers when there is excess water available

Shafick Adams

Scientists visiting the Windhoek groundwater recharge scheme.

Close to 60% of South African towns either use groundwater as a sole source or in conjunction with surface water.

The WRC together with the Department of Water published an Artificial Recharge Strategy in 2007.

Even in the Kruger National Park groundwater is a valuable source of water.

Danie Vermeulen

Prof Danie Vermeulen of the University of the Free State at a production site in the US just completed before it is rehabilitated.

Danie Vermeulen

Active fracking site, US.

Building SA's fracking knowledge base

Unconventional gas mining and in particular the exploitation of shale gas in the pristine Karoo has been a hot topic and highly debated issue in South Africa since 2011.

Hydraulic fracturing is the fracturing of rock by a pressurised liquid. Induced hydraulic fracturing, or fracking, is a well-stimulation technique in which a high-pressure fluid (usually water mixed with sand and chemicals) is injected into a wellbore in order to create small fractures in the deep-rock formations in order to allow natural gas, petroleum, and brine to migrate to the well.

In South Africa there is a genuine concern that, despite its promise to ease the energy crunch in our country, hydraulic fracturing or fracking poses a threat to available water supplies, both groundwater and surface water systems.

The technique is commonly used to enhance the production of low permeability formations such as tight sands, coal beds, and deep shales. Hydraulic fracturing is a technically complex process. Fracking not only involves the injection of potentially hazardous chemicals but also the management of these chemicals at the surface.

The WRC has commissioned several research reports looking at the state of fracking and the potential impact on water resources.

An early report commissioned by the WRC in 2012 concluded that the volume of gas in the Karoo Supergroup formation is still unknown and no relevant data is available to give even a rough estimate. The project aimed to define the state-of-the-art in terms of the Karoo hydrogeological conditions, potential shale gas reservoirs and the activities associated with fracking. The report also gave high level guidance on monitoring the fracking activities.

One of the leading fracking experts in South Africa is geohydrologist and geologist Dr Danie Vermeulen, Director of the Institute for Groundwater Studies (IGS) at the UFS. He has conducted some of the preliminary research into the possibilities of fracking.

According to Dr Vermeulen, unknowns to be addressed in research and exploration are the gas reserves and gas needs of South Africa. Do we have enough water? What will be the visual and social impact? Who must do the exploration?

"Only exploration will give us these answers," says Dr Vermeulen. Water use for shale-gas exploration is lower than for other kinds of energy, but the fact that the Karoo is an arid region makes the use of groundwater a sensitive issue. Dr Vermeulen highlights this aspect as his major concern regarding shale-gas exploration.

He also believes that dolerite intrusions in the Karoo are an unresearched concern. Dolerite is unique to the South African situation. Dolerite intrusion temperatures exceed 900 °C.

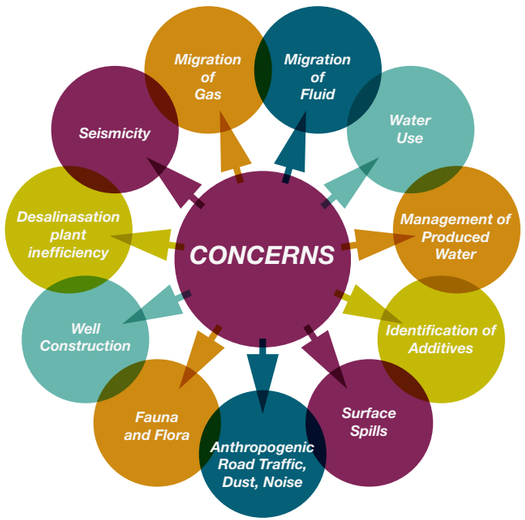
Amid increasingly heated debates over the impact of the mooted shale gas extraction in the Karoo, WRC research manager Dr Shafick Adams said it was time South Africa gave science a chance to speak.

While the exploitation of shale gas holds promise for South Africa with regard to boosting energy security, mitigating carbon emissions and enabling economic and social gains, there are also potential negatives, such as water scarcity, potential toxicity and environmental degradation.

There has been particularly strong resistance to the proposed use of the shale gas extraction method, hydraulic fracturing, or fracking in some quarters.

In early 2014, the final regulations for the exploration of shale gas in the Karoo were being consolidated. An inter-Ministerial committee had been focusing on the public comments and inputs to the draft regulations, which include looking at the terms for an environmental-impact assessment. These stipulate that water resources should not be polluted. They also propose drafting a geological map of the area, which could indicate potential structural problems.

Several environmental concerns have been flagged around hydraulic fracturing.



"In addition to its environmental sensitivity, the Karoo is also one of the driest parts of the country, and currently the water intensive hydraulic fracturing or fracking methodology is being examined as the mining methodology of choice to harvest the Karoo shale gas. In a country that is energy stressed and being increasingly challenged because it is a net large importer of oil, shale gas holds much promise."

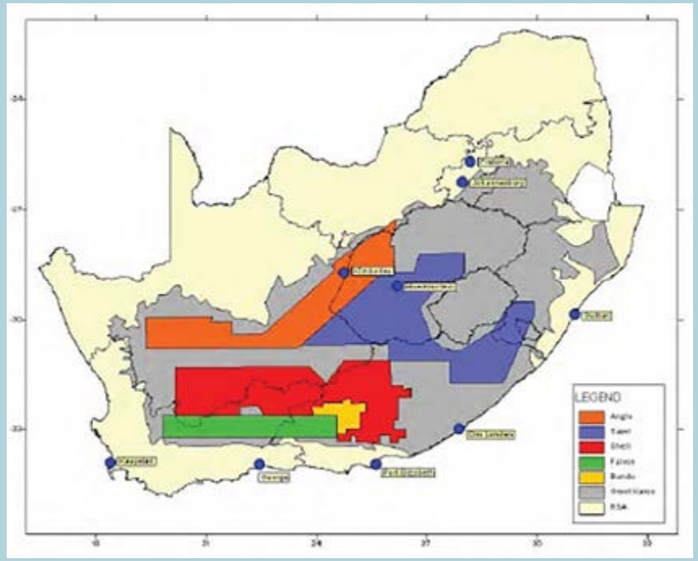
– Dhesigen Naidoo, WRC CEO

The draft regulations were open for public comment after being approved by Cabinet in October 2013. Proponents of shale gas exploration, together with lobby groups against hydraulic fracturing, or fracking, submitted extensive documents backing up their arguments for and against fracking.

The final regulations are keenly awaited.

"Proponents are arguing past each other and the politics and emotions are ahead of the science. We should allow science to inform policy and informed decision-making. Over the next few years, the answers will start to emerge. There is also an opportunity to review the lessons learnt by other countries to make South Africa a global leader in applying and developing best practices in this domain."

– Dr Shafick Adams, WRC Research Manager



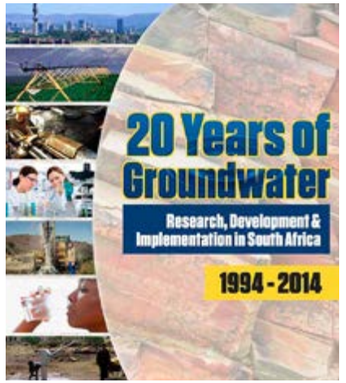
Current exploration areas and companied involved in hydraulic fracturing in South Africa.

20 Years of Groundwater Research, Development and Implementation in South Africa

A new publication tracing the history and outcomes of South African groundwater research, development and implementation over the past 20 years has been published by the WRC.

Within the span of two decades, groundwater has become a source of living water to communities in every corner of our country. The most visible change has been from the past focus on resource exploration to country-wide quantification of groundwater resources. Research focus has shifted to resource protection and understanding of groundwater as part of the overall hydrological system and ecosystem.

The publication reflects this transformation and also offers a glimpse of recent advances made in both assessment and management of this vital resource. The authors are Prof Eberhard Braune of the University of the Western Cape, Dr Shafick Adams of the WRC, and Fanus Fourie of the Department of Water.



Chapter 7

Human capital development

The importance of focused and targeted skills development within the water sector is a fundamental ingredient for supporting the socio-economic development of South Africa while sustaining its scarce natural resources. Having good, knowledgeable people at all levels of water value chain management is critical.

The WRC has taken up this challenge by making the development of a skilled water science force a key organisational priority. In the science and technology domain the WRC manages to support the training of some 500 Masters and PhD students each year.

Since 2001 the WRC has supported 6 952 students, most of them from designated groups.

The WRC's human capital development portfolio is as diverse as the country we live in. The provision of financial support to students working on WRC projects, and from institutional sponsorship of national capacity building events, career guidance and a recently published comic book teachingyoung people about the importance of valuing water – building a workforce that is adequate in size, capable in skills and strong in leadership all require a nuanced approach to capacity building.

"From initiation of projects to publishing of WRC reports, I appreciate the cooperation with scientists in a range of disciplines, the creativity of the innovation cycle and ensuring results are useful for decisions and actions in practice. In the process it is particularly encouraging to observe how young researchers participating in the research effort obtain experience and gain self-confidence to discuss their research findings and respond to constructive criticism."

– Dr Gerhard Backeberg, WRC Executive Manager: Water Utilisation in Agriculture.

Capacity development: a personal journey of challenges and growth

It is widely recognised that capacity building and sustainable knowledge transfer are critical concerns for several sectors in Southern Africa, and the water sector is no different. The loss of intellectual assets is a major threat to effective water management particularly in water-scarce countries such as South Africa where the onus has always correctly been on the scientific community to find technological solutions for sectoral challenges.

The repercussions for the sector include high staff turnover as well as the loss of skills and institutional memory. Young people entering the water and sanitation sector in South Africa are therefore faced with the threefold challenge of developing their skills; finding mentors to help them do so; as well as grappling with the added responsibility of re-learning knowledge that could have been retained through sustainable knowledge transfer policies and programmes.

In response to these challenges, the value add of the WRC's human capital development portfolio is that of a glue organisation linking students to supervisors, providing real and relevant in-the-field experience for young people, enabling the completion of appropriate qualifications, growing the sector skills base and linking individuals to a water and sanitation community. In more recent years, the WRC has made capacity building a core requirement of all WRC projects.

Moreover, students have found their experiences working on WRC projects to be invaluable in their personal growth and development. A recent WRC project investigated the experiences of WRC-supported students in order to produce a user-friendly resource for students that would aid them in managing the transitions experienced in water research projects. A wide range of anonymous student stories were collected.

The state of postgraduate human resources in the water and sanitation domain

As pointed out by the Presidential Review Committee on Human Capital Development pre-1994, the education and training capital in South Africa was gratuitously prejudiced towards furthering white progress. Since the advent of democracy in 1994, South Africa has made significant gains and progress in overcoming the skills development legacy of the past. By its nature, skills development is a long-term process and thus sustained and efficient interventions are necessary to achieve enduring sustainability of the water sector.

For the two decades the WRC has placed strong emphasis on building research capacity in South Africa. This it does through support to post-graduate (Masters and PhD) students participating in its research projects. Since 2001 (when student numbers started to be systematically recorded) the WRC has supported 6 952 students. In the 2013/14 financial year alone the WRC supported 484 students. It is encouraging to note that many of these former students are now research project leaders in their own right and/or are serving as members of steering committees as well as reviewers of new proposals.

This is a substantial contribution to the amount of postgraduate degrees completed in the water and sanitation field. In a WRC project examining the state of production of post-graduate human resources in South Africa, the findings show that 250 PhDs and 1 331 masters of different types (e.g. MSc; MA etc.) were awarded during the period 2000 to 2011. These figures could be considered adequate for the South African reality. South Africa currently produces a small number of post-graduate students in general (1 380 PhDs during 2009) and in comparison to the field of energy – another multidisciplinary field – the field of water produces four times as many post-graduate students.

In recent years the WRC has adjusted its portfolio to train and mentor new research leaders. Around 50% of research leaders on new projects are now from designated groups and mostly less than 50 years old. This is both assisting with the national transformation project as well as building the next generation of researchers. Historically, most projects lay within universities, however, it is encouraging to note that 22% of new projects are now performed by small, medium and micro enterprises and have had record participation of historically disadvantaged individuals in the projects portfolio.

The general consensus from the community of practice is that the value-add of this injection of diversity is already having a positive impact on the overall portfolio. This large number of Masters and PhD candidates provides the critical mass required for the next generation of academics and researchers in the water sector.

The crowning achievement in this domain is the greater than 70% representation of students in WRC projects who are previously disadvantaged individuals.

From Masters student to Chair of the Board

"As an ecologist focused on estuaries I have witnessed first-hand the impact of the WRC. I have been involved in WRC research since my days as an MSc student and completed my PhD on a WRC project focused on the freshwater requirements of estuarine plants. This was a very enriching experience having the best estuarine scientists in the country on a steering committee providing valuable input and advice on my research."

Janine Adams, Professor of Botany at Nelson Mandela Metropolitan University and former Board Chair of the WRC

From young hydrogeologist to President of WISA

Dr Kevin Pietersen's paths first crossed with the WRC when he worked at the CSIR in Stellenbosch as a hydrogeologist. Here he completed his Masters degree as part of a Commission project on the Table Mountain Aquifer. This was followed by a large-scale project in partnership with the University of the Western Cape, which formed the basis of his PhD. Dr Pietersen's career path later led him to become Water Resource Management and later Director: Water Centred Knowledge at the WRC. He then left the organisation to lead his own groundwater consultancy. He has also served as the President of the Water Institute of Southern Africa.

How do current students experience WRC support?

- "I have always had a passion for water-related activities. WRC funding provided me with the opportunity to continue developing my skills as a researcher."
- "WRC funding changed my life totally and gave me a platform to look to the future with confidence."
- "I consider it a privilege and a major responsibility to be awarded a WRC bursary as the funding essentially stems from the general SA public."
- "This [WRC funding] opportunity has opened more doors for me and is leading to some very interesting collaborations with other researchers in my field."
- "Working as part of a WRC project team gave me the opportunity to learn from accomplished academics and professionals which would not otherwise have been possible."
- "Presenting my initial findings at one of the stakeholder meetings was a very informative experience as I got valuable feedback that helped me shape my research focus and helped me interrogate further ideas."
- "When I started my PhD I felt a lot of pressure and had low self-confidence, but working with other students at my level I found comfort and encouragement."
- "It was a wonderful journey. I learned a lot and managed to overcome some gaps from the previous degree. I would advise everyone to work on a WRC project because there is a lot to learn."

(Student feedback from 2014 project investigating the experiences of WRC-supported students)

The WRC Empowerment Fund

An exciting new development in the realm of capacity building has been the appointment of the WRC as the implementing agent to facilitate the Empowerment Project on Water Resource Management for the Department of Water, which will contribute to the development of previously disadvantaged socio-economic researchers in water resource management.

The aim of the project is to develop and implement a cross-cutting programme to contribute to transformation in the researchers and practitioners of the water and wastewater sectors. The project will preferentially select projects that will directly contribute to building the capacity of previously disadvantaged individuals in the roles of project leaders and principal researchers. These Empowerment Projects will receive intensive mentorship and be precursors to full-scale WRC projects.

Strategic capacity-building initiatives

In addition to the focus on human capital development in the WRC funding model, the institution has also embarked on a wide range of strategic capacity building initiatives with various partners.

These include support to national and local government as well as the development of new training material for different levels of learners and for academic institutions.

FETWater

A programme called FETWater was launched in 2002 as a direct response to a 1998 study by the Department of Water, the United Nations Educational, Scientific and Cultural Organisation (UNESCO) and the World Meteorological Organisation (WMO), which revealed a marked lack of human resources and competencies in the local water sector. This deficiency not only jeopardised the implementation of the National Water Act, but also hampered the country's ability to conform with, and take advantage of, global trends in integrated water resources management.

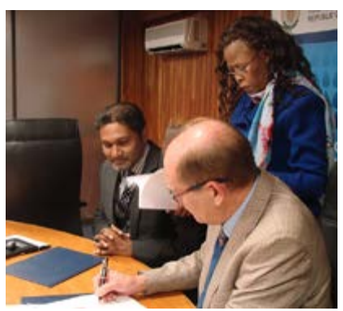
FETWater was initially aimed at developing and transferring knowledge so that a critical mass of water scientists could be created to facilitate the process of the implementation of the Act. The creation of knowledge and its transfer was conducted via small training networks, composed of the leading individuals and institutions in the country in each thematic area.

Phase one saw the establishment of six networks focusing on themes such as resource directed measures, groundwater, the beneficial use of water, and expertise development in catchment management. While FETWater provided financial and structural support, these networks identified particular needs in their fields of expertise and developed specialised content for training courses that build the capacities of students, practitioners, water management professionals and industry stakeholders.

During 2007, phase two came on stream when the Department of Water and UNESCO signed an education and training agreement to build additional, much needed capacity in the South African water sector. FETWater phase two provided institutional support and financing in the form of seed funding to encourage the creation of training networks as a method for co-operation between universities, research institutions, as well as public and private sectors in the country.

The second phase saw 1 052 professionals in the South African water sector receiving training through the FETWater programme. Concurrently, a vast amount of training material was produced, and two groundwater test sites were developed at the universities of

FETWater students and lecturers during a field trip to Namibia.



The DWS and the WRC signed a Memorandum of Understanding (MoU) appointing the latter as the implementing agent for the new phase of the Framework Programme for Education and Training in Water, also known as FETWater in early 2014.

Pretoria and KwaZulu-Natal. The programme places special emphasis on the training needs of women and previously disadvantaged individuals.

In early 2014 the Department of Water and WRC signed a new Memorandum of Understanding appointing the latter as the implementing agent for the third phase of FETWater. The programme will run until September 2017.

By the end of 2009, 1 052 professionals in the South African water sector received training through the FETWater programme. Concurrently, a vast amount of training material has been produced, and two groundwater tests sites were developed at the universities of Pretoria and KwaZulu-Natal. Emphasis has also been given to the training of women and previously disadvantaged individuals.

The new capacity building needs and requirements that will be considered in Phase III are the advancement of technologies in the water space, climate change and variability, strengthening of the water regulatory system and development of regulatory tools, local government capacity building using water as a catalyst for economic growth and development, developing stronger inter-governmental relations, specialised skills and knowledge to manage water taking into account the whole value chain and more importantly indivisibility of the hydrological cycle.

However, the most crucial directive of Phase III will be the National Water Resources Strategy II (NWRS II), and will be guided by the priorities set in NWRS II for the next five years. Addressing participants at the signing ceremony, Acting Director-General, Trevor Balzer stated that "FETWater provides a practical expression of the NWRS II, and to making an impact in terms of capacity into the sector, as well as on the ground."

Also speaking at the signing ceremony, Dhesigen Naidoo, WRC CEO indicated that "The expectation is very high around Phase III, but it fits in well with where we are as a country. Capacity development in general, and scientific training in particular is at another level of the game to where we were 10 years ago. In the science and technology space, the water sector actually performs extraordinarily well. We are currently 18th in the world with regards to knowledge production."

Funding of the FETWater Phase III will be supported mainly by direct and indirect contributions to the programme by the Government of South Africa, as well as by UNESCO through the Flanders UNESCO Science Trust Funds (FUST).

"The WRC is very keen to take this science partnership to another level, and we're very keen alongside that, to take the water debate to the next level, and the Category 1 Centre at Rhodes University and the Category 2 Centre at UKZN will help us achieve this progression" stated Naidoo.

WRC 101 for project leaders

Over the past few years, the WRC noted an encouraging trend of proposals being submitted by research groups who have previously not applied to the WRC for funding. Many established research groups also have new project leaders managing WRC projects.

The WRC, like any other research funding organisation, has project management and administrative requirements, which are reviewed periodically. Additionally, the Commission has sought to improve its interaction and coordination with current and prospective project teams, in order to streamline administrative processes and to render to the research community a better understanding of the WRC's strategic objective as defined in its five-year Corporate Plan.

This involves informing institutions of the WRC's focus areas and direction for the prioritisation of funds in the next financial year, as well as encouraging WRC staff to gain a better understanding of how various institutions operate.

In this regard, the WRC conducts the informative and increasingly popular one-day WRC 101 course for aspiring and new project leaders to, among others, understand the WRC research cycle; discover the research priorities of the Commission and the fund allocation for each of the priorities; prepare a comprehensive proposal; manage the various aspects of a WRC project; understand the contractual and financial audit requirements; and know what resources are available to enhance the success of the project.

Supporting Young Water Professionals

In addition to assisting students, the WRC is also an ardent supporter of the Young Water Professionals – a joint initiative of the International Water Association and the Water Institute of Southern Africa. Established in South Africa in 2009, the aim of this programme is to fulfil the present and future needs of the water and wastewater industries in southern Africa, an aim which requires the continuous development of a workforce that is adequate in size, capable in skills and strong in leadership.

To fulfil this aim the YWP body aims to provide opportunities for young professionals in the water sector to meet and communicate; provide career development opportunities for YWPs; and to support employers with the recruitment and retention of YWPs. Membership includes all members up to, and including, the age of 35 years old, as well as those members who recently started a career in the water sector.

"The YWP programme is fully inclusive, with no agenda regarding gender, location, race or nationally," said former YWP President, Dr Jo Burgess, in 2010. "Any and all individuals with an interest in any aspect of water, and especially those with a need to find a community of colleagues to belong to, are welcome.

According to former YWP President, Dr Inga Jacobs, young people have found the programme immensely supportive in career development, networking, technical skills training and having a supportive network of individuals who are going through the same challenges when developing their career.

At present, the YWP programme has more than 1 000 student members and over 3 200 professionals, with provincial chapters set up in the Western Cape, Eastern Cape, KwaZulu-Natal, Limpopo, Gauteng and further afield in Zimbabwe, Mozambique and Namibia.

Attendees of the 2013 YWP Conference in Stellenbosch.

From PhD student to leading hydrologist

Currently head of the Centre for Water Resources Research at the University of KwaZulu-Natal, Prof Graham Jewitt first cut his teeth on a WRC project during the Kruger National Park Rivers Research Programme doing his PhD in the early 1990s. This remains a career highlight. "The big strength of that initiative was the way it was structured to allow high levels of interaction between junior, senior and emerging scientists, and the way it operated across disciplines." Today, Prof Jewitt is a world leading hydrologist. He is also the Umgeni Water Chair of Water Resources Management.

Knowledge Tree Awards

The WRC held its inaugural Knowledge Tree Awards at the 2013 Water Research, Development and Innovation Symposium, held in Pretoria.

The awards recognised outstanding performances by various WRC-funded researchers in different disciplines within the water domain. The awards are linked to the six impact areas of the WRC Knowledge Tree, the corporate planning tool which guides all WRC operations, and acts as a yardstick by which the Commission's impact is measured in key domains.

In the category 'Transformation and Redress' the winner was Prof Ochieng Aoyi of the Vaal University of Technology, for his work in establishing and growing the water and wastewater research group in the Department of Chemical Engineering.

There were two winners in the 'Sustainable Development Solutions' category, namely Prof Lingam Pillay of Stellenbosch University, for his development of an innovative woven-fibre micro-filter for drinking-water supply, and Prof Leon van Rensburg of the University of the Free State, for the development of guidelines for the management of salinisation of agricultural lands.

The category, 'Informing Policy and Decision Making' also had two winners, namely Dr Sharon Pollard of AWARD, for her contribution to the research comprising the Shared Rivers Initiative, and Dr Ronnie McKenzie from WRP Engineers, for his role in compiling the 2012 State of Non-Revenue Water in South Africa.

The first winner in the 'Human Capital Development in the Water and Science Sector' category was Prof James Blignaut of the Department of Economics at the University of Pretoria, for his dedication to growing capacity in the water sector by training no less than 11 post-graduate students on his latest WRC project. The second winner in this category was Prof Neil Armitage of the University of Cape Town, for growing the cross-disciplinary Urban Water Management group.

In the 'Empowerment of Communities' category' the winners were Simon Bruton of Ground Truth, for his development of the public education tool MiniSASS, used for river health monitoring, and Jonathan Denison, for his development of the comprehensive learning materials on water harvesting and conservation aiding food security.

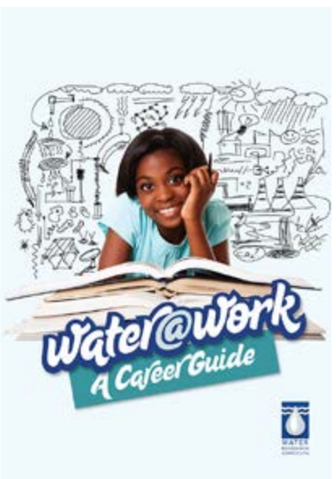
The last two winners were in the 'New Products and Services for Economic Development' category. They were private researcher and consultant, Dr Nico Benadé, for the development of the WAS system, and Oliver Ive of Amanz'abantu Services, for lending private sector support to the pilot project involving franchising of water services to schools and homesteads in the Eastern Cape.

Attracting an even younger cohort

In addition to the various capacity building initiatives supporting students and young professionals, the WRC has embarked on a relatively newer journey over the past ten years sparked by the demand to attract younger school learners into the water sector.

Water@Work Career Guide

The WRC revised and republished its successful *Water@Work Career Guide*, originally published 10 years ago. The new guide lists detailed information on no less than 62 career options in the water sector, ranging from accounting and agriculture to social science, water history and zoology. The colourful guide, which is available electronically or in hard copy, is intended as an overview of career paths available in the world of water. It is an ideal resource for learners ready to make subject choices or prospective students exploring possible areas of study. New areas of study, such as polymer science, one focus area of which is nanotechnology, have also been included in the guide. Readers can also find an exhaustive list of useful contacts, including those institutions which offer bursaries and internships.



The updated Water@Work Career Guide.

A comic book to inspire water careers!

In a similar vein, the WRC has created South Africa's first water research-focused graphic novel or comic book for wide public dissemination and use. The novel, aimed at children aged 11-15, follows the adventures of the Thirsty Three, namely Royston, Mpho and Steyn, as they uncover the value of clean water and the role played by water science. The first instalment of the proposed series includes an introduction to the WRC as a unique South African organisation, and its function to assist Government in fulfilling its mandate to providing sustainable services to South African communities.

It is envisaged that this graphic novel series can go a long way towards sharing the South African water story with a new generation of South Africans in a language that they can identify with. The comic is available electronically on the WRC website and hardcopies can also be order through the web site. Future discussions with the Department of Education is planned to further market and distribute the comic book to learners as part of their curriculum. With this kind of interest in water through early childhood development, imagine what the next twenty-year review would look like!

Conclusion

Although the formal products of the WRC are its research, the most important impact is felt by the individuals who grow within the research project and those who benefit from it. The WRC has a huge responsibility to produce the necessary human capacity that is needed by the sector, but we would not be able to achieve our impact objectives were it not for the thousands of project leaders and team members, supervisors and students, experts and new entrants, who ensure that research outcomes are communicated and used to ensure greater awareness and uptake.

Boldly braving a man's world

Chemical engineer Dr Katherine (Kitty) Foxon was involved with WRC-funded projects from the time of her PhD. The latter was a WRC project, which analysed an anaerobic baffled reactor for the treatment of domestic wastewater. She worked as a research fellow for the Pollution Research Group at the University of KwaZulu-Natal before becoming a lecturer at the same university, authoring several WRC research reports. She has since become Group Leader Strategic Research at the Sugar Milling Research Institute NPC.

Chapter 8

Prospects 2014 and beyond

The National Development Plan 2030: Our future - make it work says South Africa belongs to all and the future of our country is our collective future. Making it work is our collective responsibility. All South Africans seek a better future for themselves and their children. The National Development Plan is a plan for the country to eliminate poverty and reduce inequality by 2030 through uniting South Africans, unleashing the energies of its citizens, growing an inclusive economy, building capabilities, enhancing the capability of the state and leaders working together to solve complex problems.

"Our ability to be water secure depends on the ingenuity, innovation and dedicated effort of all who live in South Africa."

- Dhesigen Naidoo, WRC CEO

Water is a strategic resource critical for social and economic development and there is growing concern about the potential impact of water-related risks. This is attributed, in part, to the poor state of its water ecosystems. South Africa also ranks 148th out of 180 countries in terms of water availability per capita, according to the 2012 World Water Development Report.

We have made gains in recent years as indicated by the Environmental Performance Index (EPI) hosted at Yale University. The EPI ranks South Africa 107 out of 178 countries overall and 72nd on issues regarding water sanitation. In the latter South Africa has had an improvement of 22.01% on access to sanitation in the last ten years.

While these improvements are encouraging, the target of universal access to sustainable services with a concomitant provision of 'new' water for accelerated growth remains a big challenge.

Water supply and sanitation services, which depend on adequate management, are a priority for most South African communities. Their effective and sustainable management is essential for community health, development and cohesion, and continued economic

SA has a small but productive water research community.

activity. Some noteworthy WRC activities that look to the future, as well as broader water sector activities looking ahead and beyond 2014 are outlined below.

The State of Water R&D

The creation and maintenance of a coordinated, comprehensive, and balanced national water research agenda, combined with a regular assessment of the state of water RED in South Africa, represents the nation's best chance of dealing effectively with the many water crises sure to mark the 21st century.

The WRC wishes to develop and implement the *State of Water R&D Project* to address the need for a national reporting mechanism that consistently reports on, evaluates and critically appraises the status of R&D trends in the water sector. This project comprises several components. Each will feed into the broader framework to be conceptualised in the *State of Water R&D in South Africa Report*, a series of biennial reports that provides an empirical basis for further investigation on policies, programmes and partnerships to support water research and development in South Africa. The *Report Series* will be based on extensive desk research and on field work, as well as complementary pulse studies commissioned by the WRC and other existing studies.

The primary objective of the project is to provide a dedicated reporting mechanism and critical appraisal of water R&D trends in the country. As such, it will contribute to, and ultimately inform the sector's knowledge base and provide empirical material for additional research on policy, programmes, capacity, geographic spread and financing issues related to water R&D.

The outcomes of the project will become the point of contact for a broad sectoral overview of water R&D trends in South Africa. The project will eventually lead to the development of a national water R&D agenda for the sector. This will be achieved through extensive stakeholder dialogue, and will be brought to fruition in the *Water Foresight Study*.

Several Pulse Studies have already been conducted and will together, form the first *State of Water R&D Report* to be launched in 2015.

The Aquaduct Study and questions for future research

Limited historical data are available to describe water research in South Africa over the first half of the 20th century. Many authors recognise that this period was dominated by technological developments, breakthrough research and projects in water storage and transfer, and frequently characterised by a positivist approach to nature and development. But what are the future research questions for the next 20, 50, 100 years?

water availability

148th

South Africa ranks 148th out of 180 countries in terms of water availability per capita

A WRC project employed horizon-scanning methodologies to identify and prioritise current and future water research questions through the participation of a wide range of researchers from across the country, and to relate these questions to research paradigms, issues and concerns in water in South Africa. Over 1600 questions were collected, reduced in number and then prioritised by specialists in the water sector. The majority (78%) of questions offered by respondents in the South African case study dealt with relatively short- to medium-term research requirements with 47% of questions focused on medium-term issues such as service delivery, sanitation, access to water, pricing and water quality. Additionally, there was also a small set of questions that is arguably more closely deal with with medium- to long-term critical concerns of sustainability, establishing green economies and implementing new forms of integrated, adaptive governance. These kinds of questions pose extraordinary challenges necessitating considerable financial and institutional support. Two examples of these kinds of questions are:

- How can innovative process technologies, including nanotechnology, be applied to benefit water and wastewater treatment process?

- What are the life cycle and systematic impacts of acid mine water and how can these be managed, mitigated, remediated and beneficiated?

The Water RDI Road Map

The WRC is working on a *National Water R&D and Innovation Roadmap (RDI) for South Africa*. The Department of Science and Technology's (DST's) ten-year plan *Innovation Towards a Knowledge-based Economy* recognises the importance of science and technology in improving the country's competitiveness and economic growth. The water sector is recognised by Government as one that provides opportunities for job creation and economic development, particularly in areas of water treatment and wastewater beneficiation.

A national viewpoint is required to provide a ten year roadmap for innovation in the water and wastewater sectors of South Africa. A co-funded WRC/DST project was launched to:

1. Provide a platform for South Africa to be the **best in the developing world in water technologies** and to compete with leading countries in providing sustainable solutions.

2. Provide at least one **breakthrough technology** every five years.

3. **Increase the numbers of small and medium sized enterprises** (SMMEs) operating in the water sector, and not only consultancies as the aim is to increase job creation.

4. Increase **access to water for rural communities**, and include **sanitation provision for all** in a sustainable manner.

The project comprises three phases. The first is a status quo assessment of the water and wastewater sectors, against which future scenarios can be measured. The second phase entails the development of the Water Research, Development Innovation Plan and focuses on the transition from applied research through industrial development to commercialisation and/or application of the products that emanate from South African research. Phase three looks at a framework for the implementation of the Water Innovation Plan.

The Water Foresight Study

The Foresight study will use as its point of departure the findings of all the above-mentioned studies to plot out different scenarios of the future of water R&D. This process will begin shortly after the Water RDI Road Map study has been completed and will be used to guide the WRC's strategic planning processes.

Water and Sanitation Summit, August 2014

Water and sanitation services remain one of the core challenges of our time globally, and particularly for South Africa's growing political economy. Yet, while South Africa has met the MDG targets in these areas, our primary goal remains that of universal access to safe and sustainable water and sanitation services to all in South Africa. Only when we have enabled this expansion of the frontiers of human

WRC CEO, Dhesigen Naidoo, at the National Water and Sanitation Summit.

Acting Director-General, DWS, Trevor Balzer and COGTA Minister Pravin Gordhan.

Minister Nomvula Mokonyane and Elizabeth Moroaswi.

dignity can we begin to talk about growth and prosperity in earnest.

In this regard, the ushering in of a ministry unifying water and sanitation, and also the appointment of the Minister of Water and Sanitation, Ms Nomvula Mokonyane, and Deputy Minister, Ms Pamela Tshwete, were generally welcomed by the water sector. One of the first tasks of the new ministry was to call on stakeholders in the water family to come together and define our working relationship at the National Water and Sanitation Summit, held from 1 to 2 August 2014 at the Birchwood Hotel in Boksburg, Gauteng.

The aim of the Summit was to engage with stakeholders on the primary challenges facing water and sanitation in South Africa, and to identify game-changers and develop innovative solutions that will enable us to take a significant leap forward as we collaboratively develop a national vision for water and sanitation over the next five years, but also over the longer term.

Various topics were discussed ranging from meeting the service delivery challenge; to the water and sanitation policy environment; and from water research, development and innovation choices; to the state of South Africa's water resources; and finally, the role of the private sector.

The deliberations of the Summit will feed into Department's upcoming strategic planning process. Several partners representing different stakeholder groups would be invited to this session. In addition to that, A *National Water and Sanitation Summit Declaration* was drafted and agreed upon and well as the commitment by all sector partners present to work with the Department in order to develop a *10-Year Water and Sanitation Plan.*

The next 20 years

At the time this book was published, the world's leaders met in New York City, for the 69th session of the UN General Assembly to launch an intergovernmental process in preparation for the adoption of the post-2015 development agenda. The optimists believe that the new development agenda will revive several neglected challenges but the sceptics believe that not much will change.

Since 2000, the world reached targets on reducing poverty, increasing access to improved drinking water sources, improving the lives of slum dwellers and achieving gender parity in primary school. Yet the sanitation target lags behind, maternal health is still low, and inequalities within and among countries remain high, and employment levels particularly among youth remain high.

And while the sanitation target lags, policy-makers look to the professional community to provide appropriate technologies and are not always satisfied by what they find.

Water and sanitation services remain one of the core challenges of our time globally, and particularly for South Africa's growing political economy. And despite several major achievements in water services provision, recently, Minister Mokonyane made a bold statement by saying that the target of eradicating the buck system by December 2014 will not be met. "[O]n behalf of the President, I must apologise to the people of South Africa in that we were overambitious in targeting the completion of the bucket eradication backlog by December 2014, a target that we will not meet. However, with the budgets that we have secured and the plans we have in place, we will meet the target during the 2015/16 financial year."

Members of the South African water and sanitation sector applaud her for her open and transparent approach.

According to the 2012 National Report on the Status of Sanitation Services roughly 1.4 million formal households still required sanitation services and around 0.5 million households in informal settlements were making use of interim services. This situation is not due to a lack of trying or willpower. Eradicating the sanitation backlog is one of the most challenging aspects to most, if not all, developing countries across the globe. One of the difficulties associated with sanitation provision is linked to the availability and appropriateness of technologies to meet changing demography, user preferences, budgetary constraints and water resource requirements.

Traditionally, we would implement conventional flush toilets connected to the waterborne sewerage network. However, new challenges associated with water availability, climate change, pollution and the rising costs associated with conventional technology are making us rethink and evaluate sanitation delivery, and more specifically the need for different solutions. New technologies bring about another set of issues regarding user acceptance and institutional management of waste streams post-toilet implementation.

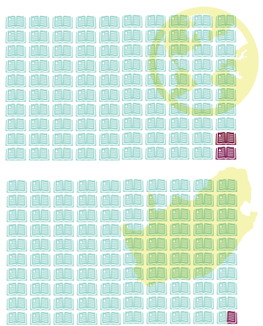
In response, several new sanitation technologies and innovations are beginning to enter the South African market from all over the world. Toilets come a dime a dozen in all shapes and sizes with as many "Made in …" stamps. Some of these have been developed whilst some have been improved upon in order to meet the various requirements for sanitation access across a wide variety of settings (from urban environment to the rural). However, in South Africa there has been no mechanism to document or adequately establish the appropriateness of these innovation responses.

Consequently, the innovations that are available or have been developed are often not well understood or appraised. In some cases, the lack of information has led to the wrong choice of sanitation technology being implemented,

To ensure the future of sustainable water supply innovative solutions are required.

A nanofiltration plant provides clean water to the small village of Madibogo, in North West.

Ending the lack of access to safe water and sanitation is critical to addressing water equity globally, and can act as a catalyst for greater innovation to deliver human well-being and a sustainable future.



water publications

1.7%

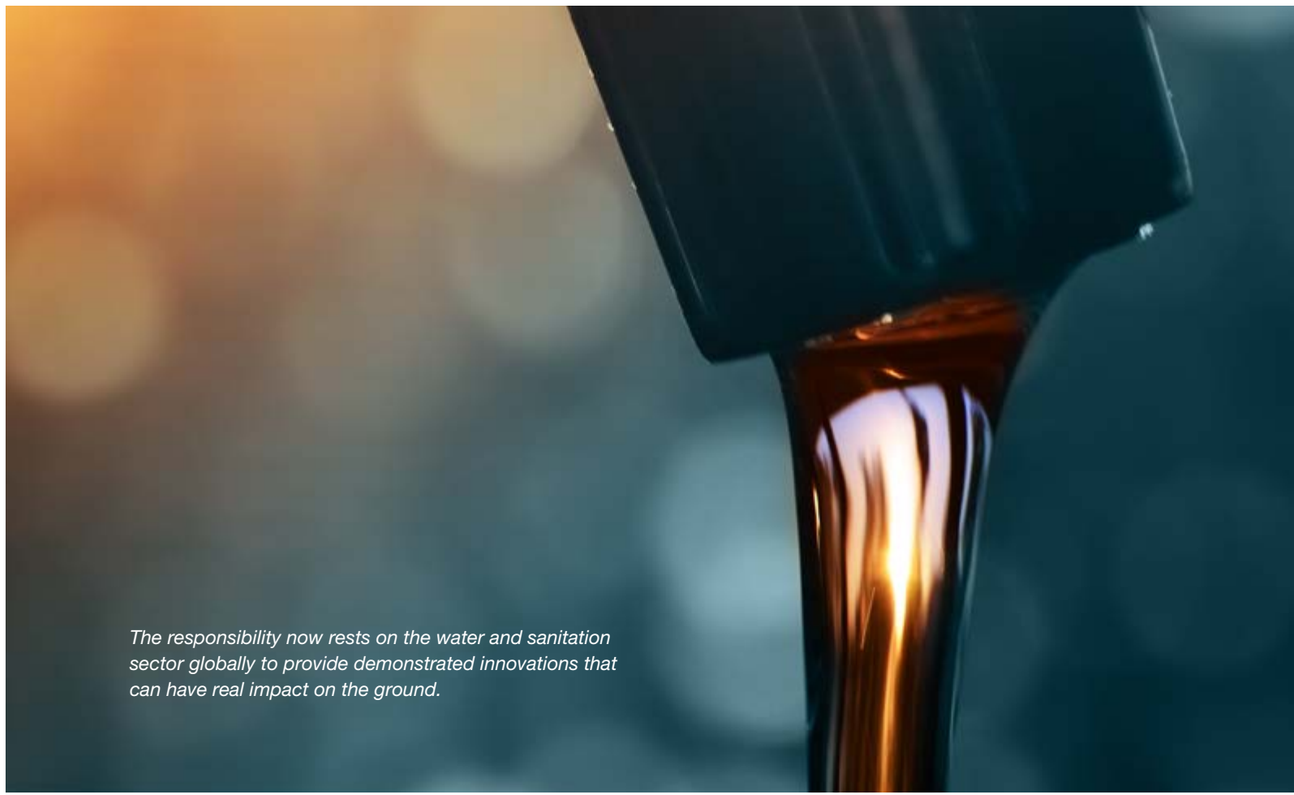
South Africa contributes 1.7% of global publications in water while the average overall for the country is less than 0.5%.

the proposed technology not meeting its intended purpose and / or uncertainties of the functioning, institutional and operational and maintenance requirements of the new technologies have led to toilets being operated in an unsustainable manner. This has often led to serious disrepair beyond normal operational and maintenance requirements several months or years after implementation. For this reason, emerging technologies are often met with scepticism and therefore fail to achieve wider uptake and application.

The responsibility now rests on the water and sanitation sector globally to provide *demonstrated* innovations that can have real impact on the ground.

Indeed, ending the lack of access to safe water and sanitation is critical to addressing water equity globally, and can act as a catalyst for greater innovation to deliver human well-being and a sustainable future. Only when we have enabled this expansion of the frontiers of human dignity can we begin to talk about growth and prosperity in earnest.

Where will we be as a sector in the next twenty years (hopefully some of us will still be around!)? We may have to put this book into a time capsule and review our progress then, but what is clear is that the future is meeting us half-way to the present – already the world and the water sector is changing – and we are proud that the WRC and its partners are right there leading the way.



Abbreviations and acronyms

ADE	Aquifer-dependent ecosystem
AIDS	Acquired Immunodeficiency Syndrome
AMCOW	African Ministers' Council on Water
AMD	Acid mine drainage
ARC	Agricultural Research Council
ARC-ISCW	Agricultural Research Council's Institute for Soil, Climate and Water
BABE	Burst and Background Estimate
BNR	Biological nutrient removal
CB:WHIG	Community-based water harvesting interest group
CeBER	Centre for Bioprocess Engineering Research
CEO	Chief Executive Officer
CERM	Consortium for Estuarine Research and Management
CMA	Catchment management agency
COD	Chemical oxygen demand
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
DBSA	Development Bank of Southern Africa
DEA	Department of Environmental Affairs
DNA	Deoxyribonucleic acid
DSS	Decision support system
DWS	Department of Water and Sanitation
EDC	Endocrine disrupting chemical
EIA	Environmental impact assessment
ELISA	Enzyme-linked immune-assays
eWQMS	Electronic Water Quality Measurement System
ES	Equitable Share
FAO	Food and Agriculture Organisation of the United Nations
FBW	Free basic water
FRU	Freshwater Research Unit
GIS	Geographical information system
GRI	Global Reporting Initiative
GWRC	Global Water Research Coalition
HIV	Human Immunodeficiency Virus
ICID	International Committee on Irrigation and Drainage
IFRs	Instream flow requirements
IRWH	In-field rainwater harvesting
IRWH&C	In-field rainwater harvesting and conservation
IWA	International Water Association
IWRM	Integrated water resources management
KNP	Kruger National Park
KNPRRP	Kruger National Park Rivers Research Programme
KSA	Key Strategic Area
LFM	Low-flow meter
MB:WHIG	Municipal-based water harvesting interest group
MBR	Membrane bioreactor
MDG	Millenium Development Goal
MIG	Municipal Infrastructure Grant
NAEBP	National Aquatic Ecosystem Biomonitoring Programme
NATSURV	National Industrial Water and Wastewater Survey
NDP	National Development Plan
NEMA	National Environmental Management Act
NEPAD	New Partnership for Africa's Development
NFEPA	National Freshwater Ecosystem Priority Areas
NIWR	National Institute for Water Resources
NMMP	National Microbial Monitoring Programme
NSBA	National Spatial Biodiversity Assessment
NSDS	National Skills Development Strategy
NWA	National Water Act
NWP	National Water Policy
NWRS	National Water Resource Strategy
NWU	North West University
PPC	Parliamentary Portfolio Committee
PRV	Pressure-reducing valves
R&D	Research and development
RDI	Research, Development and Innovation
RDP	Reconstruction and development
RQO	Resource quality objective
RU	Rhodes University
SADC	Southern African Development Community
SAEON	South African Environmental Observation Network
SAIAB	South African Institute for Aquatic Biodiversity
SALGA	South African Local Government Association
SANBI	South African National Biodiversity Institute
SANCI	South African National Collection of Insects
SANCID	South African National Committee on Irrigation and Drainage
SANParks	South African National Parks
SASAQS	Southern African Society of Aquatic Scientists

SASRI	South African Sugarcane Research Institute
SRFA	Sanitation Research Fund for Africa
SSA	Support services agent
S&T	Science and technology
SU	Stellenbosch University
SWB	Soil Water Balance (computer program)
SWPN	Strategic Water Partnership Network
TAC	Technical assistance centre
TCTA	Trans-Caledon Tunnel Authority
TIA	Technology Innovation Agency
TMG	Table Mountain Group (aquifer)
TSFC	Tswelelopele Small Farmers Cooperative
TUT	Tshwane University of Technology
UASB	Upflow Anaerobic Sludge Blanket
UCT	University of Cape Town
UD/VIDP	Urine diversion ventilated improved double pit toilet
UFS	University of the Free State
UJ	University of Johannesburg
UKZN	University of KwaZulu-Natal
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNISA	University of South Africa
UP	University of Pretoria
UV	University of Venda
UWC	University of the Western Cape
WAR	Water allocation reform
WAS	Water administration system
WC	Water conservation
WDM	Water demand management
WEROP	Wave energy reverse osmosis pump
WFD	Wetting front detectors
WHO	World Health Organisation
WISA	Water Institute of Southern Africa
WRC	Water Research Commission
WR2012	Water Resources 2012 study
WRM	Water Resource Management
WSA	Water services authority
WWF-SA	World Wide Fund for Nature South Africa
YSF	Young Scholars Forum
YWP	Young Water Professional

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