THE WATER WHEEL

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WHAT IS FIRE MANAGEMENT DOING TO THE KRUGER'S WATER?

WATER RESEARCH COMMISSION

wader

WATER TECHNOLOGIES DEMONSTRATION PROGRAMME

A KEYSTONE FOR WATER TECHNOLOGY INNOVATION

VISION

To bridge the gap between water research and the market to achieve a connected water innovation system that delivers socio-economic benefits for South Africa.

The WAter Technologies DEmonstration ProgRamme (WADER) aims to bridge the gap between the R&D and commercialisation stages of the water innovation continuum by moving technologies out of the laboratories and proving them in real-world, test situations.

By coordinating the demonstration of water technologies in operational environments, WADER aims to increase the adoption of appropriate technologies and enhance the water innovation value chain. High-level demonstrations will serve to assess the technical, social, economic, regulatory and environmental attributes of the technologies. Each technology demonstrator will entail multi-player collaborations and a strong technology transfer component i.e. the transfer of skills, knowledge, methodologies, etc. to academia, government, business and civil society.

WADER WILL

• Collaborate • Coordinate demonstrations • Inform • Connect stakeholders • Assess and showcase technologies

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• Provide funding • Endorse technologies • Accredit/certify technologies, individuals and/or organisations
• Generate standards • Commercialise technologies

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WATER RESEARCH COMMISSION

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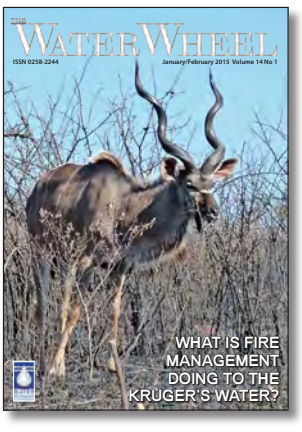


Fluid Thoughts

WRC CEO, Dhesigen Naidoo

Coming of Age – Moving knowledge to action

The year 2015 sees us entering the milestone of our 21st year of democracy. Our country is a young adult, and none too soon as the challenges that we face are going to require the creativity and adventure of an adolescent as well as the maturity of an adult to be managed successfully. The reality of our water scarcity and our insufficient energy security has become stark. The negative knock-on effects on food and nutritional security as well as health security are increasingly sharpened.

In addition, we are facing this in a time of budgetary tightening and further economic contraction. The temptation in such times is strong to gather all your available resources and invest in Band-Aid solutions to address the immediate problems and shore up the ability of the state to ensure the social security net. While this might provide short-term relief in many quarters, this does not amount to an investment in our future prosperity and well-being.

We need a combination of short-term interventions to address the immediate challenges and relieve the incredible stress on the water system, while concomitantly developing smart, creative, innovative and sustainable medium- to long-term solutions for both national water security as well as international competitiveness. While some may consider this incomprehensible in the wake of lead articles on a weekly basis highlighting the precarious nature of South Africa's current water fortunes, others will recall that many of the countries that we today consider highly successful had the beginnings of that growth trajectory in times of extreme hardship.

South Korea (Republic of Korea) is today regarded as one of the world's most successful economies with Korean brands in electronics, motor vehicles and communications being household favourites worldwide. In the modern era, the turnaround of South Korea from a primarily agrarian, largely subsistence economy to become one of the world's leading industrial economies had its genesis in the devastating civil war of the 1950s with the conscious choice to use the pathway of a knowledge based economy as its path to post-conflict recovery. Similarly, Finland, now regarded as one of the most innovative countries in Europe on the back of such successes as forestry biotechnology, logistics and wireless communication, began its knowledge based innovation journey in the 1990s with its own economic crash precipitated with Perestroika. Until that point, Finland had enjoyed economic success as the gateway for the world to the then isolated Russian economy. From the most basic consumables, to the most sophisticated devices sourced from the Western world, the preferred pathway was through

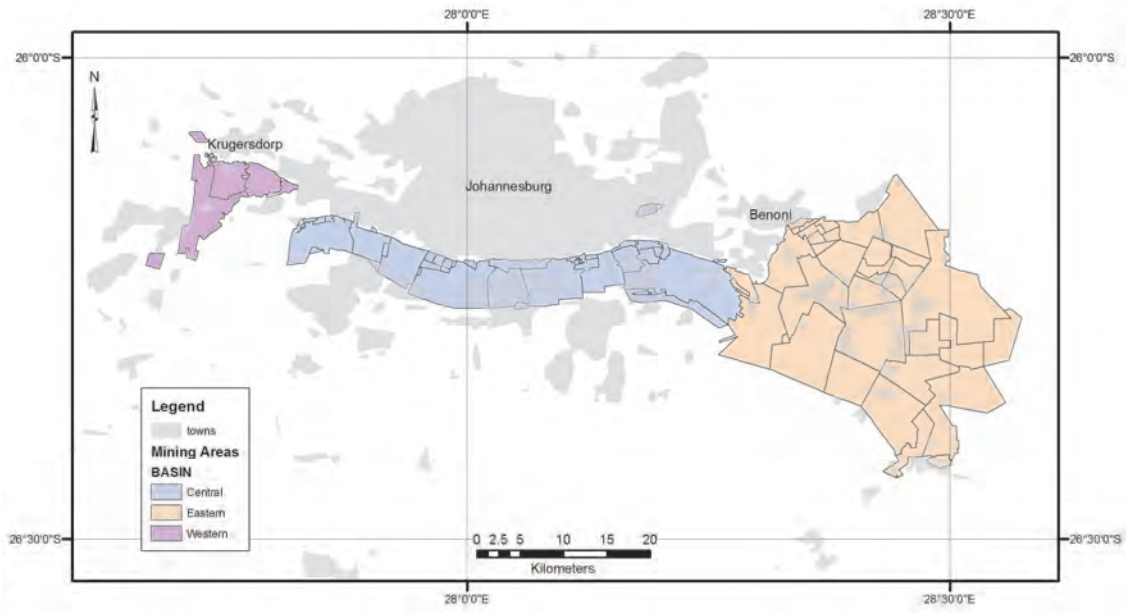


Figure 1
The biggest focus of South Africa's mine-water challenge has been the three large Gauteng basins. The manner in which we tackle the long-term solutions must afford the prospect of not only managing one of biggest pollution challenges, but also the opportunity to become a world leader in solutions for mine-water and brines challenges – a fundamental global challenge for the 21st century. We have the research derived knowledge that gives us formulas for intervention that will not only yield a freshwater resource, but also holds the potential for significant minerals recovery from the polluted mine-water.

the Finnish corridor. Gorbachev's Perestroika and the great thaw in the Cold War saw a rush from the West to interact directly with Moscow and the implications for the Finnish economy were dire. The Finnish response was, as had happened with South Korea before, an active and intensive investment in science, technology and innovation to ensure a much more competitive future to Finland. And what we have seen in the last 25 years was the rise of small, remote Finland to a global player of note. This is a narrative that can be repeated for most countries that occupy the top listings in the World Competitiveness Yearbook. This is also a choice that South Africa has declared itself on as a matter of official policy and more recently reiterated in the manifesto of the ruling party in the run up to the 2014 national elections.

The year 2015 must be a point of inflection as we up the game toward a more entrenched knowledge based economy. In the water domain the opportunities are enormous and the need is gargantuan – from tackling the challenge of acid mine-water to energy efficient localised wastewater treatment to low/no water sanitation solutions. The achievement of a higher level to water security and the expansion of the frontiers of dignity through accessible safe sanitation will require us as the water science and technology community to up the game. We need to accelerate our efforts to bring Knowledge to Action. This requires us to more actively package scientifically derived knowledge in a form that brings a much larger group of people into the conversation in a manner that strongly empowers participation and influences decision-making. We also need to expand our efforts to bring laboratory proven solutions to demonstration as the bridge to on-the-ground implementation at scale. In the Water Research Commission portfolio alone we have more than 50 of such candidates. The third vital component of the Knowledge to Action saga is the deepening and expansion of existing partnerships and the development of new ones. Partnerships across sectors (public and private), across domains and disciplines and covering the entire innovation value chain. Addressing South Africa's immediate water and sanitation challenges while simultaneously building our economic competitiveness is the best recipe to ensure sustainability. Let us use 2015 to build the South Africa Incorporate team that gears us to that prosperous future. A future that ensures a water secure South Africa, with universal access to safe services, and an opportunity to become a world leader in water and sanitation solutions and technologies.

UJ appoints new Executive Dean of Science

The University of Johannesburg (UJ) has appointed Prof Debra Meyer as the new Executive Dean of the Faculty of Science.

Prof Meyer is currently a professor of and the Head of the Department of Biochemistry at the University of Pretoria. She holds a PhD degree in Biochemistry and Molecular Biology from the University of California Davis and a Masters of Science degree in Biochemistry from one of UJ's legacy institutions, the Rand Afrikaans University. She has completed executive management training at the Gordon Institute of Business Science and Harvard Business School.

Prof Meyer has extensive research and teaching experience. She was invited to, or a visiting professor at, numerous international institutions, including the University of California San Francisco, Harvard University, Imperial College and Iowa State University.

Her research has been published in over 80 peer-reviewed international journals and conference proceedings. Prof Meyer is the recipient of numerous research awards, including the National Research Foundation TW Kambule Awards in 2004 and 2010 and the Academy of Science for the Developing World Award in 2005.

Prof Meyer is also known for presenting the weather on SABC 2 for more than 12 years, and is an avid language and AIDS activist. She recently launched her own television programme on KykNET, called 'Debra deel', which aims to make scientific discoveries and achievements accessible to a general audience.

Says Prof Meyer: "I see my contribution to the future success of UJ through my commitment to an internationally competitive Science Faculty where the levels of research intensity increases constantly and innovative, quality learning and teachings inherently linked to research and grounded in committed community engagement.

New shrimp species discovered in Cape Peninsula water

A tiny new shrimp, called the 'stargazer mysid' by divers because of its eyes' apparent permanent upward gaze, has been found in the extensively sampled waters of False Bay, Cape Peninsula.

The new shrimp species is described in a joint paper by Emeritus Prof Charles Griffiths from the University of Cape Town and international shrimp expert Prof Karl Wittmann, which has been published in the journal, *Crustaceana*.

The shrimp is the ninth Mysidopsis species found in southern Africa, and is officially named *Mysidopsis zsilaveczi* after the diver, UCT alumnus Guido Zsilavecz, who has made the discovery.

"Though previously unknown to marine biologists, the pretty shrimp is a common sight among divers," said Zsilavecz, an avid underwater photographer who brought the shrimp to Prof Griffiths to identify. When he was unable to identify the species samples were sent to Prof Wittmann at the University of Vienna in Austria, who confirmed that it was indeed a new species.

Prof Griffiths was surprised by the shrimp's bawdy colouring and 'fake eyes'. "They act like the eye spots on moths' wings," he explains.

The divers who first saw the small crustacean, a mere 10 to 15 mm long, calls the shrimp 'stargazer mysid' because its eyes seem to gaze permanently upwards. The apparently large, upward-staring eyes are just a trick of nature, as the eyes of shrimps don't have a pupil or iris.

Instead, they are compound eyes like those of insects and consist of many simple elements that each look in a different direction. The vivid ringed patterns are thought to be there to make the eyes appear to belong to a much bigger creature, and hence to scare off predators.

Letters to the Editor

More research needed of renewable hydropower opportunities in SA

Thank you very much for the rather excellent promotional article introducing the WRC's new hydropower research (*Water Wheel* July/August 2014).

Having the opportunity of being a member of the team researching the subject I would like to highlight a few aspects with regard to implementation and development of small hydropower (SHP) hidden particularly in existing water supply and return flows infrastructure (i.e. hydraulic assets). It is commendable that the WRC recognised the need for the research accounting for the new hydropower technology, particularly small-scale hydropower.

Research in this sphere of energy generation is reaching its momentum, but new constraints were identified that are not all that advantageous for the development of particularly small-scale hydropower. The research conducted to date has determined ways on how to implement the available new technology devices suitable for optimising use of existing water supply and distribution infrastructure to obtain the best utilisation of South Africa's most previous resource.

The hydro-energy generated is a handsome trade-off. The WRC's new report, *Conduit hydropower development guide* (**Report No. TT 597/14**) provides the guidelines on how to cost and implement well suited and sustainable small-scale hydropower installations, taking into consideration conditions presently prevailing in South Africa.

Implementation and development of hydropower in South Africa is being constrained by a whole host of challenges, the most stringent being the legal/regulatory requirements relevant primarily to implementation of small-scale hydropower. This is, if compared to other renewable energy technologies (such as wind and solar power), slowing the process of healthy development of most appropriate renewable energy hydropower.

As per the Department of Water and Sanitation's (DWS's) policy the non-consumptive hydropower installations (<20 MW) are required to consider the following charges:

- Hydropower installation integrated within the DWS's infrastructure: a) fixed charge: R10/kW/annum, b) variable charge: R0.01/kWh sent out;
- Hydropower installation developed downstream of DWS's infrastructure and downstream of a dam wall: a) fixed charge: R5/kW/annum, b) variable charge: R0.01/kWh sent out.

Exemplifying for the combined energy output (i.e. kWh sent out) of the new Sol Platje and Merino hydroelectric installations in the Free State, the DWS can claim from the independent power producer some R0.6-million annually for the water use besides the fixed charges and all other charges relevant to the other renewable energy technologies.

All types of hydropower potential in South Africa has been identified and for the first time quantified before the shortages in electricity supply significantly manifested in 2008 by frequent blackouts and prolonged outages. Based on the conclusions of a Department of Energy study commissioned in 2002 along with the subsequent responses of the South African government to the regional energy crises and to climate change threats, the potential of hydropower development for electricity generation in South Africa is possible. This includes a potential of 70 GWh/year from refurbishment and upgrading of existing hydropower assets; and more than 1 000 GWH/year from retrofitting existing non-powered hydraulic assets, to name just two options.

Some 1 400 GWh/year is a moderate estimate of small-scale hydroelectricity output which can be generated from existing hydraulic assets in the ownership/administration of the state, paratatals, the local government and industry/mining entities. This potential is easily obtainable from the local sources.

All the incentives and enabling environment with regard to the legal/regulatory and financial requirements are at present not promoting small-scale renewable energy projects (< 1 MW) including hydropower. The commercial banks and other lending institutions are reluctant to finance small capacity projects thus forcing potential developers to go on their own with the development, if they can afford such.

The startup capital for hydroelectric capacity of one MW installation, satisfying a project hydrological, geotechnical and environmental requirements can cost a developer between R1-million and R3-million depending on the type of hydropower proposal. However, the hydropower retrofit to existing infrastructure situated within the existing scheme servitude is the cheapest of all other hydropower types of development.

Scrapping the internationally applied REFIT programme and replacing it with the REIPP procurement programme bidding process promoted the foreign investments in developing an intermittent capacity from other renewable resources such as solar, but seriously retarded the highly local content-based projects, particularly with regard to small-scale hydropower development. For example, a wind-based project is eligible for approval with a provision of three years of wind data in comparison to a small hydropower project which must provide ten years of hydrological data to be considered eligible for consideration in the REIPP procurement programme bidding process.

Further research in utilisation of existing hydraulic assets for the hydropower retrofit should focus on hydroelectricity generation from non-powered dams which are either standalone or situated within some of 40 water transfer schemes. The WRC in collaboration with DWS should speed up further investigation of identified potential hydropower sites. At present there is no suitable blueprint for how such assets can be retrofitted with hydropower devices to comply sufficiently with the national department and National Treasury's requirements and legalities.

It will help if *the Water Wheel* investigates firstly what is the progress and valid policies at present applied by the DWS with regard to the hydroelectricity development at non-powered hydraulic assets. Secondly, what would be the most suitable public-private partnership model to apply in hydropower retrofit of non-powered dams in the ownership/administration of the state.

B Barta, Bryanston

(Letter has been shortened – Ed)

World day celebrates our precious soils

As World Soil Day was celebrated around the world on 5 December, it offered the perfect opportunity for South Africa to reflect on the importance of this oft-forgotten natural resource.

It is not always appreciated that soil is not only teeming with life, but is responsible for nurturing human life. Virtually all the food crops grown on earth are planted in soil, not to mention fodder for livestock and the large variety of fibre crops which dress us.

South Africa is lucky to have a soil research institute in the form of the Agricultural Research Council – Institute for Soil, Climate and Water (ARC-ISCW).

One of the ways in which natural resources of any area can be utilised, and ultimately protected, is to carry out a survey of the soils occurring and to produce a soil map. The soil maps archived at ARC-ISCW date back more than 100 years.

The first map was produced by the then Cape Irrigation Department. These first maps were of the Olifants River irrigation scheme, in the Western Cape.

At that time maps were produced by hand, with boundary lines first being drawn and then coloured in. Soil maps were made in that way until the 1980s when computers became more widely used.

Descriptions of soils in the soil classification system used in those days were very general (i.e. sand, clay, loam or rock). However, old maps like these can still be used without too much extra field work, and make a valuable contribution to the almost 13 600 soil maps archived at ARC-ISCW as part of the soil information system national asset.

Since 1912, many irrigation schemes have been mapped. South Africa is the only nation in Africa that has a systematic, digital soil survey of the whole country, including the semi-desert and mountainous areas. To complement this, a database of over 15 000 soil profiles, along with soil analysis data (such as soil pH, texture and degree of weathering) has allowed soil scientists in South Africa to build up a large body of knowledge about soils of this country, and how to best use and conserve them.

With the completion of the national land type survey in 2002, South Africa became one of the few nations in the world where the soils of the whole country have been mapped and digitally processed at 1:250 000 scale.

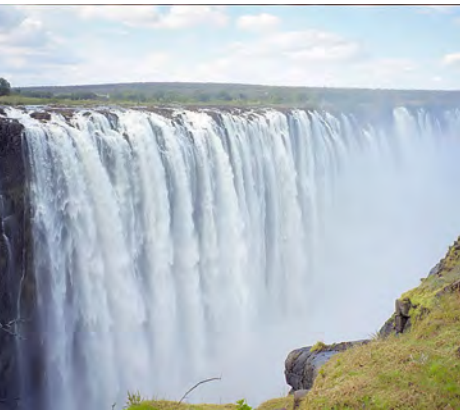
In addition to being the custodian of this knowledge, the ARC-ISCW provides specialised inputs into a range of environmental impact assessments to try and ensure that economically important development does not take place unnecessarily on valuable high potential agricultural soils, which are extremely scarce in South Africa.

Source: ARC

South Africa to get water from Zambezi River?

Minister of Water and Sanitation, Nomvula Mokonyane, has met with her Zimbabwean counterpart, Minister of Environment, Water and Climate, Saviour Kasukuwere, to investigate the feasibility of pumping water from the Zambezi River to South Africa.

The South African Minister also attended a signing ceremony of the Certified Agreement on the Cooperation on Water Resources Management and the establishment of the Joint Water Commission between South Africa and Zimbabwe.



The significant ceremony comes after a joint agreement by the two governments to undertake a technical study to evaluate the possible water resource developments and transfer options from Zimbabwe to South Africa. The proposed pipeline will draw water from the Zambezi River to Cowdray Park in Bulawayo whereafter it will run to South Africa.

"The agreement will adopt a three-phased approach. The first is to determine the viability of water resource development options at reconnaissance level, taking into account the latest information on hydrology and environmental needs," said the Department of Water and Sanitation.

Phase 2 is the pre-feasibility study of the preferred options identified in Phase 1, while Phase 3 will be centred on the feasibility study of the preferred options from Phase 2.

Source: SAnews.gov.za

New government system to streamline licensing process

Government is rolling out the 'One Environmental System' aimed at streamlining licensing processes for mining, environmental authorisations and water use.

Under this system, the Minister of Mineral Resources will issue environmental authorisations and waste management licenses for mining and related industries. The Minister of Environmental Affairs will be the appeal authority for these authorisations.

The Ministers of Environmental Affairs, Mineral Resources as well as Water and Sanitation have agreed on fixed timeframes for the consideration and issuing of the permits, licenses and authorisations in their respective legislation. The agreed time period is 300 days for the issuing of permits, licences and authorisations. In the event that a decision to issue a license is appealed, an additional maximum period of 90 days is provided.

Revamp allowing Atlantic water supply infrastructure to rise again

The City of Cape Town has announced extensive infrastructure refurbishment and preventative maintenance to the local water supply infrastructure in Atlantic.

The programme is being tackled simultaneously to a leak detection and water education programme.

The primary source of water for the area is an extensive system of boreholes and filtration systems, where water from an underground aquifer is extracted and treated to drinking standards, then stored in the Pella and Hospital reservoirs for distribution. The pumps that extract this underground water, as well as components of the water treatment works, are being serviced to ensure that future unplanned interruptions in water supply are minimised.

While the maintenance teams are working in the area, the City water department's conservation unit is embarking on a programme to convey water savings messages and create awareness of water scarcity. Cape Town is a water scarce region and, as such, residents play a crucial role in ensuring there is enough water to go around.

Source: City of Cape Town

Let us all work towards South Africa's sustainable water future

South Africans all have a role to play in ensuring there is water for all, writes Gideon Wolfaardt.

When following the news and world events, one cannot be blamed for concluding that society merely moves from one crisis to the next. While some of these crises are confined to a relatively small geographic area, with regional effect, others such as water scarcity reach much wider.

Although those living in areas with sufficient infrastructure for water supply and sanitation may hardly notice the impact of water scarcity, it has become a stark reality for many others. In fact, billions of people experience severe water-related challenges, which are typically linked with other environmental, political and socio-economic forces that further perpetuate the problem. The provision of clean water and sanitation stands out amongst these water-related challenges.

Access to improved sanitation facilities such as proper toilets remains a global concern with 2.5 billion people in developing countries still affected. It should therefore come as no surprise that the World Toilet Organisation (WTO) has intensified its efforts to raise awareness amongst the general public about the serious lack of sanitation worldwide. These efforts have eventually led to the globally celebrated World Toilet Day on 19 November.

The theme for the 2014 World Toilet Day was 'Dignity and Equality'. This is of particular relevance to Africa, where it is estimated that only 58% of the continent's population has access to safe drinking water, which means more than 300 million people in Africa do not have access to clean water. Considering the World Health Organisation's estimate that 80% of all sickness in the world is due to unsafe water and poor hygiene, the challenge is clear.

Management of water and wastewater

South Africa is not spared in this regard. In a recent SA Human Rights Commission (SAHRC) report following provincial hearings in all nine provinces in 2012/13 on access to water and sanitation, it was concluded that "Despite flattering statistics presented by government about community access to water and sanitation, many communities experience a 'starkly different reality'". Amongst the most common complaints were defective and non-working infrastructure, broken taps, leaking pipes and toilets that were never maintained or repaired, as well as comments about water and wastewater treatment plants that were poorly maintained and not designed to meet the needs of a growing population.

Overall, it was indicated that more than 1 in 10 households (1.4 million) do not have sanitation services and that at least a quarter of households in formal areas do not have adequate sanitation because of the deterioration of water-supply networks, which was exacerbated by a lack of technical expertise to ensure effective operation and maintenance.

Alarmingly, it was found that water provision in 9% of municipalities was in crisis "with an acute risk of disease", with a further 38% at high risk of deteriorating into crisis. Actions by government and the private sector to address these problems are therefore needed, and deserve recognition where initiatives are underway.

Improving our water and wastewater treatment plants as well as our water-supply networks is crucial because even though we consume 61% more water than the world average, we live amongst the 30 driest countries in the world.

Recognised by the Water Research Commission as one of South Africa's most limiting resources in the 21st century, the growing gap between water supply and increasing demand by agriculture, major industries such as mining and power generation, as well as large and expanding urban centers, is of particular concern. It seems that the country will increasingly be faced with the challenge to make difficult choices with potentially serious economic, social and environmental consequences. All of these will impact on the availability of water for household use.

Realising that South Africa's water crisis requires a multi-pronged solution, the Stellenbosch University Water Institute coordinates work on the physical, socio-economic, socio-political and technical aspects related to the crisis, and in so doing highlights its complexity. We recognise the task at hand, and although we don't have all the answers, we know that one sure way to bring relief is water conservation; a simple, effective strategy that is too often ignored by decision-makers as well as the general public, which is portrayed by high levels of water wastage, water unaccounted for, incompetent operation and poor maintenance of facilities.

While it is only natural to look at governments, NGO, employers and the like to address the problem, we all have a role to play – from fixing that leaking toilet or reporting it (and in the process saving up to 1 000 litre water per day!), promoting water saving devices, and celebrating the well-deserved recognition that this life-saving device finally got. For inspiration, read one of the many toilet stories available online or follow the advice by some experts to sit on the toilet if that is the only place where you can close your eyes for a few minutes … and breathe.

Prof Gideon Wolfaardt holds the ERWAT (East Rand Water Care Company) Research Chair in Wastewater Management and is Director of the Stellenbosch University Water Institute.

New from the WRC

Report No. 2108/1/14

Removal of metal ions from industrial effluents and acid mine drainage by metal sulphide precipitation (M Nduna & A Lewis)

The purpose of this research was to further the understanding of metal sulphide precipitation in the treatment of acid mine drainage and metal ion impregnated industrial wastewater. During the process of metal sulphide precipitation the physico-chemical properties of the precipitant material had a significant effect on the overall viability of the metal removal process. The aim of the work was to ascertain the conditions necessary for optimal metal ion removal.

Report No. TT 596/14 and TT 597/14

Conduit hydropower power plants and Conduit hydropower development guide (SJ van Vuuren; M van Dijk; I Loots; B Barta & BG Scharfetter)

South Africa is facing an energy crisis which places additional importance of harvesting all available feasible renewable energies. While the country is now well endowed with the best hydropower conditions large quantities of raw and potable water are conveyed daily under either pressurised or gravity conditions over large distances and elevations. These two reports capture's the knowledge gained under various WRC studies into conduit hydropower. A decision support system and associated tool (HydroAID) was also developed to facilitate the development process of a conduit hydropower plant.

Report No. 1982/1/13

Primary producers as sinks for nitrogen and phosphorus in the Great Brak Estuary (GC Snow & LRD Human)

The Great Brak Estuary is a temporarily open/closed estuary on the southern Cape coast that frequently experiences blooms of filamentous green macroalgae. This is indicative of an estuary in a poor ecological state. The main aim of this project was to identify the sources and determine the loads of nitrogen and phosphorus entering the estuary through point source discharge, diffuse discharge, atmospheric deposition and remineralisation from organic material trapped in the sediment. The study also sought to determine the biomass and cover of macrophytes and macroalgae in the estuary; measure the nitrogen and phosphorus content in living plant material; describe the environmental conditions in the estuary that favour macroalgal blooms; and provide recommendations to be included in the Great Brak Estuary Management Plan.

Report No. TT 601/14

Environmentally sustainable beneficiation of brewery effluent: Algal ponding, constructed wetland, hydroponic vegetables and aquaculture (CLW Jones; PJ Britz; R Scheepers; S Power; A Cilliers & R Laubscher)

This project aimed to develop a sequence of effluent treatment methods using existing technologies, such as algal ponding and constructed wetlands, to develop a unique, low cost, low-tech, environmentally sustainable industrial water treatment process. It also aimed to combine these technologies with the production of algae, vegetables and fish in such a way that the end result was not only treated industrial effluent, but also the production of recovered water available for reuse and/or used for producing valuable downstream products.

Report No. 1930/2/14

Methods for the determination of the ecological Reserve for estuaries Version 3 (J Turpie – Editor)

This document describes, and serves as a manual for, the accepted approach for the determination of the ecological Reserve for estuaries, which is the quality, quantity and timing of freshwater inflows that is guaranteed for each estuary. It is intended for use by managers and scientists involved in organising and carrying out Reserve Determination studies on estuaries.

Report No. 2037/1/13

Hyperspectral remote sensing to detect biotic and abiotic stress in water hyacinth (Eichhornia Crassipes) (Pontederiaceae) (SW Newete; BFN Erasmus & MJ Byrne)

Water hyacinth is the most notorious aquatic weed in the world. Various methods are prescribed to control it, however, this requires regular monitoring of the weed's physiological status in relation to the habitat, in order to evaluate the success of the intervention. This report investigates remote sensing as one such a monitoring tool.

Report No. 1923/1/13

Influence of regional environmental factors on the distribution, characteristics and functioning of hydrogeomorphic wetland types on the Maputaland Coastal Plain, KwaZulu-Natal, South Africa (AT Grundling; EC van den Berg & ML Pretorius)

The Maputaland Coastal Plain stretches from the town of Mtunzini in the south to Kosi Bay in the north and continues north towards the town of Cabo Santa Maria. Not only are the wetlands in this plain important for the maintenance of the rich biodiversity of the area, but they are equally important for the local communities as a key resource in subsistence agriculture. This aim of this project was to understand the regional environmental factors that control the distribution, characteristics and function of different wetlands types on the Maputaland Coastal Plain including interactions with the underlying Maputaland Coastal Aquifer.

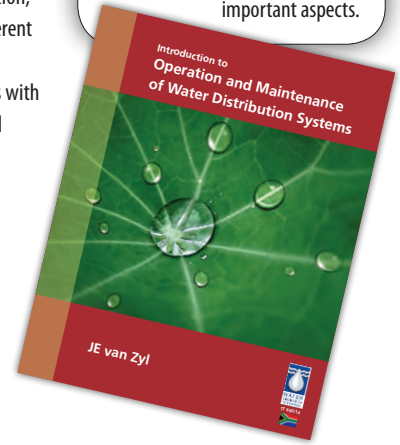
New guide book aimed at improving operation and maintenance of water supply systems

A reliable supply of clean and safe water is the first and most critical municipal service that people require. South Africa has made great strides in addressing the inequalities of the past in the provision of water, but unfortunately the focus on expanding service provision has often been at the expense of adequate operation and maintenance of existing infrastructure. This has resulted in increased levels of leakage and non-revenue water, maintenance backlogs and problems with service provision.

Proper operation and maintenance are indispensable to ensure that capital investments on new infrastructure result in sustainable service provision. Without it, a new water distribution system will soon decline to a point where service provision is compromised, leading to greater water losses, financial losses and health risks to consumers.

The aim of this book (**TT 600/14**) is to assist service delivery by making information on proper operation and maintenance practices available in a practical and accessible way.

The approach adopted in the book is to provide the reader with an understanding of the process leading to system decline, measuring system performance and the best practices in operation and maintenance of water distribution systems. It aims to provide guidance to empower the reader to implement a proper operation and maintenance system in practice, focusing on the most common and important aspects.



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Free online science education resource launched

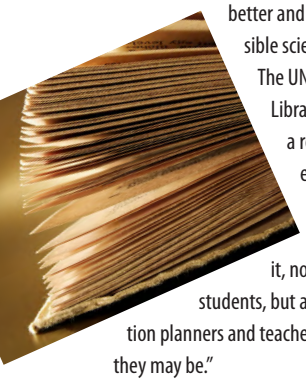
The United Nations Educational, Scientific, and Cultural Organisation (UNESCO) has launched the World Library of Science (WLoS), a free online science education resource for a global community of users.

Developed through the joint efforts of UNESCO, Nature Education and Roche, the WLoS was created to give students around the world, especially those in disadvantaged regions, access to the latest science information as well as the opportunity to share their experiences and learning through discussion with their peers in a shared learning environment.

The WLoS is a science resource library stocked with over 300 top-quality articles, 25 eBooks, and over 70 videos from the publishers of *Nature*, the most cited scientific journal in the world. It is also a state-of-the-art digital platform that provides a community hub for learning. Users can join classes, build groups and connect with other learners.

Specifically, the WLoS seeks to make science learning accessible to students everywhere in the world.

"The world needs more science and more scientists to face today's global challenges," said UNESCO DG Irina Bokova. "Achieving this requires better and more accessible science education. The UNESCO World Library of Science is a remarkable and exciting new tool that will help provide it, not only to students, but also to education planners and teachers, wherever they may be."



To access the library, Visit: http://www.nature.com/wls

Clean water and sanitation 'missing pieces' in HIV puzzle

Access to clean water and basic toilets is an essential but neglected part of the management and treatment of HIV/Aids, according to a WaterAid and SAfAIDS report released ahead of World Aids Day on 1 December.

The new report, *An integrated approach to HIV and water, sanitation and hygiene in southern Africa: A gap and needs assessment*, shows that 70% of all people living with HIV in the world reside in sub-Saharan Africa. This equates to approximately 25 million people.

Clean water is critical to keeping people living with HIV healthy, for taking antiretroviral (ARV) drugs and for the good hygiene required to minimise infections. Yet, 35% of people in sub-Saharan Africa are living without access to clean water and 70% are without basic sanitation. This leaves many people living with HIV suffering from chronic diarrhoea and unable to care for themselves or their families.

Diarrhoea compromises the effectiveness of ARV drugs by reducing the body's ability to absorb nutrients from food and medicine. Some 90% of people living with HIV in southern Africa suffer from diarrhoea. An overwhelming majority of these cases, 88% are linked to unsafe drinking water, inadequate sanitation and poor hygiene.

"In the last three decades, medical research has made great strides in helping to turn HIV from a death sentence into a more manageable condition. It defies logic that despite so much progress on education and in delivering ARV drugs, there has not also been a focus on making sure people living with HIV/Aids also have clean water, basic toilets and the means to wash themselves and keep their surroundings clean," reported WaterAid CE Barbara Frost.

The assessment focused on people living with HIV in Lesotho, Mozambique, Swaziland and Zambia.

To access the report, Visit: file:///C:/Users/laniv/Downloads/Integrated-approach-to-HIV-and-water-sanitation-and-hygiene-in-Southern-Africa%20(1).pdf

International funding for Kariba Dam repair

The World Bank International Development Association (IDA) is funding the repair of the Kariba Dam to the tune of US$25-million.

The Kariba Dam, built between 1956 and 1959, provides more than 50% of Zambia and Zimbabwe's electricity, benefiting an estimated four-and-a-half million people. During these six decades, the dam has been a key driver of regional growth and development and a major source of flood control and river flow management in the Zambezi River basin.

The repair project, with total financing of US$300-million, is being co-financed by the African Development Bank and the European Union. It will help the Zambezi River Authority, which is responsible for the management of the Kariba Dam, to reshape the dam's plunge pool and refurbish its spillway, as well as improve dam operations in order to bring it up to international safety standards.

"Rehabilitation of the Kariba Dam is an important component of the World Bank's larger programme for boosting the energy security of southern Africa," said Makhtar Diop, Vice President for Africa. "There is much more to be done in reaching that goal, but [this funding] is an important milestone in securing the Kariba Dam for the coming decades."

He added: "The Kariba Dam is woven into the social and economic lives of our two peoples. We remain strongly committed to our continued partnership in ensuring that the benefits of regional cooperation flow directly to the people of our countries."

Source: World Bank

Scientists reveal parchment's hidden agri stories

Millions of documents stored in archives could provide scientists with the key to tracing agricultural development across the centuries, according to new research completed at Trinity College Dublin and the University of York.

Thanks to increasingly progressive genetic sequencing techniques, the all-important historical tales these documents tell are no longer confined to their texts; now, vital information also comes from the DNA of the parchment on which they are written.

Researchers used these modern scientific techniques to extract ancient DNA and protein from tiny samples of parchment from documents from the late 17th and 18th centuries. The resulting information enabled them to establish the type of animals from which the parchment was made, which, when compared to genomes of their modern equivalents, provides key information as to how agricultural expansion shaped the genetic diversity of these animals.

This information therefore gives the scientists an unrivalled resource to analyse the development of livestock husbandry across the centuries. The research has been published in the journal, *Philosophical Transactions of the Royal Society B*.

Noted professor of population genetics at Trinity College Dublin, Daniel Bradley: "This pilot project suggests that parchments are an amazing resource for genetic studies that consider agricultural development over the centuries. There must be millions stored away in libraries, archives, solicitors' offices and even in our own attics. After all, parchment was the writing material of choice for thousands of years, going back to the Dead Sea Scrolls.

"Wool was essentially the oil of times gone by, so knowing how human change affected the genetics of sheep through the ages can tell us a huge amount about how agricultural practices evolved," he added.

Water's role in rise and fall of Roman Empire investigated

Smart agricultural practices and an extensive grain-trade network enabled the Romans to thrive in the water-limited environment of the Mediterranean, a new study shows.

But the stable food supply brought about by these measures promoted population growth and urbanisation, pushing the Empire closer to the limits of its food resources. The research, undertaken by an international team of hydrologists and Roman historians, has been published in the journal, *Hydrology and Earth System Services.*

Stretching over three continents and persisting for many centuries, the Roman Empire was home to an estimated 70 million people. In such a vast area ensuring a stable food supply was no easy task, particularly given the variable and arid climate of the Mediterranean region.

So how did the Romans maintain reliable food supplies to their cities for centuries under such challenging conditions?

To find out, Brian Dermody, an environmental scientist from Utrecht University, teamed up with hydrologists from the Netherlands and classicists at Stanford University in the US. The researchers wanted to know how the way in which Romans managed water for agriculture and traded crops contributed to the longevity of their civilisation. They were also curious to find out if these practices played a role in the eventual fall of the Empire.

"We can learn much from investigating how past societies dealt with changes in their environment," said Dermody. He draws parallels between the Roman civilisation and our own. "For example, the Romans were confronted with managing their water resources in the face of population growth and urbanisation. To ensure the continued growth and stability of their civilisation they had to guarantee a stable food supply to their cities, many located in water-poor regions."

In their peer-reviewed paper, the team focused on determining the water resources required to grow grain, the staple crop of the Roman civilisation, and how these resources were distributed within the Empire. It takes between 1 000 and 2 000 litres of water to grow a kilo of grain. As Romans traded this crop, they also traded the water needed to produce it – they exchanged virtual water.

The researchers created a virtual water network of the Roman world. "We simulated virtual water trade based on virtual-water poor regions demanding grain from the nearest virtual-water rich region in the network," explains Dermody.

The team used a hydrological model to calculate grain yields, which vary depending on factors such as climate and soil type. The authors used reconstructed maps of the Roman landscape and population to estimate where agricultural production and food demand were greatest. They also simulated the trade in grain based on an interactive reconstruction

of the Roman transport network, which takes into account the cost of transport depending on factors such as distance and means of transportation.

Their virtual water network indicates that the Romans' ability to link the different environments of the Mediterranean through trade allowed their civilisation to thrive. "If grain yields were low in a certain region, they could import grain from a different part of the Mediterranean that experienced a surplus. That made them highly resilient to short-term climate variability," says Dermody.

But the Romans' innovative water-management practices may also have contributed to their downfall. With trade and irrigation ensuring a stable food supply to cities, populations grew and urbanisation intensified. With more mouths to feed in urban centres, the Romans became even more dependent on trade whilst at the same time the Empire was pushed closer to the limits of their easily accessible food resources. In the long term, these factors eroded their resilience to poor grain yields arising from climate variability.

"We're confronted with a very similar scenario today. Virtual water trade has enabled rapid population growth and urbanisation since the beginning of the industrial revolution. However, as we move closer to the limits of the planet's resources, our vulnerability to poor yields arising from climate change increases," concludes Dermody.

- To access the original article, Visit: http://www.hydrol-earth-syst-sci.net/18/5025/2014/hess-18-5025-2014.pdf

Wetlands more vulnerable to invasives as climate changes

In the battle between indigenous and invasive wetland plants, a new Duke University study finds climate change may tip the scales in favour of the invaders – but it is going to be more a war of attrition than a frontal assault.

"Changing surface-water temperatures, rainfall patterns and river flows will likely give invasive alien plants such as Japanese knotweed, hydrilla, honeysuckle, privet and other noxious species an edge over less adaptable native species," noted Neal Flanagan, visiting assistant professor at the Duke Wetland Centre, who led the research.

Increased human disturbance to watersheds and nutrient and sediment runoff into riparian wetlands over the coming century will further boost the invasive species' advantage, the study found.

"It's death by a thousand small cuts. Each change on its own may yield only a slight advantage for invasive species, but cumulatively they add up," reported co-author Curtis Richardson, Director of the Duke Wetland Centre and professor of resource ecology at Duke's Nicholas School of the Environment.

If left unchecked, over time these changes will reduce the diversity of plants found in many wetlands, and could affect the wetlands' ability to mitigate flooding, store carbon, filter out water pollution and provide habitat for local wildlife, the authors warned. The findings have been published in the journal, *Ecological Applications.*

Citizen science network – Communities working towards South Africa's water security

To measure is to know. If we want to conserve our increasingly scarce water resources we need to first measure its health.

The members of the Triwaters Tour – adventurers Brett Merchant, Franz Fuls, and Troy Glover, who are traversing the Vaal and Orange rivers from source to sea, took time out last year to attend a three-day SADC Citizen Science workshop in Howick, KwaZulu-Natal, to learn more about the discipline of citizen science, miniSASS and the power behind the citizen science movement.

For three days delegates from South Africa, Botswana, Zimbabwe, Zambia, Swaziland and Lesotho came together to share their experiences on mobilising communities to leverage the power of citizen science towards a goal of a sustainable future. The event was hosted by the Wildlife and Environment Society of South Africa (WESSA), with support from the British High Commission, Department of Water and Sanitation and GroundTruth.

"High-profile decision-makers from civil society and government addressed the delegation in what was clearly not just another green-washing exercise, but a deliberate and focused commitment in response to the world's dwindling resources and climate change," said the Triwaters team.

The highlight of the event was the miniSASS exercise the team conducted under the supervision of experienced scientists in the Ingobongo stream below Shelter Falls. Delegates received first hand advice on how to best conduct miniSASS sampling, empowering them to transfer the skill to others in their own regions.

It was refreshing to have the opportunity to sample in a pristine stream. One group member even found a pollution sensitive stone fly – with an observation score of 8.2 this stream was classified as Unmodified (i.e. in natural condition).

Through intensive workshops delegates were exposed to other citizen science tools, such as the Turbidity meter that measures water clarity in a stream, which will empower citizen scientists who are interested in the health of rivers, streams, wetlands, estuaries and measuring rainfall.

Anisa Khan from Ecoschools enlightened the team on taking citizen science to schools through action and enquiry-based projects that achieve improved water use efficiency, water quality, access to water, sanitation, and sustainability through a seven-step framework on whole school development.

Mark Graham of GroundTruth explained the logic behind miniSASS while Bongani Madikizela, Research Manager at the Water Research Commission, took the team on a journey starting at the birth of this river monitoring tool. Together, they explained how miniSASS – a condensed version of a larger scientific tool, SASS – evolved into a simple yet accurate citizen science tool.

Looking at the motivation behind citizen science, Mike Ward of WESSA explained to delegates the various methodologies of scientific observation, while elaborating on the great value that citizen science has for formal scientists. It became clear that communities have a very important role to play in the collection of scientific data that is used by scientists in complex models, which then become tools for national and international strategy and policy-making.

Serving traditional science is only a part of the power of citizen science. Through many of its methods, citizen science can directly empower communities and the individuals who conduct the sampling. Basic analysis of the findings can indicate sources of pollution, and to some extent even severity. This can provide a platform that communities can use themselves to improve their immediate environment to their own direct benefit.

By the end of the workshop delegates were empowered to formulate their own workshops to start citizen science projects around river health: who to network with, conducting field work, reporting strategies, action taking and other concepts to create a solid foundation for new projects.

"With many other expert speakers also addressing the delegation, it was clear that citizen science, and miniSASS, is bound to become the next big thing in southern Africa's conservation drive," noted the Triwaters members.

Triwaters Tour is part of this drive, and plans to empower riverside communities along the Vaal and Orange Rivers early in 2015, providing communities with tools and techniques that they can use themselves to influence the sustainability of the areas where they live.

- To learn more about the Triwaters Tour, Visit: http://www.triwaterstour.com/
- To learn more about miniSASS, Visit: http://www.minisass.org/

The Triwaters team posing with delegates attending the workshop.

Regional partnership spearheads aquaculture capacity development

In response to a general decline in capture fisheries in sub-Saharan Africa, the governments in this region have encouraged investments into the aquaculture sector, both at smallholder and commercial levels, as an alternative. The aquaculture sector, however, needs technologically skilled human resources to guide it, but the region lacks a vibrant regional 'fit-for-purpose' training programme that holistically contributes to a lasting solution to this enduring food security challenge.

Strengthening the links between the higher education institutions (HEI) in the region and a sharing of teaching and research capacity, modern technologies and research into the demands of the fisheries and aquaculture sector are integral to increasing fish production and the sustainable management of resources.

Growing regional capacity through training at PhD level in aquaculture and fisheries science is imperative to this cause. This is the incentive behind the 'concerted fit-for-purpose PhD training in aquaculture and fisheries to improve food security and livelihoods in sub-Saharan Africa' project. Besides Rhodes University, partnering universities are Lilongwe University of Agriculture and Natural Resources (LUANAR), in Malawi, the University of Eldoret, in Kenya and Makerere University, in Uganda.

This project is one of a number of projects that form part of the Edulink II programme that is funded by the African, Caribbean and Pacific Group of States – European Union (ACP-UP) Cooperation Programme in Higher Education.

The objectives of the project are to review the capacity and teaching facilities at the partner institutions, visit a lead aquaculture/fisheries science teaching institution in Africa and in Europe, develop PhD curricula in aquaculture and fisheries science, constitute an academic advisory board and to start implementing the curricula.

With a well-established and internationally recognised PhD programme, Rhodes already has experiences that it can share with its partners in addition to a model for the joint supervision of students that would allow the department and South African Institute for Aquatic Biodiversity (SAIAB) staff to partner in capacity building and staff exchange programmes.

Rhodes is also expected to benefit from the development of strong partnerships with these other African universities, which may in turn attract additional international students. The programme will also allow Rhodes to ensure that these international students have a good foundation from which to work. A working knowledge of the programme will also allow them to design their own PhD and MSc curricula to cater for students from more diverse academic backgrounds.

"Our role at Rhodes is to initially assist and advise in developing the curricula with opportunities to possibly get involved in drafting them to possibly form collaborative student supervisory teams with staff from the partner universities in time to come," reported Dr Cliff Jones, senior lecturer in the Department of Ichtiology and Fisheries Science. "Ultimately, our own aquaculture and fisheries curricula is likely to benefit from this project too – there is always room to improve and grow."

Last year, Dr Jones along with Drs Daniel Sikawa (LUANAR), Phillip Raburu (Eldoret) and Robinson Odong (Makerere) attended the RUFORUM (Regional Universities Forum for Capacity Bulding in Agriculture) Biennial Conference in Maputo, Mozambique, where they facilitated a conference side-event interaction among fisheries and aquaculture actors in Africa and beyond.

The project partners met again at Rhodes later in the year to identify what the university has to offer the project going forward and to develop a work plan for 2015.

Rhodes University

Members of the fit-for-purpose PhD training at the inception meeting held in 2013.

Rhodes University

Dr Cliff Jones of Rhodes University's Department of Ichthyology and Fisheries Science and student Elethu Duna setting a gill net on an Honours fieldtrip.

What happens to soil water when savannahs burn?

A recently published study provides valuable insight into the relationship between water and fire in savannah landscapes. Article by Petro Kotzé.

Typically, the iconic savanna landscape is one of rolling grasslands scattered with shrubs and isolated trees. About 20% of Earth's land surface is covered by savanna, most of it in Africa. African Savanna make up 35% of South Africa's land area, but the most iconic representation of this landscape is probably the world-renowned Kruger National Park (KNP).

The savanna landscape is a complex one. Its structure and production are controlled by the availability of water over space and time, but fire, nutrients and herbivory are regarded as further primary drivers that control this dynamic system. Among these, fire is used extensively as a management tool in the KNP in order to achieve the park's various ecological objectives. As such, research objectives are often geared towards finding out what type, frequency and intensity of fire should be implemented for the most ideal results, says Skukuza based fire ecologist, Navashni Govender, SANParks Programme Manager: Fire Ecology and Biogeochemistry.

There is a long history of fire research in the park, and experimental burning plots (EBPs) have been operated since the mid-1950s. Yet, a topic that has not received much attention in the KNP is the impact of long-term fire management on soil hydrology. This is particularly important for scientists and managers to understand in a fire driven landscape as is found in this park, and even more so in light of climate change and bush thickening.

Work that was done in the EBPs by Mills in 2003 showed that there was capping or soil crusting taking place with more frequent fires, says Govender,

but these soil samples were taken to a laboratory for analysis. "We wanted a field study. There was a big gap in our understanding of fire and soil properties," she says. Consequently, the KNP's scientists wanted to find out how fire should be varied over different soil types and rainfall zones, and what effect this would have on the soil properties, infiltration and run-off.

Govender and Dr Eddie Riddell, Manager: Water Resources, Kruger National Park, then applied for, and received, funding for such a project from the Water Research Commission (WRC). SANParks Junior Scientist, Tercia Strydom, subsequently completed her Masters on the project, through and with support from fellow Honours student, Thomas Rowe, at the Centre for Water Resources Research at the University of KwaZulu-Natal.

The resulting WRC report, '*Pyrohydrology in African Savannas*' was published by the WRC late last year. It is the first time that the impact of fire on the hydrology of an African savanna has been documented. The results not only provide practical recommendations to the park's existing fire management plan, but also valuable insight into the interaction between water, fire, soil, vegetation and herbivores within this complex system.

SETTING UP THE EXPERIMENT

In a very large nutshell, Kruger is divided into two main geologies, namely granite and basalt. The western half of the KNP is dominated by granite and gneiss soils, while the eastern half is dominated by nutrient rich basalt soils. A narrow band of Karoo sediment runs along the junction.

A concern on the basalts is the loss of large trees and forage, and fire is thus reduced in order to give vegetation the opportunity to escape the fire trap. On the granites, bush thickening is a concern, and hotter and more frequent fires are applied to combat this, says Govender. The EPB's are spread over these landscapes, across high-rainfall and low-rainfall areas, as well as in a wilderness fire zone which is allowed to burn naturally.

The EBPs are so well established, that there is a lot of data to work from, says Strydom, and they were thus employed for this study as well. The bigger question was unpacked in a number of objectives. Firstly, to understand the effects of varying long-term fire treatments (annual vs. no burn vs. a variable fire regime) on soil hydraulic properties on basalt and

Petro Kotzé

Fire used extensively as a management tool in the Kruger National Park.

granite. Secondly, to investigate the effects of long-term fire treatments on surface runoff and sediment yield. A last objective was to determine the effect on soil water balances.

From May 2012 to December 2013 the soil hydraulic properties in the EPBs were determined by measuring hydraulic conductivity at the soil surface and between 2 and 7 cm of the soil surface. Soil compaction was determined and organic matter (total carbon) measured. The water retention capacity was inferred and vegetation characteristics such as grass biomass and basal cover were measured.

Different rainfall intensity simulations were constructed in order to measure the effect of different fire regimes on surface runoff and sediment yields.

***Below:** Post-graduate students, Tercia Strydom and Thomas Rowe measuring runoff by simulating rainfall events in the field.*

***Bottom:** Tercia Strydom measuring soil infiltration rates using an infiltrometer.*

Photos supplied

The subsequent surface runoff was measured and sediment collected for analysis. The soil water balances on the different burn plots were measured by using remote-sensing analyses, which allowed researchers to determine evapotranspiration rates and water balances for the different fire regimes.

DOES FIRE AND SOIL WATER MIX?

The main finding was that soils are capable to recover relatively soon, says Strydom. "We were quite amazed to find no difference between the soil properties of plots that burned fifty years ago, and those that burned three years ago." However, she notes, "This makes sense. This is how these systems have evolved." Natural savanna systems would burn every four to seven years, which would give the soil enough time to recover between fires.

The study revealed that the slowest infiltration rates took place immediately after a fire, and that this was most noticeable at the soil surface. These effects would dissipate within approximately two-and-a-half years. So, the effect of fire frequencies on soil hydraulic properties was found to be negligible considering that it is actually the times following a fire which plays a significant role.

Strydom says another interesting finding was the relationship between soil compaction, fire and herbivores. The more compact soil is the less water can infiltrate. While herbivores have a direct impact on this when they trample over soil, fire contributes indirectly. When the soil is burnt bare, it is more exposed to elements such as rain, leading to raindrop impact and splash and compacting soil at the surface. If herbivores trample over the soil, it was compacted deeper down.

Another important facet for researchers to understand was the soil's water holding capacity. The effect of fire on this is integral to understand seeing as it is essential in order for the veld to recover after a fire. While fire intensities are probably not substantial enough transfer heat deep into the soil and consume organic matter on the granite plots, it is believed that the huge contrast in above-ground biomass between the basaltic burn plots is responsible for the contrast in organic matter contents in the soil. As organic matter retains water, soil water retention was found to be the best on plots with no fires.

It was also concluded that long-term fire management undisputedly affects the amount of runoff generated

Shaping a science career with the helping hand of the WRC

Tercia Strydom was thrown right from the deep blue sea into the deep end when she started her career at SANParks, having to move out of her parental house in Cape Town "to the middle of nowhere" when she was accepted in the SANParks Junior Scientist Programme. This is an initiative to train, empower and mentor young scientists from previously disadvantaged groups. It allows students the opportunity to work with SANParks Scientific Services and gain practical experience while studying full-time.

She completed her undergrad studies at the University of the Western Cape in Environmental and Water Science. This was followed by her Masters in Hydrology through the University of KwaZulu-Natal's Centre for Water Resources Research, relocating to the Kruger National Park for the project. "It took me three months to realise that I don't want to go back to the big city," she says. Funded by the WRC, Strydom has now completed her Masters on pyrohydrology in African savannas, the first on the topic.

Yet, the achievements do not stop there. She was recently invited by the WRC to speak at the launch of the prestigious book, *Celebrating Twenty Years of Excellence in Water and Sanitation Research in South Africa,* which reflects on and conceptualises the last 20 years of research within the water and sanitation domain.

To *the Water Wheel*, she lists the "incredible" freedom that she was given by her supervisor, Dr Eddie Riddell and SANParks coordinator, Navashni Govender. "Initially I was overwhelmed, but I learned that I was capable of things that I didn't think I could do." She says that she has learnt that it is important to give students enough freedom while you are nurturing them, as they are likely to take on more challenges that way. "Supervisors should not be afraid to give us more scope to find ourselves," she says.

She also lists her time in Kruger as a high point. The amount of time you spend doing your

research is much greater than if you are at a university, and you are surrounded by scientists that have done it all before," she says.

She is, however, not done with Kruger yet. Strydom recently located to the park's Phalaborwa office for her PhD, again with the support of WRC funding. Her work will entail monitoring where water gets 'lost' in the Letaba River from where it is released from the Tzaneen Dam until it reaches the Kruger National Park.

The river's flow is measured in Kruger, and when it gets too low to meet the Reserve, operators in Tzaneen release more water from the dam. The amount of water that needs to be released is worked out according to the SPATSIM model, yet, when it reaches the park, it is not enough. Transmission loss is estimated to be as much as 30%.

"So, where is it going?" asks Strydom. Scientists will be investigating if it is natural loss, to the riparian vegetation and groundwater for example, or due to extraction by small-scale farmers next to the river. "Once we know how much water naturally gets lost, the dam operators can compensate," she says.

"The study results not only provide practical recommendations to the park's existing fire management plan, but also valuable insight into the interaction between water, fire, soil, vegetation and herbivores within this complex system."

from the savannnas of the KNP. This is due to a number of factors. The frequency of fires will affect the amount of water lost through vegetation (via evapotranspiration). Reduced vegetation cover will also result in less rainfall interception and thus exposing the soil surface to direct raindrops which, as mentioned, inhibit infiltration because soil is compacted. Less vegetation cover is believed to be responsible for the increased runoff rates observed on the annual burn plots in the granitic region of Pretoriuskop.

In conclusion, the impact of fire on soil water balances was found to be significant in both the granitic Pretoriuskop area, characterised by sandy soils and higher rainfall, as well as the basaltic Satara area, characterised by clayey soils and lower rainfall.

Petro Kotzé

Photo supplied

***Top right:** The Limpopo River forms the border between the Kruger National Park and Zimbabwe. Questions are now being asked about the impact of fire on catchment processes.*

***Middle right:** Measuring hydraulic conductivity in the field.*

***Below:** Charred soil providing evidence of veld burning.*

Photo supplied

These impacts may have knock-on effects on large-scale catchment processes. "Even though what we measure might only be on a plot scale, it automatically has a cascading effect," reports Strydom. You might have more runoff after a fire because water is not infiltrating. This runoff will go into a stream and into a larger river, as a result of the fire. Because water moves, the impacts are bigger."

THE IMPLICATIONS FOR MANAGEMENT

A recommendation from this study is that management must actively ensure that the veld does not burn as often as every two years, says Govender. Soil properties require a minimum of two years to return to pre-fire conditions on both the granitic and basaltic regions of the park in order to ensure that catchment hydrological properties are not adversely affected by unsuitable burning regimes. She adds that management must also consider the trampling effect on infiltration, and the impact of different intensities of rain and run-off on possible erosion.

An interesting element to keep in mind is that the loss of water through transpiration and evapotranspiration has an impact on water delivery in catchments, says Govender. How then, would bush densification effect this, and how must fire be used as a management tool?

According to the final report, these results could need to be extrapolated and confirmed at a catchment scale, considering that the park management policies are designed for large-scale areas. A further recommendation is that they work in fire catchment zones, instead of fire management zones. "Even though it would seem quite impractical in a place like Kruger, it is something that we must think about," notes Govender.

Accordingly, they have already started a project to look at the landscape across 'supersites' – large areas across granite and basalt geologies and low and high rainfall areas. According to Govender, "we need to upscale to understand what is happening in the landscape over a larger area."

To order the report, *Pyrohydrology in African Savannas* (**Report No. 2146/1/14**) contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download a digital copy. ❑

Raising a glass to SA's groundwater

As South Africa stands on the verge of its third decade of democracy it offers a time of reflection of what has been achieved over the last two decades since that historic day in 1994 when all South Africans voted for the first time. For the local groundwater sector, the 20-year celebration of South Africa's democratisation offered the opportunity to reflect on its own journey. Lani van Vuuren reports.

To celebrate the sector's achievements, the Water Research Commission (WRC) with the Department of Water and Sanitation (DWS) and the University of the Western Cape published a new book, *20 Years of Groundwater Research, Development and Implementation in South Africa*. The book was launched in Cape Town late last year.

According to co-author and WRC Research Manager, Dr Shafick Adams, the book is the result of a decision to take stock of the achievements of groundwater hydrology in South Africa while celebrating 20 years of democracy. "The book highlights the changes that have taken place in terms of groundwater resource development and management in South Africa since the political transformation of the country." The main author of the book is Everhard Braune, a well-known groundwater specialist.

There is no doubt that the groundwater sector has experienced enormous change over the last two decades. Arguably the greatest accomplishment has been the incorporation of groundwater as a public resource through the National Water Act (NWA) of 1998. Earlier groundwater legislation was based on the riparian system, founded partly on the principles of Roman-Dutch law. Under this system, the rights to groundwater were held by the owner of the overlying property, who could essentially abstract groundwater with little or no control.

Today, in terms of the NWA, South Africa's groundwater is recognised as a common asset, whose ownership is vested in the state and which is subject to all the stipulations of the Act. Groundwater has now been included in a variety of policies, strategies and regulations, and is now recognised as a crucial link in the integrated water resource management chain.

How much groundwater do we have?

The total volume of available, renewable groundwater in South Africa (known as the utilisable groundwater exploration potential) is 10 300 million m^3/a (or 7 500 million m^3/a under drought conditions). We currently use between 2 000 and 4 000 million m^3/a of this groundwater.

The change in legislation also meant that groundwater could now take its rightful place as a significant source in meeting the country's water supply demands. This resource has been instrumental in South Africa jumping from just little over 60% of population having access to safe water in 1994 to 95% today. The majority of these supplies (50% to 90% of communities served depending on province) have been served from groundwater sources.

"In terms of volumes it represents a very small portion of the overall water supplied, but in terms of the national objective of development and the elimination of poverty and inequality, it represents major progress," explains Dr Adams. "In addition, groundwater has moved from an ignored resource to within the top three options for many areas."

Even in South Africa's towns and cities, groundwater is becoming increasingly important. Around 22% of towns use groundwater as a sole source while 34% use groundwater in combination with surface water.

With opportunities of surface water development becoming increasingly scarce, groundwater will and needs to play a bigger role to meet the country's growing water requirements into the future. "In the last three years groundwater developments have grown faster than surface water developments in the context of total water use in South Africa," reports DWS's Fanus Fourie, also a co-author. "This is not surprising if you consider that 40% of all groundwater in South Africa has not yet been used or developed."

Greater use of groundwater sources does indeed hold great promise for accelerating sustainable access to improved water services and augmenting supply in many parts of the country. The lead times for developing groundwater resources are far shorter than typically found in big surface water development projects, which allows for delivery of the benefits far sooner. There is also scope for substantial cost savings in developing local decentralised groundwater-based schemes, instead of big regional surface water schemes with major pipelines conveying water from distant impoundments.

The NWA for the first time explicitly requires the establishment of a water resources information system and regular monitoring and assessment of resources. A unique feature of South Africa's groundwater occurrence is the predominantly fractured rock environment. Through systematic and increasingly integrated work these systems are now well understood in terms of modes and emplacement, fracture development and hydraulic behaviour.

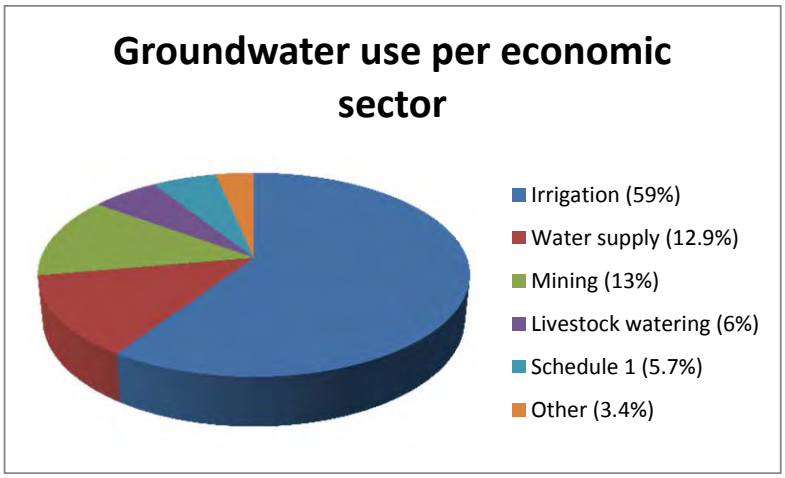
The systematic countrywide quantification of South Africa's groundwater resources followed out of a national groundwater mapping programme of the then Department of Water Affairs and Forestry, launched jointly with the WRC in 1992. Its first output, largely based on the lifelong work of Dr JR Vegter, was a series of national maps and explanatory documents published in 1995. In parallel, the department published a set of 21 hydrogeological maps covering the country at a scale of 1:500 000.

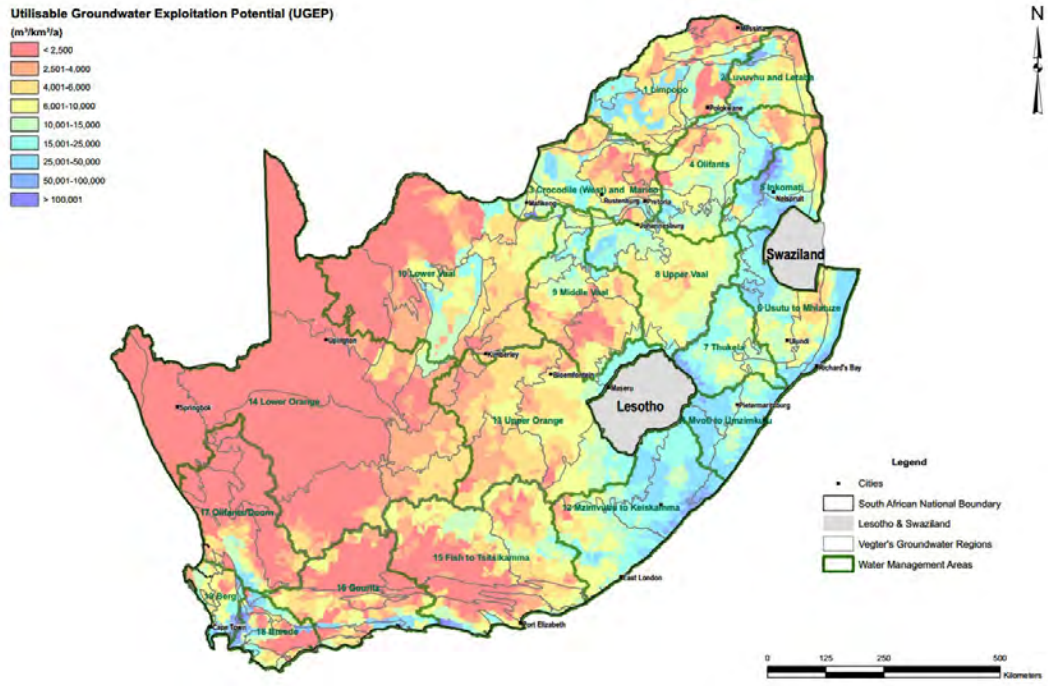
For Fourie, the latter is a significant highlight for the sector as it was a national attempt to characterise the country's groundwater. This eventually led to the Groundwater Resource Assessment Phase 2 (GRA2) project, the key findings of which were eventually included in the fourth iteration of the Surface Water Resources of South Africa, or WR2005.

The South African groundwater sector is supported by a small, but productive research community, to which the WRC readily contributes. "The WRC has been strategically funding projects to meet both current priorities and future needs. It has a strong groundwater portfolio, even with limited funds available," reports Dr Adams. "At the same time, the WRC has been partnering with the Groundwater Division of the Geological Society of South Africa in creating awareness of the resource and providing training and knowledge sharing platforms."

The current research portfolio speaks to both current and anticipated future issues. For example, the WRC is funding several projects around the issue of unconventional gas mining. "The latter projects are designed in such a way that the knowledge gleaned from them

Who is using groundwater in South Africa?





South Africa's utilisable groundwater exploration potential (Source: WR2005).

can be applied much wider than just the unconventional gas industry," says Dr Adams. At the local level, where groundwater is mostly used, the Commission is also developing the required tools and capabilities to manage groundwater resources optimally.

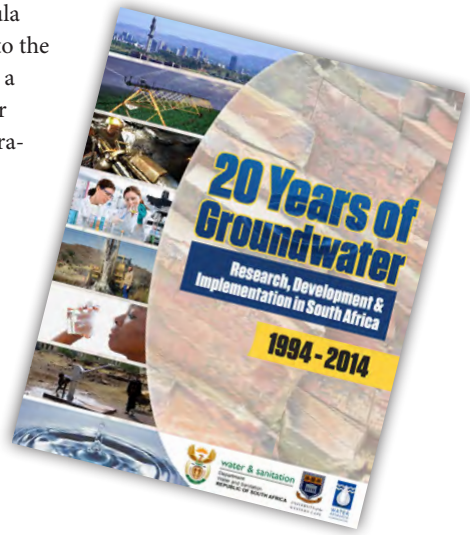
Much of this research has found its way through the various stages of policy and strategy formulation into implementation. A sterling example is the Artificial Recharge Strategy, says Fourie. "South Africa was only the second country in the world to develop such a strategy in addition to all the practical guidelines, tools and information. This placed us in the big leagues with Australia, India and the USA."

Dr Adams has much praise for South Africa's groundwater professionals. "South Africa certainly does not have a skills or capability shortage [in this sector] and most groundwater problems can be solved by local professionals. The challenge we do have is that most of these skills sit within the private sector. This does not necessarily bode well for implementation and enforcement. We have hundreds of local municipalities using groundwater – sometimes as a sole source – but they rarely have groundwater professionals in their employ. This is something that must change and is of great concern, especially if we want to unlock more groundwater for drinking water supplies and economic development."

The failure of some groundwater schemes has caused many municipalities to distrust this resource. However, investigations of failed groundwater supply schemes show that while the blame is often placed on the resource the real cause is almost always either due to failure of infrastructure (e.g. blocked borehole screen) or unsuitable pumping regimes that are related to lack of monitoring.

Groundwater-based systems are typically used in small scattered settlements – which are precisely the areas where the institutional resources capable of supporting reliable delivery of fuel and spares, quick dispatch of spares and ready access to skilled maintenance personnel are least likely to be found. This is an issue which must be addressed going into the future.

There is no doubt that groundwater still has much to offer South Africa. If managed correctly our aquifers can go a long way to ensuring South Africa's water secure future. As DWS Minister Nomvula Mokonyane concludes in the foreword to the book "All of South Africa's citizens have a role to play in ensuring the legacy of our underground treasure remains for generations to come."



To order the book, *20 Years of Groundwater Research, Development and Implementation in South Africa* (**SP No. 78/14**) contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; Email: orders@wrc.org.za or Visit: www.wrc.org.za to download an electronic version. ❑

COLBYN VALLEY – The ultimate urban wetland survivor

Few residents of the City of Tshwane are even aware that, against all odds, a functioning wetland – which includes a 7 000-year-old peatland, persists in the heart of Pretoria. Article by Tamsyn Sherwill.

Located just 5 km from the Union Buildings, and flanked by the N4 and N1 highways, the Colbyn Valley wetland is a unique asset to the capital city. The wetland, which covers an area of about 15 ha, is formed by back-flooding of the Hartbeesspruit as it flows through a poort between two quartzitic ridges, along with the contribution of groundwater and subsurface drainage from seeps upstream. This has also created favourable conditions for the accumulation of peat. Peat forms when low-energy flows and permanent water-logging enable partially-decomposed plant material to accumulate. Active accumulation of peat depends on a slow rate of decay in oxygen-deprived (anaerobic) conditions.

Peatlands anywhere in South Africa are a relatively rare discovery – only about 10% of our wetlands contain peat. And, once discovered, peat is often exploited as a resource, mined to use as a potting medium, fuel source, adsorbent or filter material. Flow through a peatland is often diverted or channelled and the peat is left high and dry, catches fire and, after millennia of slow accumulation, is gone.

Yet the Colbyn peatland persists, tucked away under a dense bed of reeds. Occupying just over a hectare, the peat layer in Colbyn has been estimated to be about 7000 years old, and is 2.4 m thick at its deepest point, with an average thickness of 1.5 m. The total volume of peat in Colbyn amounts to about 15 000 m^3.

Peatlands, or mires as they are also known, can be further classified as either fens or bogs, depending on whether they receive their water from direct precipitation only or from surface runoff or groundwater. Fed by a stream and groundwater the Colbyn peatland is a fen – and, more specifically – a tall

emergent (having emergent vegetation) reed-sedge (the type of emergent vegetation that ultimately becomes peat) fen.

Wetlands in general provide irreplaceable natural infrastructure for managing our water resources. The Colbyn wetland plays a vital role in groundwater retention, which helps to ensure year-round flow in the Hartbeesspruit. Wetlands are formed by slow flow, and their emergent vegetation slows this flow even further, dampening floods, and resulting in deposition of suspended particles and removal and retention of sediment. Chemical pollutants are also trapped or adsorbed, and the incredibly productive wetland vegetation is able to take up excess nutrients which could contribute to increased algal and water-weed growth in dams and reservoirs downstream.

HOTSPOT AND CORRIDOR FOR URBAN BIODIVERSITY

Though wetlands by their very nature are relatively species poor (usually being dominated by a very specific vegetation type), they form vital patches in the overall landscape mosaic, greatly increasing the overall number of species which an area can support. The greater Colbyn Valley is now conserved within the recently proclaimed Colbyn Wetland Nature Reserve, covering an area of about 60 ha, and including areas of grassland as well as the neighbouring tree-covered rocky ridges. Several animal species depend for at least part of their lifecycle on the wetland or surrounds – notable sightings over the years have included genets, duikers, hedgehogs, elephant shrews, water mongooses, and even the threatened red rock rabbit. The renowned bird expert, Geoff Lockwood, once described Colbyn Valley as 'the best birdwatching spot in Pretoria', and today almost 150 species can still be spotted here.

A collection of interconnected natural areas has far more value for biodiversity conservation than a single isolated reserve, and Colbyn Valley plays a critical role in this regard as a node connecting several of the capital's natural or open spaces. As most of Pretoria's green belts run east-west, along the east-west striking quartzite ridges, the north-south link provided by the Hartbeesspruit is vital in linking the Strubenskop and Meintjieskop ridges with the Magaliesberg, and then, further on, to Roodeplaat Dam. The reserve also forms part of an east-west corridor connecting the Silverton Ridge and Pretoria National Botanical Garden with Meintjieskop and beyond.

A COLOURFUL HISTORY OF USE, ABUSE, THREAT AND RESCUE

The area known as Colbyn Valley was originally part of the farm Koedoespoort, allocated to Lourens Cornelius Bronkhorst in 1859, whose heir sold the farm to the Wesleyan Methodist Missionary Trust in 1885. The portion of the farm on which the wetland is located was later allocated to the University of Pretoria for agricultural research, and eventually donated to the then Pretoria City Council as a 'nature area'. Damaging impacts on the wetland date back to its use for agriculture – drainage ditches and irrigation trenches have drained parts of the wetland and caused much of the peatland to dry up.

The historic NZASM railway line, remains of which can still be seen in the reserve, was routed around the wetland area, but the more recently built Koedoespoort line now divides the wetland in two, and has caused compaction of the soil and altered drainage conditions. In the 1970s a block of flats

Tamsyn Sherwill

Dr Piet-Louis Grundling demonstrates the water-holding capacity of peat. Dr Grundling's association with the wetland as a volunteer specialist has continued since the late 1990s.

was built below the wetland's keypoint at the exit of the poort, close to the 1:50 year floodline. This resulted in channelling of the stream, a deepened river course and headward erosion into the wetland. To add insult to injury, the wetland has also been bisected by the N4/N1 highway interchange, bringing with it increased high-energy stormwater loads. With no fencing or access control, the area attracted illegal dumping as well as 4x4 owners, who raced their vehicles along parts of the wetland, compacting areas of peat.

In the 1990s the City Council put in an application to develop the site as a golf course. This was finally a big enough threat to stir local residents and wetland lovers to action – the Friends of Colbyn was formed, and was able to successfully oppose the development. Then in the late 1990s an unlikely band of wetland guardians emerged – a group of Grade 11 pupils from CR Swart High School decided to adopt the Colbyn wetland as a rehabilitation project, under the auspices of the National Youth Development Trust. Their interest in the wetland had been sparked by a discovery of what they thought was peat moss, and which they called on local wetland specialist Dr Piet-Louis Grundling to verify.

Uncertain whether there was even peat in Colbyn, Dr Grundling visited the wetland with the group and discovered peat deposits in an old agricultural drain along a tributary of the Hartbeesspruit. The pupils gave the badly degraded wetland area the name 'Mosstrosity' (a play on peat moss, though no peat moss has ever actually been found to occur in Colbyn), referring to their group as the 'Mosstrosities'.

Heavy rain in early spring causes flash flooding: floodwaters overflow the spillway of the gabion weir at the wetland keypoint.

Tamsyn Sherwill

The Mosstrosities and Friends of Colbyn became instrumental as environmental watchdogs and intervention agents in the Colbyn Valley. In August 1999, when a pipeline was put through the wetland without an EIA having been done, compensation was requested from the City Council, and eventually granted in the form of money for wetland rehabilitation. At about the same time, headward erosion at the keypoint had begun to undercut the railway line, leaving the Koedoespoort service, literally, 'hanging'. Friends of Colbyn and the Mosstrosities were able to convince Metro Rail that a full wetland assessment should be done before a decision could be made on any actions to secure the railway line.

On the basis of the resulting report, a number of rehabilitation measures were planned and implemented, with the assistance of the city's Nature Conservation department: Compaction caused by the pipeline was addressed by loosening of the soils and re-vegetation, restoring subsurface drainage to downstream areas. A construction drain was filled up, and excavation rubble flattened. A fence was put up to prevent 4x4 traffic and dumping. While loosening the compacted areas, invasive aliens such as kikuyu were removed, and the areas reseeded with wetland grasses. Once drainage had been restored to downstream areas, bulrushes (*Typha capensis*), cottonwool grass (*Imperata cylindrica*) and a sedge were planted in the rehabilitated areas. Finally, Metro Rail and the City of Tshwane constructed a significant erosion prevention structure – a gabion weir – in the poort, thereby stabilising the wetland's keypoint. In 2002, Working for Wetlands also installed a series of smaller gabion weirs to stabilise the natural stream channel, and to facilitate rewetting of the area extending back to Stanza Bopape (previously Church) Street.

AN UNCERTAIN FUTURE?

Disaster averted, interest in the wetland from the public and volunteers began to wane, and it was only the emergence of a new threat in 2012, with the identification of a site adjoining the wetland as the likely future location of a major park-and-ride facility, that led to efforts to revive the Friends of Colbyn – now re-established as the Friends of Colbyn Valley. As every lobbyist knows, drumming up support and creating awareness is much easier in the face of a direct and imminent threat for people to rally around. But several more indirect and ongoing threats challenge the health and integrity, and even the continued existence, of

the Colbyn wetland. Though protection of the area as a nature reserve is a comforting new development, this protected status doesn't extend to the catchment.

The catchment includes the suburb of Hatfield, which is becoming ever more densely developed with time. An increase in the area of hard surfaces like tar and concrete leads to increased high-energy runoff, with the potential to erode the wetland and stream banks and deepen the river channel downstream. Further development of the catchment is also likely to result in deteriorating water quality.

Another silent but no less destructive assault comes in the form of botanical invaders. Colbyn Valley has been infiltrated by a number of alien plants, such as kikuyu, morning glory, bugweed, poplar, syringa and lantana, and, most recently, the deadly pompom weed. Alien plants displace indigenous ones, along with all of the life these support, and often also use large amounts of water.

There are also direct human impacts on the broader nature reserve. A number of people use the area as a pedestrian shortcut, and cut the fence to do so, and others have made the reserve their home, leading to problems of litter, cutting of trees, increased erosion from the development of footpaths, disturbance or killing of wildlife, and accidental or intentional setting of fires in the winter months, which has led to most of the reserve now burning on an annual basis. A recent disturbing development is the targeting of the area by a group of young men who have been spotted hunting in the reserve with a pack of trained dogs.

Finally, the many and often conflicting priorities of local government have resulted in relatively little money or manpower being available for any but the most basic management activities. But the biggest threat to the Colbyn wetland could also turn out to be the biggest opportunity to secure its survival – its urban location makes it an ideal site for wetland and other environmental education initiatives. Colbyn Valley is a living textbook of wetland structure, function, degradation, and rehabilitation. And as our cities become ever more built-up, congested, noisy and ugly, natural areas within the city are valued ever more highly by residents, as an essential contributor to their wellbeing and quality of life. It is clear that the Colbyn Wetland Nature Reserve already plays such a role, for residents and visitors alike. Some have even mentioned having a connection to the wetland and a desire to see it persist simply from driving past it every day.

Tamsyn Sherwill

Imperata cylindrica ***(cottonwool grass) in full flower during spring.***

Birders enjoying Colbyn Valley.

Tamsyn Sherwill

The reedbed in the peatland just 3 months into the growing season, after having been reduced to ashes the previous winter.

A reedbed in the Hartbeespruit catches fire during winter.

SHARING THE LOVE – SHARING THE LOAD

The continued existence of the Colbyn Valley wetland and peatland is a tribute to the efforts of ordinary citizens, vocal residents and visionary schoolchildren. Fortunately, the law is now firmly on the Colbyn wetland's side, with protection offered by legislation such as the National Water Act and Protected Areas Act, and which didn't exist in earlier days when the wetland took its biggest blows from development.

Effective catchment management is key to conserving aquatic ecosystems. Recent developments in stormwater management and green technologies offer a means to mitigate the effects of catchment development and reduce the intensity of stormwater runoff, for example, through implementation of sustainable urban drainage systems and permeable pavements.

But the law and technology can only do so much, and the efforts of volunteers and activists will continue to play a central role in promoting and acting for the conservation of wetlands and other 'wild' places. Unfortunately, the role of the Colbyn wetland in residents' everyday lives has shrunk over the years. Whereas previously the area was well-used by local families for walking and other recreation, this is almost unheard of now due to perceptions that the area – like many open spaces – is unsafe. As fewer people visit this becomes a self-fulfilling prophecy, as the area becomes more unsafe and more attractive to vagrants or criminals.

Tamsyn Sherwill

Building a wetland model, as part of a 'wetland basics for kids' course held to celebrate World Wetlands Day 2014.

The recently revived WESSA-affiliated Friends group for the area, the Friends of Colbyn Valley, have thus focused their initial efforts on raising awareness by getting people back into the wetland. In the words of Jeff Johnson in the documentary film *180° South*: "If you love a place, you have a duty to protect it. And to love a place, you have to know it first." Efforts to know the wetland and reserve better include securing the services of volunteers for specialist surveys of the fauna and flora. A rare Lycaenid butterfly was recorded in the area in a 1991 survey, and efforts are now being made, with the help of local consultants Afribugs as well as the Lepidopterists' Society, to find it again.

More direct interventions planned for the future include the construction of a fish ladder to help fish overcome the barriers presented by the gabions, and putting in litter traps to reduce the importing of rubbish via the stream. The Department of Environmental Affairs, facilitated by ICLEI's Local Action for Biodiversity programme, has recently begun a process to pilot the development of a Biodiversity Management Plan for an Ecosystem (BMP-e), as outlined in the Biodiversity Act and subsequent Norms and Standards, in the Colbyn Valley. If successful, the resulting management plan for the Colbyn wetland could be the country's first ever BMP-e.

As the story of Colbyn shows, one of the greatest challenges to maintaining momentum is when lobbying efforts succeed, threats are neutralised and complacency starts to creep in. It is also often the case that efforts of community-based organisations tend to pivot around a small group of – or often even lone – 'champions', and when they become disillusioned or exhausted, or their circumstances change, energy toward the cause dissipates and can take years to build up again.

These challenges can only be overcome by proactive vision-oriented approaches that actively work against people's more reactive, threat-focused habits. Networks can buffer against the ups and downs of isolated champions. For example, Friends of Colbyn Valley is a member of the Adopt-Moreletaspruit forum, part of the Department of Water and Sanitation's Adopt-a-River programme, which is able to successfully support and channel the concerns and actions of a range of smaller stakeholder groups. Hopefully, as the Colbyn wetland begins to again take up its rightful place in the capital's collective imagination and experience, a shared passion to protect this special site will become self-sustaining.

- Sources: Knoll C (2000) Schoolgroup spearheads rehabilitation of urban wetland/peatland. *Urban Green File July/August 2000.*❑

Do invasive alien plants really use more water? STUDY INVESTIGATES

Prosopsis *invaded floodplain of the Doorn River at Brandkop farm in the Northern Cape.*

All photographs courtesy CSIR

The threat posed to South Africa's scarce water resources by invasive alien plants is well known. But can one alien plant species really have that big of an effect on groundwater? A team from the CSIR is investigating.

The threat of groundwater-dependent alien invasive plants individually consuming up to 50 ℓ/day of water, presents a myriad of challenges for an already water-scarce South Africa. Approximately 10 million hectares of land have been invaded by alien invasive plants in South Africa.

Prosopis is a dominant groundwater dependent alien invasive species found in the arid and semi-arid parts of South Africa. A deep-rooted shrub, the plant originates from Central America, and was first introduced to Namibia and the north-western parts of South Africa mainly for fodder, fuel and share in the late 1800s. This species is well-known for its ability to thrive under semi-desert conditions by accessing groundwater using its deep tap root. Tap roots have been found at depths exceeding 50 m.

Various *Prosopsis* species have become invaders and have spread to other parts of the country. They have invaded the Nama karoo and arid savannah in parts of the Western Cape, Eastern Cape, North West and Limpopo, and are spreading into adjacent grasslands. In the Northern Cape alone, studies by the North West University have fond that *Prosopsis* has invaded about 1.5 million ha or 8% of land in the province by 2007.

The rapid spread of this invasive alien plant, particularly along river courses and floodplains where it forms impenetrable thickets, has raised concerns about its impact on groundwater resources, especially for groundwater-dependent farmers and rural communities. These concerns have led to a three-year project aimed at determining the impacts of *Prosopsis* invasions on groundwater.

The project, funded by the Water Research Commission with support from the Working for Water programme of the Department of Environmental Affairs, is being conducted by a multidisciplinary team of researchers led by Dr Sebinasi Dzikiti from the Hydrosciences Research Group at the

CSIR in Stellenbosch. The study is now in its second year.

The main purpose of the study is to quantify the long-term patterns of groundwater use by *Prosopsis* invasions and compare them with co-occurring indigenous trees. This information on the impacts can then be used to prioritise areas for clearing *Prosopsis* and protecting groundwater.

"Researchers have recognised that deep-rooted indigenous trees, such as acacias also use groundwater," notes Dr Dzikiti. "Therefore, we also need baseline information on groundwater use by the indigenous vegetation that would normally replace *Prosopsis* after it has been cleared. This will enable us to determine the increment groundwater use by the invasive plant and whether this could have adverse environmental impacts, such as drying up boreholes and streams, loss of biodiversity and productive grazing land."

***Right:** Research team member, Dr David le Maitre of the CSIR and Brandkop farm owner Peter Louw inspecting a dry well in the* Prosopsis *invaded area.*

***Below:** Project team members installing an automatic weather station in the project site area.*

MONITORING THE INTERACTION OF INDIGENOUS AND ALIEN VEGETATION WITH GROUNDWATER

The research team found a site which is heavily infested by *Prosopis* and also has good stands of *Acacia karroo* in the floodplain of the Doorn River at Brandkop farm near the groundwater-dependent town of Nieuwoudtville in the Northern Cape. According to the farm owner, Peter Louw, the size of the invaded area on his property is about 400 ha, and much of the grazing land for his sheep has been invaded.

Acacia karroo is the dominant indigenous tree species that relies on groundwater in the area. It is an important indigenous species, which provides nesting sites for birds and a habitat for a range of animals.

To understand the water use of both tree species, researchers are monitoring the volumes of water taken up by both *A. karroo* and *Prosopsis* in relation to the weather, soil water content and groundwater levels. They are also measuring the water uptake by the roots of both species using water flow sensors installed on the tap and lateral roots of selected trees.

The sources of water transpired by the trees (whether soil water or groundwater) are being determined by matching the stable isotope signatures of water from twigs with different water sources. The first one-and-a-half years of the project involved monitoring the site with both species present. *Prosopsis* invasions will then be cleared and detailed monitoring will continue of the remaining indigenous vegetation for the remaining research period.

According to Dr Dzikiti, this intensive monitoring is the first of its kind in South Africa to involve detailed assessments of the interactions of both invasive alien and indigenous trees with groundwater in the drier parts of the country.

Interestingly, the greatest challenge of the experiment to date was for the team to keep their equipment running as planned at such a remote site. "Vandalism of the equipment by baboons that frequently pulled probes out of trees or used the equipment as steps to climb trees has been a major challenge," notes Dr Dzikiti. "We have had to go to great lengths to protect our equipment using several layers of fencing."

FINDINGS TO DATE

Contrary to popular belief, the amount of water transpired by individual *Prosopsis* trees has been found to either be equal to, or lower than, that of an *A. karroo* of the same size. This was because the water transport pathway (sapwood area) of the invasive alien plant stems is substantially narrower than that of the indigenous plant. However, if water use by the whole population of each species is considered, *Prosopsis* transpires at least four times more water than *A.karroo*.

"This is because the alien invasive plants were very dense compared with the indigenous vegetation," explains Dr Dzikiti. "So the ability of the *Prosopsis* to form dense thickets with large numbers of plants per unit area, rather than high transpiration by individual trees, is the main reason why their water use exceeds that of indigenous vegetation."

The researchers have further observed an interesting phenomenon during the root water uptake studies. They found that *Prosopsis* is manipulating the available water in this exceedingly dry region to its advantage while the indigenous *A. karroo* is not. Groundwater taken up by the *Prosopsis* tap root is not all immediately transpired. Much of the root water leaks out into the upper soil profile, presumably for use later when there is less water available.

The result is a greater average soil water content under *Prosopsis* than under *A. karroo*. Scientists call this phenomenon of water movement 'hydraulic redistribution', or more accurately 'hydraulic lift'. While the indigenous *A. karroo* also uses groundwater, no water redistribution occurs, and all the water absorbed by the tap roots is immediately transpired, leaving the trees with no buffer against periods of water shortage.

Besides creating a water reserve for the trees, studies around the world have found that hydraulic redistribution also plays a critical role in the survival of the associated shallow-rooted plants, which cannot directly access groundwater. Moreover, the moister soil profile under *Prosopsis* is known to improve nutrient cycling.

All these factors combine to significantly enhance the chances of survival of young *Prosopsis* seedlings, probably contributing to the rapid increase in the populations of this species compared to co-occurring indigenous trees. Stable isotope data shows that *Prosopsis* obtains about 77% of its water from groundwater compared with 53% for *A.karroo*. during the peak summer period.

The findings of this study were rather surprising, notes Dr Dzikiti. Firstly, the fact that individual Prosopsis trees are not really extravagant users of water as is widely believed was quite unexpected. "The adverse impacts of this species on groundwater and the environment at large seem to arise from the very dense plant populations whose combined effect is significant."

"Secondly, given that the growth form of *A. karroo* is not very different from that of Prosopsis, we did not expect trees of the two species growing next to each other to have different water uptake patterns," he adds. "However, we do know that when Prosopsis invasions increase, indigenous vegetation gets replaced."

The study results to motivate for the clearing of *Prosopsis* invasions with a specific focus on stands found along river courses and on floodplains. The research does suggest, however, that water savings from clearing *Prosopsis* are unlikely to be significant in areas where there are comparable densities and sizes of deep-rooted indigenous trees as there are of *Prosopsis*, or where there are more indigenous trees than *Prosopsis*.

It is hoped that the final results and recommendations from this study will go a long way towards growing the required knowledge for South Africa effectively manage the problem of invasive alien plants. ❑

***Below left:** Dr Sebinasi Dzikiti from the Hydrosciences Research Group at the CSIR installing a soil water content sensor in the root zone of* **Prosopsis.**

***Below top:** A closer view of the transpiration and root water uptake equipment.*

***Below bottom:** An eddy covariance flux tower for measuring evapotranspiration over the invaded area.*

Aubrey Withers

The desertification of a large area of supratidal saltmash on the estuary's south bank is partly due to flood attenuation levees and a causeway which obstructed water exchange.

ORANGE RIVER MOUTH – Saving the integrity of one of SA's most important estuaries

Decades of human-made impacts have left its mark on the estuary of South Africa's largest river, the Orange. Now new plans are underfoot to prevent the further degradation of this important Ramsar site. Article by Sue Matthews.

When Robert Jacob Gordon – the Dutch explorer and military officer who named the Orange River – spent a few days at the river's mouth in August 1779, he observed a large marsh on the southern bank and noted that the land was so low that it 'must be completely covered when the sea and river are high'. The only people living in the area at that time were a group of about

20 Khoikhoi, who had constructed a few dome-shaped huts from whale bones, driftwood and grass.

Today, human settlement and development – both in the immediate vicinity of the estuary and in the distant reaches of the catchment – have taken their toll on the estuary, and that supratidal saltmarsh on the southern bank now resembles a barren desert. Most of the damage has occurred since the 1960s, but the history of decline dates back to the late 1920s, when diamond-mining began in the area.

Apart from the increased presence of people and the environmentally damaging effects of mining and other activities, the estuary mouth was artificially breached when it closed, typically every few years. In fact, the recent migration of the mouth back to the southern side of the estuary has exposed old machinery that was dumped in the mouth at some stage in an attempt to keep it open and fix its position. The aim of artificial breaching was to reduce the impact of floods and maintain the quality of water drawn from the alluvial aquifer, but the practice also prevented occasional inundation of the supratidal saltmarsh.

The more enduring impact on the estuary, however, was the commissioning of the Gariep and Vanderkloof dams in the 1970s. Situated more than 1 400 km upstream, the dams have not only altered the flood regime of the river because of their large storage capacity, but also elevated low-flows during the dry season and drought periods due to their water release schedule. And, of course, the total volume of water reaching the estuary annually has been reduced significantly as development in the catchment has inexorably increased the water demand of the industrial, agricultural and domestic sectors. These changes in flow have had a variety of impacts on the ecological health of the estuary.

The prospect of new dams in the Orange River catchment has raised concerns that the estuary will be under even more pressure in the future. Lesotho's Metolong Dam will supply water to Maseru and neighbouring towns by the first quarter of 2015, while the Polihali Dam is expected to be completed by 2022. The Neckartal Dam is under construction on Namibia's Fish River, and South Africa's recently completed Reconciliation Strategy for the Orange River Water Supply System has recommended that a feasibility study be conducted for the long-mooted Vioolsdrift Dam on the Lower Orange River.

A baseline survey is conducted on the Lower Orange River for the environmental flow requirements study.

Rob Palmer

"The mouth hasn't closed since the 1990s, so salinity is increasing in the saltmarshes, which is one of the main reasons the system is declining in health."

Recognising the potential threat to the estuary – as well as the transboundary nature of the problem – the UNDP-GEF funded Strategic Action Programme of the Orange-Senqu River Commission (ORASECOM) contracted consulting firm Rivers for Africa to conduct an environmental flow requirements study for the final 150 km of the Lower Orange River, from its confluence with the Fish River to the mouth. The study also included the Fish River itself, in order to recommend release options for the Neckartal Dam, and the nearshore marine environment in the vicinity of the mouth, to assess the possible effects of changes in freshwater input. Overall project leader, Delana Louw of Rivers for Africa, headed up the team responsible for the river components of the study, while the CSIR's Lara van Niekerk led the estuary and marine teams.

The study found that in its natural, pristine state – the reference condition – the Lower Orange River would have had a mean annual runoff (MAR) of an estimated 11 373 million m^3. Today, the MAR is only 4 641 million m^3, which means that the quantity of water reaching the mouth is only about 40% of the natural volume.

The various physical, chemical and biological components of the systems were assigned a health score by specialists on the study teams, and these were integrated to determine the overall present ecological state, or EcoStatus. While the river reach attained a B/C – indicating slight to moderate modification from the reference condition – the estuary could only manage an overall health score of 51% , translating to a D.

The D represents a largely modified system, but could just as easily stand for degraded. The primary cause is the reduction in the frequency and magnitude of floods of all size classes, together with the more constant, year-round flow associated with river regulation.

"The estuary is not getting the high flows it used to, and it's not getting the low flows either," says Lara van Niekerk. "The mouth hasn't closed since the 1990s, so salinity is increasing in the saltmarshes, which is one of the main reasons the system is declining in health."

Small floods that used to regularly bathe the supratidal saltmarsh in freshwater – diluting and flushing accumulated salts from the soil – have been reduced considerably, but the same effect occurred when the mouth closed, causing the water body to start spreading over the floodplain.

"One of the critical findings from the study is that we need the estuary to close two to four times in a ten-year period," says van Niekerk. "It doesn't have to close for very long, but the water level must go up by at least a metre so that there's backflooding into the supratidal saltmarsh."

Steve Lamberth

Windblown dust and wastewater from mining activities have contributed to the degradation of the Orange River estuary.

She explains that mouth closure is achievable if river flows during the low-flow season could be sufficiently reduced and timed to coincide with high-wave sea conditions, when sand is washed into the estuary and deposited in the mouth. This is difficult to control when flows are governed by releases from the Vanderkloof Dam, which take four to six weeks to reach the estuary and must meet the needs of irrigation schemes along the way.

But the proposed Vioolsdrift Dam, only 350 km upstream, would enable flow manipulation to be fine-tuned to allow for mouth closure. Although the dam would result in a further reduction in medium-sized floods and sediment supply, the specialists believe that mouth closure is more important for improving the health of the estuary. (The dam would also be beneficial to the Noordoewer-Vioolsdrift Joint Irrigation Scheme, covered in the November-December 2014 issue of *the Water Wheel*).

Another factor that contributed to the decline of the supratidal saltmarsh was the construction during the 1960s of a causeway across it to provide road access to the beach, as well as flood attenuation berms to protect agricultural land on the floodplain the following decade. These structures prevented inundation of the saltmarsh by both freshwater flows during small floods and saline waters during exceptionally high spring tides and storm surges.

Any water that did reach the saltmarsh – as occurred in the major flood of 1988 and a mouth closure event in 1993 – was unable to escape and slowly evaporated, increasing the salinity of the soil and groundwater to the point that it inhibited seed germination and seedling establishment. By 1995 the supratidal saltmarsh had collapsed, prompting South Africa to have the estuary, which was declared a Ramsar wetland of international importance in 1991, listed on the Montreux Record – a register of Ramsar sites where ecological changes have occurred.

Sections of the causeway were removed in 1997 and 2005 in an effort to rehabilitate the now desertified saltmarsh, but this did not improve flow enough to flush out the accumulated salts. Recently it was proposed that the entire causeway as well as the levees be removed, and replaced with a berm constructed further inland to protect the town of Alexander Bay's low-lying areas and sports fields from flooding. Withers Environmental Consultants were appointed to conduct the environmental impact assessment, but just as the Final Basic Assessment Report was to be circulated for comment, the process stalled. The provincial Department of Environment and Nature Conservation – delegated responsibility for managing the Ramsar site – requested that separate applications be submitted to the national Department of Environmental Affairs for the removal and construction components.

A further complication is that state-owned mining company Alexkor is responsible for the EIA process as it is required to rehabilitate all historic disturbances associated with its activities, but the land is now owned by the Richtersveld Sida !Hub Communal Property Association (CPA), following a land claim awarded in 2007. The CPA representatives have changed during the course of the EIA process, and support for the removal of the levees has been retracted because it would result in periodic flooding of agricultural fields.

The recommendations from the environmental flow requirements study highlighted the importance of removing the causeway at least if the estuary is to be rehabilitated to its 'best attainable state' of a C ecological category. This would also require remedial actions to reduce the nutrient input from the catchment downstream of Vioolsdrift through improved agricultural practices, to control windblown dust and wastewater disposal from mining activities, and to curtail the fishing effort on both the South African and Namibian sides of the estuary. Illegal gillnetting is known to occur in the estuary, and angling pressure in the vicinity of the mouth is relatively heavy. This can only be addressed through increased compliance and law enforcement, and ideally the alignment of fishing regulations between the two countries.

The study team recommended that the remedial measures relating to 'non-flow' impacts, as well as

Kriek Heli

The Lower Orange River flows through a desert landscape to its final destination, the Atlantic Ocean.

potential flooding and water quality issues stemming from increased mouth closure, should be addressed as part of the estuary management plan. The development of the plan began in 2011, and followed a collaborative process involving government agencies, local communities and other key stakeholders in South Africa and Namibia, many of them represented on the Orange River Mouth Interim Management Committee.

The plan was structured according to Ramsar guidelines, and published in April 2013 as the 'Strategic Management Plan for the Orange River Mouth Ramsar Site'. As a result, it is now considered a wetland management plan, and will need to be tweaked to meet the requirements of the National Estuary Management Protocol, gazetted in May 2013.

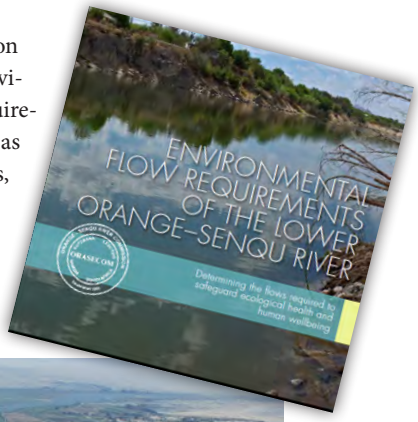
The management plan identifies a range of specific actions that should be undertaken to fulfil strategic goals and management objectives under institutional, ecological and socio-economic themes. The Northern Cape's Department of Environment and Nature Conservation (DENC) has been assigned responsibility for many of these, but its ability to implement them is largely contingent on the South African side of the Ramsar site being formally proclaimed a provincial nature reserve, in which case staff and a budget to manage it would be allocated. For some years it has been working towards this, and has already completed all the required documentation as well as a protected area management plan, but the change in land ownership and CPA representation caused what was hoped was a temporary setback.

The recent eruption of a turf war with the national Department of Environmental Affairs' Oceans and Coasts directorate, which has assumed responsibility for the estuary in accordance with the National Estuarine Management Protocol, has been a further disappointment. Management authority for the Ramsar site and responsibility for proclamation of the protected area now requires clarification. Importantly, South Africa's National Biodiversity Assessment 2011 recommends that the Orange River estuary is made a full (no-take) protected area, while the Namibian side of the estuary is bordered by the Tsau//Khaeb (Sperrgebiet) National Park.

In the short term, some of the actions identified in the strategic management plan will be undertaken by the Endangered Wildlife Trust. The NGO is the South African implementing partner for a three-year USAID-IUCN project called 'A water secure future for southern Africa: Applying the Ecosystem Approach in the Orange-Senqu basin', and in this final phase – due to end in May 2015 – has US$ 100 000 to spend on a demonstration project on ecosystem priority activities.

"We selected the Orange River mouth as our demonstration site after a consultation process with key stakeholders," says project leader and manager of EWT's Source to Sea programme, Bridget Corrigan. "We've had a field officer based there since September, and we're looking at what activities we can implement from the management plan. As a future objective, once the grant comes to an end, we hope to expand our involvement through our existing strong partnership with Conservation South Africa, which is already operational in the Namaqualand area."

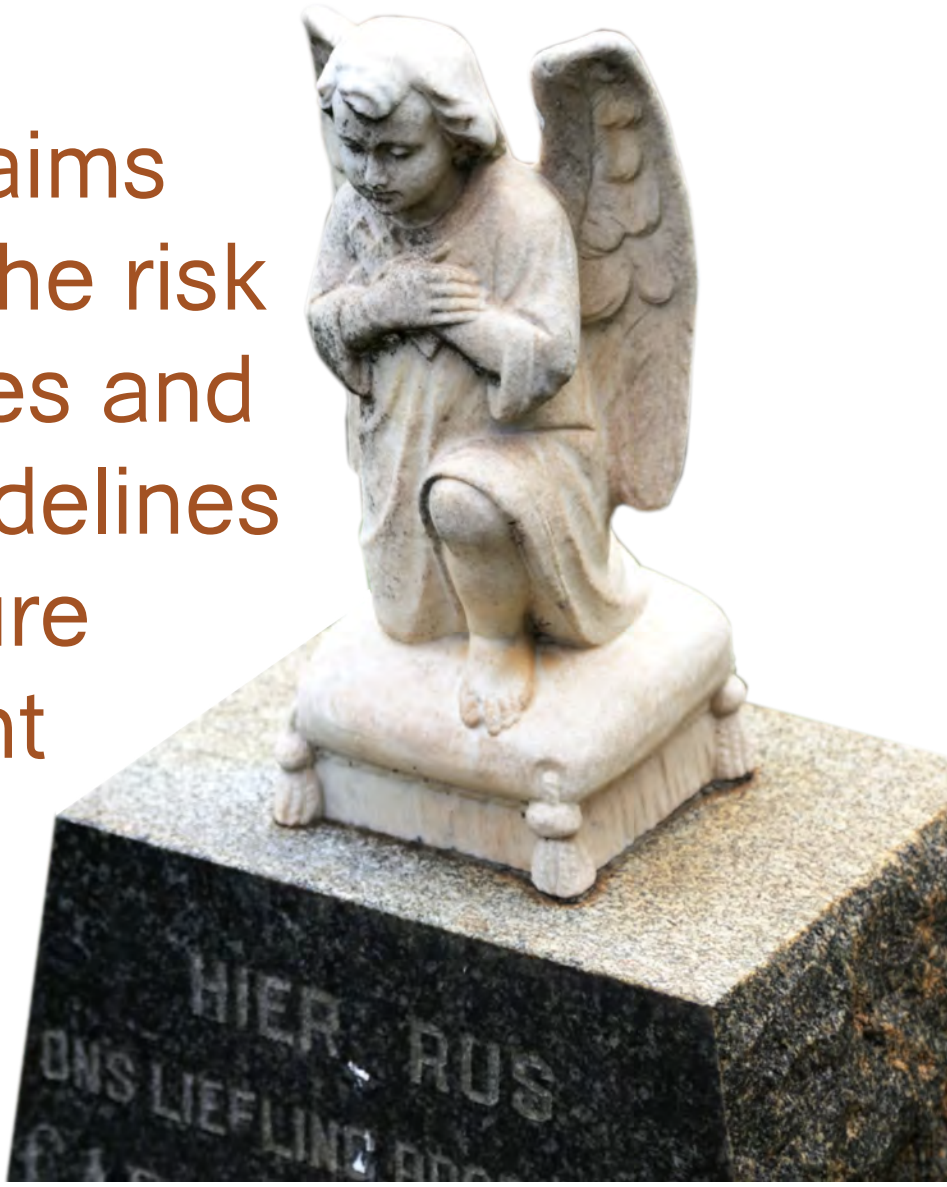
- A popular publication summarising the environmental flow requirements study, as well as the technical reports, can be accessed through http://undp.orasecom.org/resources-2/. ❑



Aubrey Withers

The Orange River estuary, situated at the South Africa-Namibia border, has been seriously impacted by changes to the river's flow regime, as well as developments associated with the mining towns of Alexander Bay and Oranjemund.

New study aims to quantify the risk of cemeteries and develop guidelines for their future development



Cemeteries have become much more than a place to bury the dead. They provide a space to remember loved ones and safeguard the stories of our past.

In the Braamfontein cemetery in Johannesburg, for example, you can see the dynamite explosion monument from 1896. It was erected in memory of 71 persons who died in an explosion at Braamfontein station on 19 February 1896. The cemetery also houses the memorial of Enoch Mankayi Sontonga, the composer of South Africa's national anthem. Valliammai and Nagappen, early martyrs of Mahatma Gandhi's passive resistance movement, are also buried here.

Today, cemeteries are also seen as opportunities to create green footprints within urban belts. For this, there's no lack of opportunity, as they have expanded exponentially as populations burgeoned and cities mushroomed.

The City of Cape Town manages 41 cemeteries, while Johannesburg City Parks takes care of 35, as well as two crematoria. In 2006, the Waterval Cemetery in Midrand opened – the first new burial ground in Johannesburg for nearly a quarter of a century. The 200 ha cemetery has space for 720 000 burials. Diepsloot Memorial Park opened in April 2007, providing much-needed space for 120 000 burials.

According to the City of Tshwane's mayoral spokesperson, Blessing Manale, "there are approximately 64 known cemeteries in the City of Tshwane." Of these, 33 are owned and directly managed by the city, while the remainder are managed and controlled by various stakeholders, such as tribal authorities, and others being informal and illegal.

In the North of the city, the Klipkruisfontein cemetery in Shoshanguve is under development, as is the 600 ha Tshwane North Cemetery in Hammanskraal, which will be the biggest cemetery in the City of Tshwane. It is being developed in stages over time, and burials are yet to commence. In terms of commissioned sites, the biggest in the City is the approximately 247 ha Zandfontein cemetery, which

currently hosts an estimated 59 635 burials. "The site still has vast open spaces that will in future be pegged into more graves," says Manale.

Except for these sites, Mabopane cemetery (in Mabopane), Heatherly cemetery (in Mamelodi/ Nellmapius), Ga-rankuwa cemetery and Centurion cemetery have been earmarked for expansion since there is available municipal land adjacent to them. According to Manale, "suitability studies for these sites are commencing in the current financial year."

Yet, the overall legacy left by cemeteries is being questioned, as is their impact on the environment or potential detrimental effect on human health has been given little thought when most were established. Of even more concern are burials in rural areas, or illegal burial grounds, where there is little or no control or monitoring.

While the topic might not have received plentiful attention in the public sphere in South Africa, the health hazards associated with burials were first recognised by British surgeon, Dr Alfred Walker, as early as the mid-19th century. Since then, the potential risk of cemeteries has become well documented, but the reality of the situation in South Africa is mostly unknown.

According to Dr Matthys Dippenaar, University of Pretoria (UP) Senior Lecturer for Hydrogeology and Engineering Geology, "the big problem is what we don't know." A 2010 report by the Department of Water Affairs describes cemeteries as 'low risk' but it could be worse in rural and peri-urban areas, where there is no regulation and people are dependent on extracting freshwater directly from its source, he says. "While it won't be a problem everywhere, it will be a problem somewhere, and we have to figure out how we can locate the high-risk areas."

Dr Dippenaar is the project leader of a new study that was recently approved for funding by the Water Research Commission (WRC). The project aim is to quantify the risk of cemeteries, and develop guidelines for new and existing burial grounds. The study will be conducted under the auspices of the UP. The holistic project will include researchers from numerous disciplines, says WRC Research Manager for Water Quality, Dr Jennifer Molwantwa. These include experts in the fields of water quality, health, environmental protection, hydrology, governance, society and regulation.

WHAT DO WE KNOW?

Early research warned of the danger of burying the dead near water sources, later establishing a clear link between water and cholera. It became widely established that groundwater could be contaminated by raw sewage and decaying bodies, after which new cemeteries were established outside city borders – a legal requirement throughout Europe and North America.

There is a host of potential contaminants that can seep from graveyards. This is not only limited to pollutants that emanate from decomposing bodies, but also from the material that they are buried in.

During the process of putrefaction of a human corpse, matter containing bacteria, viruses and organic and inorganic chemical products leach from it. Pathogens such as Anthrax and Smallpox viruses and TB bacteria are known to survive in soil and water. The fear is that certain pathogenic bacteria and viruses could filter into groundwater, spreading diseases.

A heavily ornate coffin could be seen as a sign of stature, but the damage it could do to the environment is nothing to be proud of. Varnished or painted, fitted with metal hinges and handles and treated with sealers and wood preservatives, a wide range of heavy metals and other potentially harmful compounds may be released from them. This includes lead, zinc, copper and steel. Substances such as arsenic mercury were used in past embalming and burial practises. Arsenate pentachlorophenol and formaldehyde, a carcinogen, are released from burial materials and embalming fluids.

"Any form of contamination of water resources can be a cause for concern," maintains Manale. "As it relates to burial sites or cemeteries, some form of

While specific project sites have not yet been identified, the project will look at cemeteries all over the country. This scenic resting place is located outside Garies, in the Northern Cape.

Petro Kotzé

pre-cautionary regulation has been put in place by the relevant environmental competent authorities who require an impact assessment to be conducted prior to commencing with burials on especially new sites. It is however, important to continuously monitor groundwater quality in and around existing cemetery sites, *albeit,* the residents in the City of Tshwane make use of reticulated municipal water supplies."

However, in South Africa, the legal guidelines that dictate where cemeteries should be located, were only published in 2004, and are not uniformly implemented across the country. "This is probably because cemeteries are seen as low risk," notes Dr Dippenaar. Furthermore, the guidelines are a standardised set of instructions such as the depth of the excavation and the distance that it must be located from a water source. Besides, most cemeteries were established before the guidelines were promulgated.

The first analysis of groundwater and surface water in and surrounding cemeteries were conducted in Australia by Dent in the late 1990s. He identified potential harmful elements from decaying bodies in the aquifers below cemeteries in diverse environmental settings and showed that rainfall played a major roll to transport these.

In fact, the risk of groundwater contamination through leachate from cemeteries is not uniform, and is influenced by a number of factors such as soil characteristics (type of soil, depth, pH, permeability and porosity); climate (rainfall and temperature);

"The overall legacy left by cemeteries is being questioned, as is their impact on the environment or potential detrimental effect on human health has been given little thought when most were established."

geology, the hydrological setting, and terrain features. In comparison, the most important factors in establishing cemeteries until relatively recently were that the soil had to be soft enough to dig in, the area's accessibility and the proximity of dwellings.

In South Africa, a 2012 study by Cornelia Jonker and Prof Jana Olivier investigated the mineral contamination of cemetery soils in Zandfontein Cemetery. They compared the mineral concentrations of soils within the cemetery to those off-site as well as those in zones with high burial loads with zones with fewer burials. They found that mineral concentrations of soils within the Zandfontein cemetery were considerably higher than those off-site. Soil samples in multiple burials blocks also had elevated metal concentrations. Yet, the researchers pointed out that the results do not necessarily reflect the situation at other cemeteries in Pretoria and surrounds. According to the final report, "the fact that this cemetery is located on the slopes of a mountain may cause leaching of minerals into groundwater and aggravate potential health risks."

Petro Kotzé

Issues around cemeteries do not include contamination, but also those that relate to burials where mechanical digging is not possible. In Taung, rocks are packed over bodies if a deep enough hole cannot be dug.

"It is important to continuously monitor groundwater quality in and around existing cemetery sites."

Consequently, Suzanne Toinette Janse van Rensburg investigated whether the soils of the Pretoria East and Silverton cemeteries are contaminated with heavy metals for her Honours degree. In this case, the results of collected soil samples in both cemeteries showed that the on-site and off-site metal concentrations were fairly similar. However, by closer scrutiny of the results at the Pretoria East cemetery, it became apparent that the contamination effects of the cemeteries might have been masked by slope.

The new study will now aim to identify those cemeteries that could constitute a hazard to human health and the environment in order for mitigation measure to be implemented. At the same time, it will also identify those that are correctly sited and that could be revitalized for recycling.

SETTING GUIDELINES FOR CEMETERIES

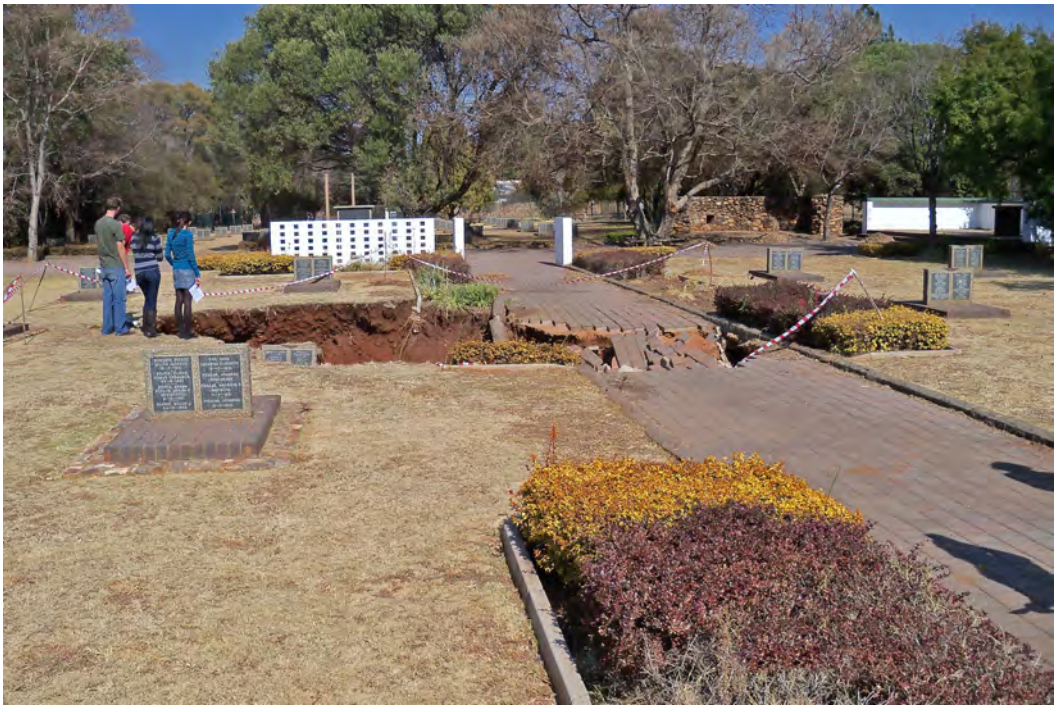
The study will run from April 2015, starting with research to create a screen of contaminants from typical sources such as decomposition, coffins and associated materials as well as fertilizers from landscaping practises.

"The goal is to integrate all disciplines already looking at the issue," says Dr Dippenaar. He adds that the worse-case scenario is that they will find contamination that could be detrimental to human health and the environment. In that case, they also have to find out if it is caused by the cemetery or industrialisation. "In order to do this, we want to identify a group of determinants that will indicate with reasonable certainty what the cause of the contamination is."

In addition, research will be conducted on cultural aspects of burials in the South African context in order to include cultural identity and heritage in the proposed guidelines. This is an "enormous" aspect, reports Dr Dippenaar. On the most basic level, this relates to the distance of people from the cemetery, particularly if they are not mobile, as well as the distance of the cemetery from water sources.

Specific study sites have not been identified yet, but they will be selected across country, and according to abiotic factors (geology, soil, geomorphology, climate and hydrology) in order to represent a wide variability and to allow for interpolation of results between sites.

"An urban cemetery such as the Pretoria East, which is located on shale, can perhaps be compared to a rural one in Temba that is also located on sedimentary rocks," says Dr Dippenaar. He explains that they can then work on a cemetery located on shale in an area with high rainfall and compare it to one in an area with a similar geology, but with low rainfall. "Maybe we can compare one in



Matthys Dippenaar,

At this cemetery in Irene another issue is clear, namely the formation of a sinkhole that is already an indication of concentrated water inflow in the sub-surface.

Johannesburg on granite with one in Limpopo on granite."

Further field work will include inspection of open graves for a thorough inspection of soils, sampling of soils from different horizons to determine the physical and mineralogical properties as well as surface infiltration and auger hole percolation tests to infer hydraulic parameters. Lastly, soil, surface water and groundwater will be sampled.

These finding will then be used to draw up the guidelines. "We want to add quantity to enable decision makers to quantify the risk." This will allow them to properly investigate all relevant aspects to ensure that the development is safe.

While monitoring and remediation is part of the project, the crux is the quantification of risk involved, in order for new cemeteries to be improved, notes Dr Dippenaar.

A WAY FORWARD

"Our hope is that we will at least educate people on what the risk is and how you can improve the risk assessment," he says. "Anything that we find will help."

The aim of the final product, which will be entitled *State of the Art Cemetery Guidelines* is to quantify the potential risk of an existing or new cemetery, and to provide guidelines on how to mitigate this. It will probably be produced in a scorecard fashion. "Our hope is that decision-makers will accept this as the best practise guidelines."

"As the implementation of the guidelines is out of our hands, it is critical to involve the South African Local Government Association." As such, the project deliverables include a knowledge transfer workshop to convey the research results to relevant stakeholders. According to Dr Molwantwa, "The findings will be most useful for local government, as the results will empower decision-makers to identify the most suitable local areas for cemeteries."

Dr Dippenaar adds that from a research perspective the project is an interesting opportunity to investigate the influence of surface material disruption on the vadose zone. The hope is that this will also create the opportunity for high-profile science research projects for Masters Students.

Dr Dippenaar is adamant that the idea is not to scare people away from cemeteries or burials. However, it is important for the public to realise that any land use has an impact. Even in death. ❑

Petro Kotzé

Research at Silverton cemetery, in Pretoria, shows that there is little difference between the metal concentrations of soil inside the property and samples taken outside the fence.

Petro Kotzé

***Top left:** Cemeteries are a place to remember and pay homage to those who have passed.*

***Left:** Today, cemeteries are also seen as opportunities to create green belts in urban environments.*

WATER Kidz

LET'S TALK ABOUT SOIL

It takes hundreds of years to grow just a tiny bit of soil!

We run on it, play in it, and plant things in it. But do we really think twice about it? Yes, I am talking about dirt or soil.

The world thinks soil is so important that they have dedicated a whole year to it. Yes 2015 will for ever be known as the International Year of Soils. On 5 December we also celebrated World Soil Day.

So what is soil anyway? Soil is like a cake made from lots of different things. Soil consists of crumbling rock or sand, clay, dead plant and animal remains, fungi and even manure. It also contains lots of tiny creatures, so many in fact that soil is called 'home' by a quarter of the world's plant and animal life. Just one shovel full of soil has more living things in it than all the humans ever born. Soil also holds 0.01% of the Earth's water.

DID YOU KNOW?

A scientists who studies soil is called a pedologist.

Not all dirt is the same. If you cut into the soil you will see many layers. This is called a soil profile. The top layer of soil is called the surface litter layer. This is where all the 'litter' of any ecosystem lies, such as leaves, branches, animal waste, and mushrooms.

The next layer down is called the topsoil layer or humus. This layer is made up of rotting organic matter from the litter layer and minerals from rocks that are weathering and breaking down over time into little bits. The rotting organic matter helps the soil hold water so it is good for growing plants.

The next layer down is called the subsoil, and is made up of crumbling rock, sand, clay, gravel and silt. Then below that is the parent material, which is the actual bedrock underlying all the soil layers.

Soil influences many areas of our lives. It is an important part of our ecosystem. Whatever soil is made up of (called the composition of the soil) has a direct effect on the plant and animal life there. Think, for example, about sand in a desert compared to the soils in a rainforest.

Important for that other scarce resource, water, is that soil is a natural filter and regulator of water flow. One of the key functions of soil is to act as a natural purification system (many modern water treatment plants use sand filtration systems as part of the water purification process, for example). Over time soil has the ability to filter, absorb and transform substances. Polluting substances can become trapped in the soil, therefore preventing them from reaching clean water supplies.

Soil is also a key regulator of water flow. Soil can absorb much of the rain that falls on it, but the amount varies according to texture, structure, organic matter content and vegetation cover. Well-structured loamy soil under grass or woodland acts like a sponge and can absorb as much as 40% of its volume as water. Soil also acts like a tap, turning water flow on and off by storing and releasing water for plants when needed.

People designing cities and towns now realise that covering soil with materials such as concrete and asphalt can make floods worse as it reduces the soil needed to absorb the water. When this happens more water

ADDITIONAL RESOURCES

- Visit the website for the International Year of Soils, www.fao.org/soils-2015/en/
- Watch a video on the importance of soil, https://www.youtube.com/watch?v=YdBpLfhuZuk
- Africa has its own soil atlas, Visit: http://eusoils.jrc.ec.europa.eu/library/maps/africa_atlas/

World Soil Day organism poster

will flow over the land, causing floods and possible damage to infrastructure.

Virtually all the food crops grown on Earth are planted in the soil, as well as all the fodder for livestock. Even some of the fibre crops we need to clothe us need soil. Think of cotton, for example. We also need soil for the trees that produce or paper. And what would a good game of rugby or soccer be without a nice sports field?

It takes a very long time for the Earth to create soil. In fact, it takes more than 500 years to form just two centimetres of topsoil. This makes soil a very precious resource. We should value it. Damage to the soil can disturb nature's balance and prove a threat to life.

A big problem in many areas of South Africa is soil erosion. When a raindrop hits soil that is not protected by a cover of vegetation and where there are no roots to bind the soil, it has the impact of a bullet. Soil particles are loosened, washed down the slope of the land and either end up in the valley or are washed away by streams and rivers.

Erosion removes the topsoil first. Once this nutrient-rich layer is gone, few plants will grow in the soil again. Without soil and plants the land becomes desert-like and unable to support life. Erosion occurs

The soil is full of living things, such as earthworms.

when we overstock or overgraze land by animals such as cows and goats; use inappropriate farming techniques, and plant crops down the contour instead of along it.

Soil around our homes can get polluted by fluids from leaky vehicles, pet waste, pesticides, or leftover household chemicals that are poured or spilled. When the soil is contaminated, storm water can move the pollutants along into washes and the wastewater system, causing problems in the environment and at wastewater treatment facilities.

There are various ways in which you can help protect soil. Start composting! This puts nutrients back into the soil and makes it healthier. Make sure you keep the soil healthy by not pouring leftover or used chemicals or oils on it. Help your parents in the garden by pulling up weeds. This reduces the needs to use harmful chemicals on the plants. ❑

Soil is crucial for growing plants.

DO-IT-YOURSELF SOIL DISCOVERY

For this experiment, you will need:
A waterproof table covering
A jar with a lid
A spoon
Some soil
A jug of water
Paper towels
A magnifying glass

Cover your work surface. Fill a jar halfway with soil. Add water nearly to the top of the jar. Put the lid on, and tighten it securely.

Shake the jar vigorously for half a minute, and then set it down. Let the jar stand until the soil and water settle. The soil will settle into layers.

Observe the layers in the jar, and see what you can tell about them. How many layers are there? Which layer is made of the biggest particles? Which is made of the smallest? Can you guess why?

To further examine the different layers and what they are made of, you can sort out the soil materials and examine them. Use a spoon to skim off the objects floating in the water. Place them on a paper towel.

Then carefully pour off the water on the top and scoop out the grains of the next level onto another paper towel. So the same if there is another level.

After each layer has been placed onto towels, they can be examined with the magnifying glass. What else can you tell about the different layers after further examination?

Source: For this and other soil experiments, Visit: http://www.howstuffworks.com/crafts/other-arts-crafts/science-projects-for-kids-soil-experiments.htm

Celebrating the role of water and sanitation research in SA's democracy

On 26 November 2014 the Water Research Commission (WRC) launched its latest special publication, *South Africa's 20-year Journey in Water and Sanitation Research*. The book intertwines the country's journey since democracy with the journey and developments in water research and democracy. It also presents a story of scientific transformation.

In a message read by Department of Water and Sanitation (DWS) Ministerial Advisor, Dr Thele Moema, at the event Minister Nomvula Mokonyane said that the 'treasure' of the South African water sector was the water science and technology community led by the WRC. "The science brothers and sisters in this water family have grown the science and technology base, and have ensured that in these 20 years of our democracy we have become a global player of note." The audience also heard reflections from long-time WRC researcher, Prof Graham Jewitt of the University of KwaZulu-Natal (UKZN), former WRC Research Manager, Dr Nozi Mjoli and WRC-supported student, Tercia Strydom of South African National Parks (SanParks).

WRC CEO, Dhesigen Naidoo, on the podium.

Learner, Aneeq Naidoo, WRC Executive Manager Eiman Karar, WRC Executive Manager, Dr Inga Jacobs-Mata and independent consultant, Dr Nozi Mjoli.

Former WRC Research Manager, Dr Nozi Mjoli, reflected on her experiences as the Commission's first black woman in a managerial position.

Independent consultant, Dr Marlene van der Merwe-Botha with DWS DDG Anil Singh.

Dhesigen Naidoo (WRC), Prof Graham Jewitt (UKZN), Dr Thele Moema (DWS), Aneeq Naidoo (learner), Tercia Strydom (SanParks), Lani van Vuuren (WRC), Anil Singh (DWS) and Dr Inga Jacobs-Mata (WRC).

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The Water Reasearch Commission 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 South African communities, reducing inequality and growing our economy while safeguarding our natural resources. The WRC supports sustainable development through research funding, knowledge creation and dissemination.

The knowledge generated by the by the WRC generates new products and services for economic development, it informs policy and decision making, it provides sustainable development solutions, it contributes to transformation and redress, it empowers communities and it leads various dialogues in the water and science sectors.

The WRC Vision is to have highly informed water decision-making through science and technology at all levels, in all stakeholder groups, and innovative water solutions through research and development for South Africa, Africa and the world.

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