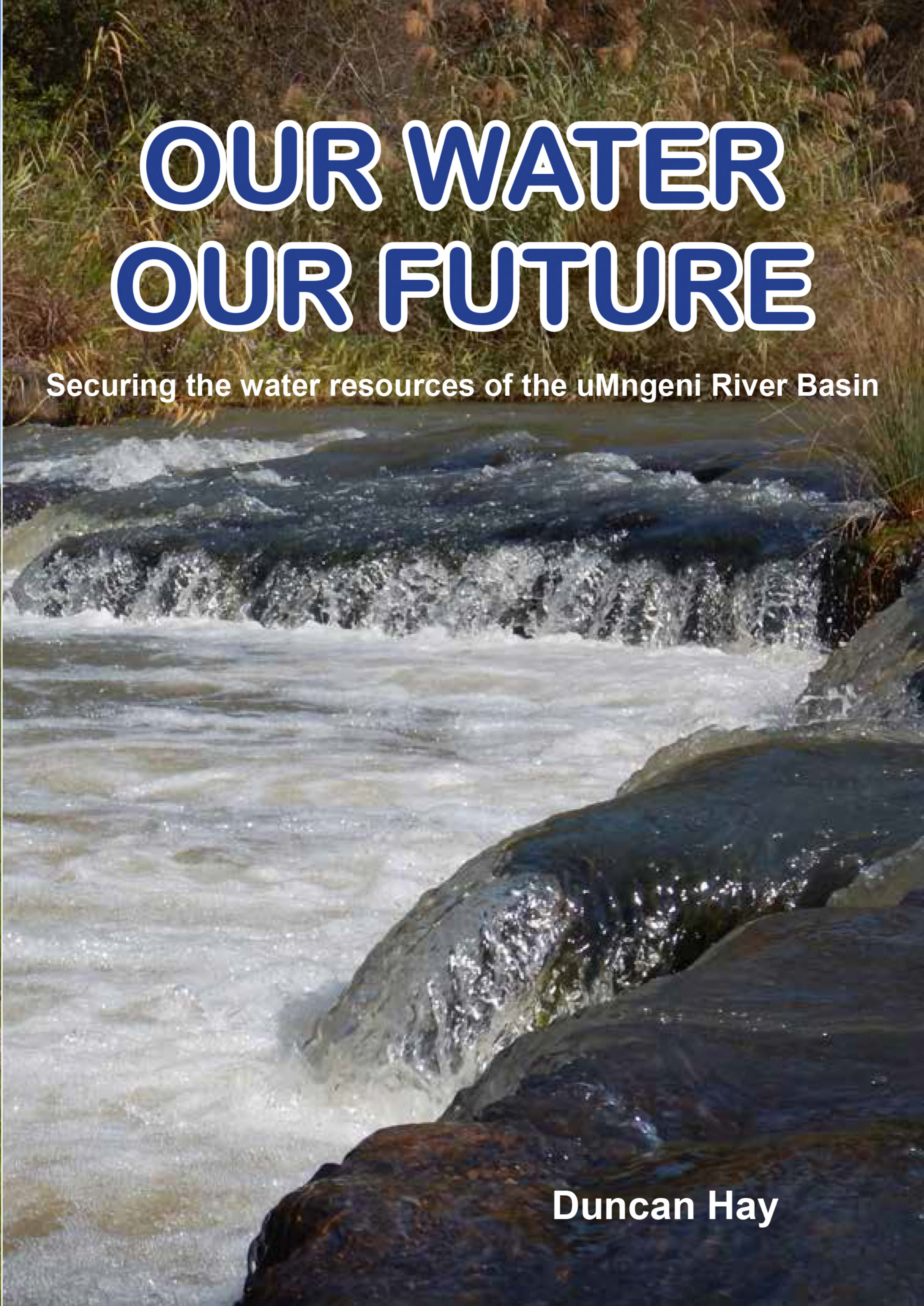
OUR WATER OUR FUTURE

Securing the water resources of the uMngeni River Basin



Duncan Hay

Contents

An electronic version of this handbook can be downloaded from:
http://inr.org.za/wp-content/uploads/2014/06/uMngeni-Handbook.pdf .

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Onward dissemination is encouraged.

August 2017

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Cover photographs: Duncan Hay

Midmar Dam wall **Duncan Hay**

Preface

I have an intense personal and professional interest in the uMngeni River Basin. It is where I live, work and play. In 2015, as part of a field trip, we were viewing Midmar Dam and being addressed by a technical manager of the dam. He explained that Midmar was fed by the uMngeni River which has its headwaters in the Drakensberg Mountains! I was concerned at how little he knew but soon discovered that this was pervasive. Very few people, including myself, had a good understanding of the uMngeni River Basin – its hydrology, ecology, people, management and governance. I was also concerned that numerous post-graduate researchers were studying aspects of catchment processes without a broad understanding of the entire river basin.

In the context of our work as part of the International Water Security Network I decided to do something about it – to provide a general overview of the river basin and the issues facing it. The result is this handbook. I have tried to keep it as non-technical and 'non-academic' as possible – so that anyone with an average education can pick it up and read it in about an hour, and understand the main points. I have expressed opinions with which some might disagree. That is fine as it is through disagreement and contestation that we learn.

So as not to disrupt the flow of the narrative I have not used conventional referencing. What I have done is provide a list of select references at the end. These are all online so are easily accessible.

Enjoy.

Duncan Hay
August 2017

Some background

It is a simple fact – without water we die .....

Introduction: our water resources as an enabler

It is a simple fact – without water we die – it takes a week or less depending on conditions. So, water is an enabler at the most fundamental level – it enables life. Together with air, food, shelter and our ingenuity, water provides the foundation for us to live satisfying and productive lives.

By way of an example, off the coast of Turkey is an island, Gemiler Adasi. It contains the ruins of five Byzantine churches built from the fourth to the sixth century AD. The island is not only a monument to religion; it is also a monument to water conservation. The island was and remains arid with no springs, streams and rivers. But, through human ingenuity almost every building and walkway was designed in such a way as to channel rainwater into underground cisterns for storage and later use. This enabled ecclesiastical communities to thrive there for centuries. They were driven off the island by war, not a lack of water.

In the same way but on a different and much greater scale development of the water resources of the uMngeni River Basin enables six million people to live and prosper. It also serves South Africa's third largest regional economy which contributes 11% or about R 460 billion to national GDP. In South Africa, which has a low and erratic rainfall, our relatively abundant local water resources are our competitive advantage. Almost everyone in the basin has access to water for domestic and industrial use. It allows our fairly thirsty agricultural sector

The Byzantine ruins on Gemiler Adasi **Unknown**

to thrive, most notably dairy, beef, poultry, pork, sugar cane, and commercial timber flourishes. Conservation efforts are centred on the river system – uMngeni Vlei, uMngeni Valley Nature Reserve, Fountain Hill, Cumberland – and the various nature reserves around our dams. Finally, education, sport, recreation, tourism and spiritual practices are all enabled by these water resources.

Despite the relative abundance of our water resources we are discovering just how vulnerable our system is – by the system we mean the catchment and its people. The recent drought has exposed the fragility and inadequacies of our engineered infrastructure, our green infrastructure, and our governance and management systems. Everywhere we look we see declining and deteriorating conditions and, in some instances, desperation and despair.

In order to ensure a sustainable future for ourselves and our river basin we know that it cannot be 'business as usual'. The 'business as usual' approach – rapid development and a focus on dam construction to supply more water to more people – might have served us well in the past but it is now a contributing cause of the vulnerability we encounter. If we want to become more resilient we now need to think differently and act differently.

The purpose of this handbook is to introduce the uMngeni River Basin in a water resource management context. It is designed to inform anyone with a general interest. It describes briefly our water resources; provides a summary of water resource development; explains how water is governed and managed; identifies some of the key issues affecting the health of the river basin, and suggests some ways in which we might address these issues. Overall it encourages us to think a little differently and hopefully a little more holistically about the governance and management of this precious resource.

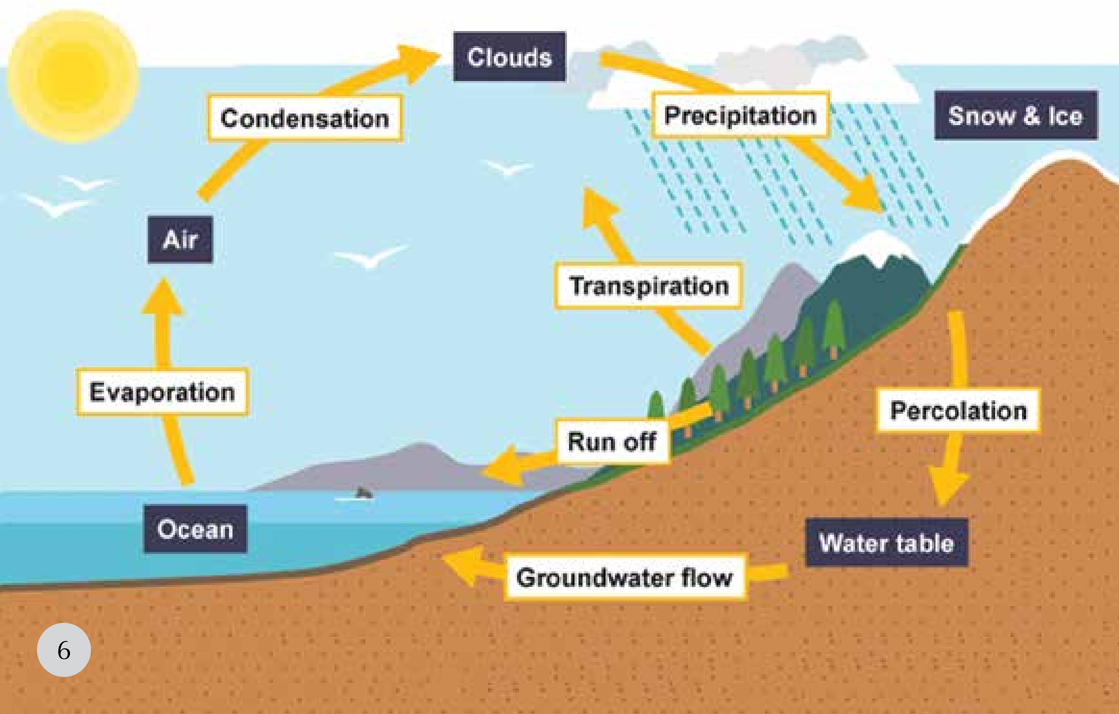
What are our water resources?

Our water resources are not only the water that flows from a tap. They include our wetlands, riparian areas, underground aquifers and estuaries. And, because our soils, grasslands and indigenous forests play a critical role in purifying water and regulating its flow we cannot engage in water resource management without considering the entire catchment and its ecological processes – we need to consider the entire landscape. And we cannot engage in water resource management if we don't understand and appreciate the effect our activities have on the catchment. So, our unit of governance and management is the social and ecological system that is the uMngeni River Basin.

A good starting point is to understand how water flows, who uses it, how it is used, and what affects this use. Where does our freshwater come from? Below is an illustration of the hydrological cycle. Our freshwater evaporates from the sea, condenses and forms clouds and precipitates as rain, snow or hail. Then it either evaporates or is transpired back into the atmosphere, or percolates into groundwater or runs off as surface flow.

The uMngeni River Basin covers an area of 4 440 km^2 and has an average annual rainfall of a little under 1000mm. That means that, theoretically, rainfall

The hydrological cycle



Midmar Dam stores 245 million cubic metres of water   Graham Jewitt

provides about 4 billion cubic metres of water for us to work with. The reality is a bit different. Most of this rainfall evaporates directly and is lost to us. Much of what reaches the soil is taken up by plants and transpired back into the atmosphere. Practically, we do access and use some of this water as it is the basis for our rain-fed agriculture, primarily timber, sugar cane and pastures. Some of this passes through into subterranean aquifers becoming what is termed ground-water. The balance passes over or through the soil into rivers, streams and wetlands. This we measure as Mean Annual Run-off (MAR).

The average MAR for the uMngeni is 674 million cubic metres which constitutes about 15% of total annual rainfall. If we add the MAR of about 400 million cubic metres from the Mooi River upstream of Spring Grove Dam and Mearns Weir (a transfer scheme across to the uMngeni that we discuss later) we have 1074 million cubic metres of total available water. The uMngeni is a short river, and the rainfall is highly seasonal and erratic. This means we have to optimise storage for dry seasons and drought. The overall dam storage capacity (including Spring Grove Dam) is about 940 million cubic metres and excluding Spring Grove Dam about 800 million cubic metres.

But our dams are not the most important water storage areas; our soil in the river basin has the potential to store 1 642 million cubic metres, nearly double the holding capacity of our dams. The better soil is conserved the more water it can store which provides a compelling argument as to why we need comprehensive soil conservation.

Licensed ground-water use from boreholes in the basin is about 1.5 million cubic meters per annum. This is probably an under-estimate as not all water use from boreholes requires that one registers as a water user. Even if it is an underestimate, groundwater use currently constitutes a very small proportion of the basin's overall water budget.

Focusing on the surface water let's take a journey down the uMngeni River from source to sea. We start out at uMngeni Vlei, a protected conservation area and important wetland. Here the water supports society's conservation aspirations, and sustains the wetland and its associated life-forms. It also performs an agricultural function supplying water to the cattle that graze seasonally in and around the wetland. The water then flows downstream where it encounters a large dam surrounded by holiday cottages. Here it supports mainly recreational and aesthetic use – boating, fishing, bird-watching, and relaxing – and there is some additional stock watering.

Leaving the dam, passing through additional wetlands and cascading down the escarpment the uMngeni enters commercial agriculture territory where water is abstracted for crop and pasture irrigation and stock-watering. Some of it evaporates, some enjoys productive use and is transpired, and much of the balance flows back into the river system. The water then reaches Midmar Dam, the primary source of domestic and industrial water for the Midlands, Pietermaritzburg and parts of Durban.

Midmar also has an important recreational function hosting swimming, boating, sailing, fishing and canoeing activities. Assuming the water flows from Midmar to Pietermaritzburg it is piped to a water treatment works and then on to homes and businesses. If it reaches a home some might be used to irrigate a garden then evaporate and transpire or flow back into a river or stream, or it might be used in the home, proceed from there into the sewage system

Canoeing – an important recreational activity **Duncan Hay**

and onto a waste-water treatment works. Here it is treated and flows into the Msunduzi River, a tributary of the uMngeni. Flowing down the Msunduzi and subsequently back into the uMngeni it might be used directly from the river for domestic, irrigation, recreational (canoeing) and spiritual purposes. From the uMngeni it flows onward into Inanda Dam. From Inanda Dam it might flow downstream to where it meets the sea in Durban. Alternately it might end up supplying the south-Durban Industrial Basin where it is used and recycled several times (there is a water recycling facility servicing the industrial area) before entering a waste water works, then an estuary and finally the sea.

Two critical and linked points to note are firstly that the same water can be used numerous times by different users as it flows down the river – it is a renewable resource supplying numerous and diverse benefits to numerous and diverse users. Second, water is purified every time it re-enters the natural system – pathogens die as they are exposed to sunlight, nutrients are used or removed and pollutants are processed. The wetlands, streams and rivers act as a very efficient waste water works at no or little cost to us.

So, rainfall is seasonal and erratic, water can be used multiple times while it flows through the system, a large proportion of water that has been used flows back into the system and subterranean borehole water can become part of surface flows. Add to this an inter-basin transfer augmenting the supply of water into the uMngeni River Basin and that, through reticulation systems downstream, water in one catchment can end up as waste water in another catchment, then one can imagine that trying to develop a water budget for the river basin is a little difficult. But we can identify and quantify some of the major uses and users:

- Umgeni Water processes and supplies about 400 million cubic metres of water annually from the uMngeni system and supplies it on to several water service authorities. eThekwini, Ugu and iLembe municipalities combined use about 78% of this, Msunduzi Municipality (Pietermaritzburg area) 14.2% and uMgungundlovu 7.8%.

- Over a period of six months (April – September 2016) about 64 million cubic meters of water was transferred from the Mooi River system to the uMngeni to supplement supply during drought conditions.

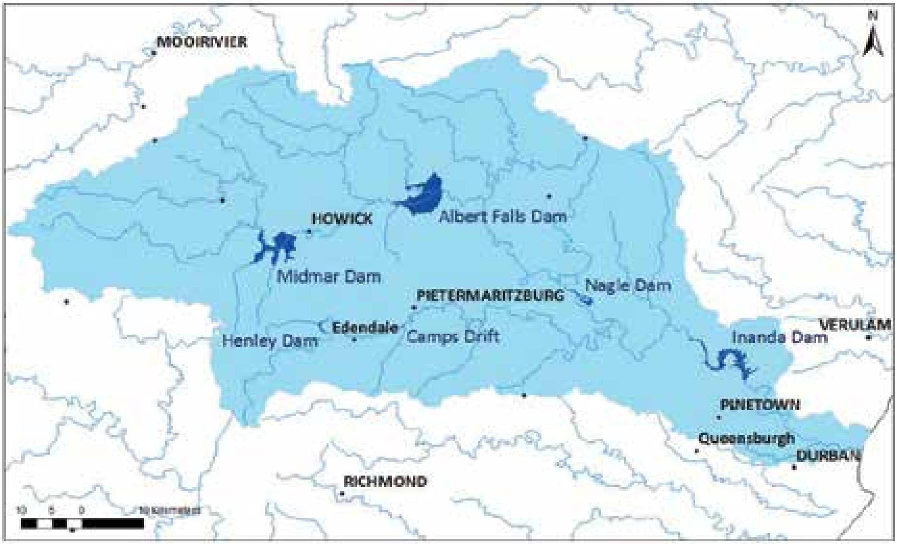
- The area under commercial forestry plantation in the basin is 88 000 hectares. These plantations reduce streamflow by approximately 64 million cubic metres per annum.

- Alien invasive wattle trees in the catchment are estimated to consume 7.2 million cubic metres of water over and above what would have been consumed by natural vegetation. This might not seem like much relative to the 400 million cubic metres processed by Umgeni Water but, during a drought, small amounts become critically important and it equates to the annual water requirements of 100 000 people.

- Formal water licensing for irrigation purposes indicates that farmers are entitled to abstract about 58 million cubic metres per annum from the rivers, streams and dams.

Removing invasive wattles greatly increases water yield **Andrew Fowler**

A brief history of water resource development



uMngeni River Basin illustrating dam development **DWS**

Water resource development in the uMngeni River Basin has focused primarily on dam construction and the linked establishment of water delivery infrastructure.

The first substantial dam to be built was Henley upstream of Pietermaritzburg. It was completed in about 1943 and its wall was lowered for dam safety reasons following the 1987 floods. It was decommissioned in 1996. Henley was followed by Nagle Dam constructed in 1948. It was specifically located on the uMngeni River at a point which allowed water to flow from it by gravity to Durban. Midmar Dam, upstream of Howick Falls, was completed in 1965 and its wall was raised in 2004. Its location also allows flow by gravity to Pietermaritzburg and Durban. Albert Falls Dam, downstream of Howick Falls, was completed in 1976. It feeds water via the uMngeni River to Nagle Dam which now acts primarily as a balancing reservoir rather than a storage dam.
Inanda Dam, which is located downstream of the confluence of the uMngeni and Msunduzi Rivers and supplies water to Durban and the North Coast, was commissioned in 1989. In 1983, during extreme drought and as an emergency measure, Mearns Weir was built on the Mooi upstream of the village of Mooi

River and water was supplied via a transfer scheme to the Mpofana Stream, a tributary of the uMngeni. This system has been used on a regular basis ever since and the weir was raised from 2m to 8m in 2003. A little upstream of Mearns Weir, Spring Grove Dam and an associated transfer scheme were commissioned in April 2016.

Future augmentation of supply is in the advanced planning stage. Smithfield Dam will likely be built on the Umkhomazi River upstream of Richmond and supply water via a transfer scheme to a tributary of the uMngeni.

The capacity of the currently existing storage dams is as follows:

Dam	Capacity in $metres^3$
Spring Grove	140 million
Midmar	235 million
Albert Falls	290 million
Nagle	25 million
Inanda	252 million
Total	942 million

Rapid urbanisation occurs in the basin **eThekwini**

The River Basin – some demographics

Two municipalities constitute the major portion of the river basin - eThekwini Metropolitan Municipality towards the coast with a population of about 3.45 million people and, inland, the uMgungundlovu District Municipality with a population just over 1 million. Almost the entire population, as well as coastal residents to the north and south of eThekwini, are dependent on the water resources of this river basin for their well-being.

Census data for uMgungundlovu from 2011 allows us to define the socio-economic character of the upper river basin, the main source of water resources, fairly accurately. Average annual household income is about R 90 000 per annum which is relatively high by South African standards. The vast majority of people live well above absolute poverty levels. There are, however, significant disparities between rich and poor and there are pockets of poverty, particularly in informal urban settlements and rural communal areas.

There is a very strong urbanisation trend where rural local municipalities reflect declining populations and urban municipalities reflect rapidly increasing populations. 90% of households have access to a reticulated water supply but only 42% have water piped into their homes. Linked to this, 42% of households have water-borne sewage. 86% of households have access to electricity while household refuse collection takes place at less than 50% of homes. 30% of residents are unemployed. Government and Agriculture are the lead employment sectors in uMgungundlovu.

In terms of land-use, about 50% of land in the municipality has been transformed for residential, commercial, industrial and agricultural use.

How are our water resources governed?

Because of the way water resources connect and are connected to everything else water is everyone's business – from the individual, to the business sector, to all spheres of government. Everyone is in some way involved in water resource governance and management.

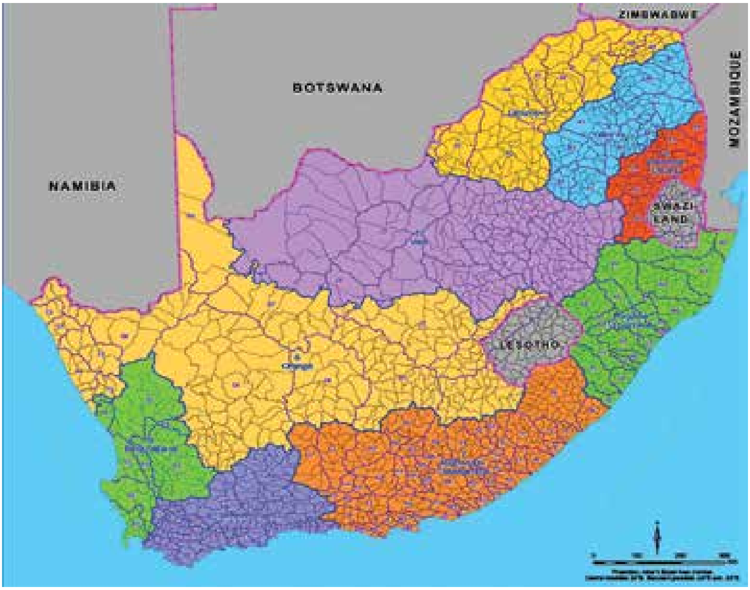
Constitutionally, South Africa's water resources are governed by the National Water Act of 1998. This Act effectively ended the era of private water rights making the state, and specifically the Department of Water and Sanitation, the custodian of our water resources. In the Act there is provision for only one right, commonly termed the 'Reserve'. This is the water required for basic human needs and to ensure continued ecosystem functioning.

Beyond this there are four types of authorised use:

- **Schedule 1** uses which are small volumes of water for household use only – no license required
- **General Authorisations** which are larger volumes of water that are generally authorised for a specific type of water use such as small-scale irrigation systems and stock watering – no license required
- **Existing Lawful Use** allows water use that was lawfully used before the Act came into effect to continue until it can be converted into a licence.
- **Licensed Water Use** which are licenses issued under the Act – usually large scale irrigation or industrial users; commercial timber production as a stream-flow reduction activity also requires such a license.

Any activities or infrastructure that alter the flow of a river or stream (dams, bridges, weirs and others) require prior approval as does development within prescribed distances of wetlands, water courses and estuaries. The discharge of any substances (treated sewage, agricultural and industrial effluent discharges) also requires prior approval.

Administratively, South Africa is divided into nine catchment management agencies (CMAs) and a number of water management areas. The uMngeni falls within the Pongola-Umzimkulu CMA which essentially covers all of KwaZulu-Natal and within the Umvoti to Umzimkulu Water Management Area. The CMA is currently in the process of being established. Resource quality objectives have been established and river reaches have been assigned classes for the water management area.



South Africa's Water Management Areas **DWS**

In terms of technical and administrative aspects of water resource management in the uMngeni River Basin, the national Department of Water and Sanitation is the regulator and planner. Large scale infrastructure development is implemented by the water utility, Umgeni Water, or TCTA (a state-owned entity that finances and delivers bulk raw water infrastructure). Those users who are abstracting large quantities of water from the system do so under the licensing system described above. Umgeni Water is one of these licensed users and abstracts water from the various dams in consultation with the Department. It supplies water to the various water service authorities: Msunduzi Local Municipality; uMgungundlovu, ILembe and Ugu District Municipalities, and eThekwini Metropolitan Municipality. These water service authorities supply domestic, business and industrial users within their areas of jurisdiction. Umgeni Water is increasingly taking on the role of waste water manager on behalf of the water service authorities in the upper catchment.

Because land-use directly affects the quantity and quality of water resources, ownership and control of land is central to the governance and management of water resources. The top three land managers/owners in the river basin are commercial agriculture, commercial forestry plantations and local/district municipality managed urban and peri-urban areas. There is also rapidly urbanising communal land in the upper Msunduzi catchment and in the area surrounding the confluence of the Msunduzi and uMngeni Rivers.

What are our key water resource management challenges?

The uMngeni River Basin faces significant water resource management challenges. The more important are highlighted below. It needs to be stressed that most of these challenges are not isolated from one another but usually work in concert to amplify problems.

Climate Change

Climate change is here and it is now. What changes are we observing and predicting? The uMngeni River Basin is getting warmer and wetter, and is subjected to increased variability and extreme weather events – more floods and more droughts, and more hail, wind and snow. The knock-on effects of this are considerable. Increased temperatures impose stress on people, livestock and wildlife; it influences the distribution of fauna and flora and it encourages the proliferation of certain alien invasive plants. While there might be more rainfall available for storage, increased evaporation caused by increased temperatures reduces the effectiveness of dams as water storage facilities.

The general consensus is that even though rainfall is increasing the overall quantity and quality of freshwater is diminishing. However, the overall availability is of less concern; of greater concern is the increasingly erratic nature of supply. Prolonged drought, similar to that recently experienced (2014 – 2016), impacts severely on society, our economy and our ecosystem. Drought also enhance the likelihood of wild fires. Agricultural production with its considerable reliance on rainfall and irrigation is affected most – crop and livestock failures will happen. More floods of greater intensity increase soil erosion and run-off of polluted water from both agricultural and urban landscapes. They also impact on a variety of engineered infrastructure – roads, railways, bridges, dams, water and sewerage reticulation, houses, businesses and electricity – the

Climate change has caused severe drought recently **Jon McCosh**

human and economic costs are considerable.

The increased incidence and severity of hail has a direct impact on crops and infrastructure, and on the insurance sector which then passes on costs to the insured.

Over and above all of this, one of the greatest impacts that climate change has is the challenge of increased uncertainty and complexity it brings to our governance and management systems. If we take the reasonable risks that might be associated with the challenges described below, and then add risks associated with climate change, the compounded risk might be catastrophic.

Poorly maintained engineered infrastructure

A large proportion of our reticulation and processing systems – freshwater, sewage and storm-water – are inadequately designed, old, poorly built and/or poorly maintained.

First, considering freshwater reticulation; as mentioned, Umgeni Water supplies about 400 million cubic metres of water annually from the uMngeni system to about 6 million people. This translates into about 200 litres per person per day. This should be enough to go around. However, wastage of this processed potable water is unacceptably high. Wastage can take a number of forms: direct leaks from pipes or unbilled authorised consumption or illegal

Some water leaks have existed for many years **Ian Carbutt**

consumption and metering inaccuracies. These combined losses are referred to as Non-Revenue Water (NRW). For eThekwini this constitutes 40% of which direct leaks account for 30%; for Msunduzi the total is 45% with leaks accounting for 20% and in uMgungundlovu the total is 61% of which about 30% constitutes leaks!

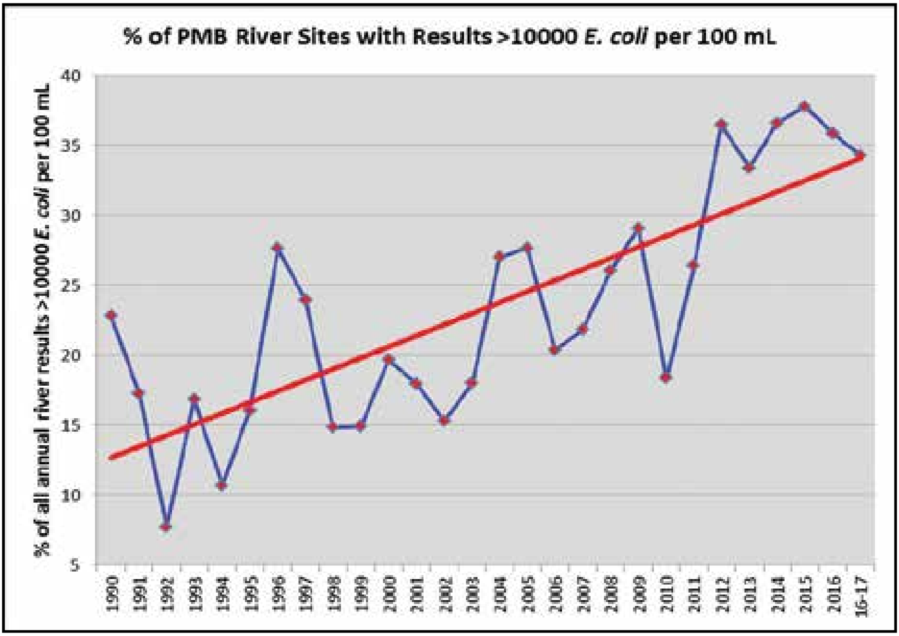
Without going into detail the bottom-line is that we are losing more water and revenue equivalents from failing municipal infrastructure and services than is being used by irrigated agriculture and commercial forestry combined. If we value the water at what it costs the water service authorities, about R 6 per cubic metre, and set the overall loss at 40% then we are wasting R 960 million annually. If we value the water at a municipal sale price of about R 20 per cubic metre we are wasting R 3.2 billion!

As was mentioned earlier, from April to September 2016, 64 million cubic metres of water was transferred from the Mooi River system into the uMngeni system to supplement supply. The calculated loss by leakage of the three water service authorities over the same period was 46-56 million cubic metres. To a large extent all that Spring Grove Dam is doing is compensating for leaks from municipal infrastructure.

Our sewage systems are in a state of decay and both large waste water works in the upper catchment (Howick and Pietermaritzburg) currently cannot cope with what is generated. Fortunately, the new waste water works for Pietermaritzburg should be fully commissioned in 2017 and construction of a new facility at Mpophomeni to reduce the pressure on Howick is being commissioned. But, importantly, much of the sewage generated is not reaching the various waste water works. Instead it flows out of broken sewers into our streams and rivers.

The Msunduzi River has become Pietermaritzburg's informal waste water works as the graph overleaf so vividly illustrates. At Mpophomeni raw sewage is flowing directly into Midmar Dam, arguably the most important water storage facility in KZN. A little downstream of the Howick Falls we have what is aptly described as the highest 'shitfall' in the world – partially treated sewage from the Howick wastewater treatment works cascades down the gorge directly into the uMngeni River. One can view the abrupt change in river water colour on Google Earth!

While gastro-intestinal pathogens present major health risks it is likely that the increased nutrient loads are of greater concern. Problems are compounded because it is not only sewage that enters the sewers. Industrial waste,



Pollution levels in the Msunduzi River are increasing **Umgeni Water**

comprising both organic and inorganic pollutants, is discharged into sewers and then escapes into our rivers and streams.

Finally, our stormwater systems: many have deteriorated to the point where, instead of discharging into rivers and streams they discharge directly into sewers. These, then overflow or leak and flow into rivers and streams. So every rainfall event, instead of diluting impact, compounds it.

What the impact of reduced water quality on human health might be is uncertain. A survey of Dusi Canoe Marathon paddlers immediately after the 2016 marathon indicated that 40% of the field contracted mild to severe gastro-intestinal infections. This is not surprising as paddlers were subjected to elevated pathogen levels on all three days of the race. Some experienced paddlers take antibiotic medication as a prophylaxis in anticipation of poor water quality.

Land transformation

Nearly 50% of the land of the uMgungundlovu District Municipality, which accounts for all the upper uMngeni River Basin, is significantly transformed. The majority of the lower catchment is also significantly transformed.

Transformed land usually means that it has been developed for some purpose and development activity is regularly linked to water use. So, if 50% of the catchment is transformed this indicates high levels of development activity which is associated with increased levels of water use. It also means that 50% of the river basin that was once grassland, wetland, riverine area or indigenous forest is no longer there to purify our water.

In an urban context specifically, why is land transformation relevant? It means run-off from rainfall is more rapid and less infiltrates the soil because there are more hard surfaces. So, it compounds the effects of both droughts and floods. Run-off carries with it a variety of pollutants and nutrients, compounding the impact. In a rural and agricultural context transformed land is often more susceptible to soil erosion and it regularly contains high nutrient levels (nitrates and phosphates).

Alien invasive plant infestations

Numerous alien invasive plant species are, literally, choking our terrestrial, riverine and aquatic systems. Water hyacinth, assisted in its growth and replication by high levels of nutrients, clogs our rivers and streams, lantana and trifid weed out-compete indigenous plants and scrub wattle and gum trees use water that might be put to productive use. As mentioned earlier, it has been calculated that were we to remove all the scrub wattle from the uMngeni River Basin we would increase water yield by about 7.2 million cubic metres per annum – enough water for 200 000 people using 100 litres per day.

The Natural Resource Management (NRM) programme of the Department of Environment Affairs currently invests about R 35 million per annum in alien

Some areas are severely eroded **DUCT**

Water hyacinth chokes sections of Inanda Dam **DUCT**

invasive control in the uMngeni. Other organisations such as Dusi-uMngeni Conservation Trust (DUCT) and various municipalities are also investing significantly but the infestations continue to increase. The scale of intervention is insufficient to deal with the problem – the rate of deterioration has been slowed but it has not stopped.

Water supply

The dominant paradigm that has driven water resource management in the uMngeni River Basin is one of ongoing supplementation of bulk supply. This has been described in an earlier section. Practically, the water resources of the uMngeni and upper Mooi systems are fully ‘captured’ and so attention has now moved to augmentation from the uMkhomazi River. Plans to build the Smithfield Dam near Richmond and supply water through an inter-basin transfer to both Pietermaritzburg and Durban are fairly well advanced.

In addition to the dams and transfer schemes there is one formal water recycling system processing 17 000 cubic meters per annum which serves the Durban South Industrial Basin.

Continual augmentation of water supply to the Durban-Pietermaritzburg economic access delivers obvious economic benefits. But there are risks and there are costs. The big risk is that on the supply-side we are almost completely reliant on one system with little in the way of a fall-back position – it is not sufficiently diverse. There is insufficient investment in rainwater harvesting, groundwater development, recycling and practical conservation measures. The costs of augmented bulk supply are both socio-economic and ecological. Socio-economically, by removing water from one area and allocating to another we deprive certain users of their constitutional rights to water resources. This is apparent downstream of Nagle Dam where, because of abstraction from the

Spring Grove Dam supplements the basin's water supply **TCTA**

dam to supply Durban, the river sometimes stops flowing.

Ecologically, the artificial increase or decrease in the amount of water flow through the system inevitably changes the system. As an example, the flow of water into the sea from rivers that contain waste water treatment works has increased significantly and so altered the mouth conditions of these systems – they remain open for longer than under natural conditions.

Agricultural intensification

Commercial agricultural activity dominates the river basin landscape. It includes primarily cattle, dairy, piggeries, poultry, sugar cane and timber production. All of these activities impact on water resources – they use water and they produce waste that enters rivers, streams and wetlands. The primary concern is that the steady intensification of agricultural production is causing an increase in the loads of nutrients which, in turn, are the drivers of eutrophication of our storage dams. This is adding to the load from failed sewage reticulation systems.

What is eutrophication and why is it of concern? Simply, nitrates and phosphates are nutrients that allow for the major proliferation of aquatic life such as bacteria, algae and macrophytes such as water hyacinth. As it increases in number, size and/or volume so the aquatic life uses up the oxygen in the water, placing all other life at risk. Ultimately the ecosystem fails, the aquatic environment becomes toxic and the cost of purifying water from dams increases considerably. Of particular concern is that the water being transferred from the Mooi system is high in both phosphates and nitrates. Eutrophication has

Dairies raise nutrient levels in water **Duncan Hay**

severely impacted Hartbeespoort Dam in North-West Province and some scientists predict that, without intervention, both Midmar and Albert Falls dams could become eutrophic in about 15 years. In some areas of Midmar and Inanda dams eutrophication is already apparent.

The second issue is that timber and dairy production are major users of water. While the uMngeni is theoretically 'closed' for timber production expansion, dairy production expansion is increasingly focused on this river basin.

The third issue is erosion, often a consequence of agricultural practices. Erosion reduces soil fertility and subsequent deposition clogs our aquatic systems and reduces the volume of water they can hold. Reduced soil quality reduces the proportion of water the soil can retain.

Solid waste management

We read earlier that less than 50% of households enjoy reliable refuse collection. In many instances these households are in urban areas and residents have limited options on what to do with this refuse. The consequence is that it is often disposed of into rivers, streams, stormwater drains and sewage systems. This reduces water quality, physically blocks systems and is aesthetically undesirable. While not in the uMngeni basin itself, solid waste entering Durban harbour after rainfall events causes significant disruptions to port operations.

Compliance and enforcement

It is common knowledge that some industries discharge effluent illegally into sewer systems and directly into rivers and streams; that some farmers abstract water without permits for irrigation purposes and cultivate illegally within riparian and wetland systems; that refuse is dumped illegally into rivers and streams; that sand-mining businesses operate without authorisation along the lower reaches of the uMngeni River, and that water service authorities themselves are not complying with discharge regulations. There is a general culture

Refuse clogs waterways DUCT

of non-compliance, and there appears to be a general reluctance and lack of capacity to enforce compliance. In addition, the various business and public sectors appear reluctant to self-regulate, to enforce compliance amongst their constituents.

Pricing and financial incentives

At a very fundamental level water is completely under-priced. Imagine; we obtain a cubic metre – 1000 litres – of purified drinking water delivered to our homes at the cost of about R 20. A toilet flush costs 20c – 2% of the cost of a loaf of bread! There is little to no relationship between the value that we obtain from this water and the price we pay and there is very little incentive to change behaviour when this vital service often accounts for less than 1% of a total household or business budget. If we reflect on usage of electricity, it was load-shedding combined with massive increases in price that changed behaviour. With water we have some restrictions but no appreciable change in price. Water services – providing people with potable water and receiving sewage and associated waste – should be a license to print money. Water is bought by a water service authority from a water utility for about R 6 per cubic metre and sold on at about R 20 per cubic metre to a largely captive market. Most of this water is then returned through a sewer to be processed and potentially sold back to the captive market or to downstream irrigators – Windhoek in Namibia has been recycling and re-selling its water for over thirty-five years. All in all a massive surplus is possible and it can be invested in further water resource maintenance, planning and development.

The reality we observe is somewhat different. Infrastructure is aging, maintenance is erratic, service is poor, cashflow is problematic. Why is this? Lack of capacity must be an issue but, as importantly, there do not appear to be the incentives in place to promote efficiency and conservation; actually the incentives are opposite and perverse. As an example, if water service authorities use more water it improves the utility's revenue stream. So, despite what is stated, the utility would want everyone to use more water as long as they pay for it. A drought comes along which forces everyone to use less water so the utility increases the water price, not to curtail use, but to make up for its lost revenue. Also, the more leaks in the water service authorities' systems the more the utility earns. Why fix and why save?

In Phnom Penh in Cambodia, arguably a developing city, non-revenue water is only about 7% of total water usage. This is because the response time to fix leaks is less than two hours and operational staff whose job it is to fix the leaks can secure bonuses of up to 25% of their salaries linked to how effectively they save water.

Governance failures

A brief reflection on the challenges described above indicates that, with the exception of climate change, they are not technically complex or complicated problems. We have the technical ability to address them but we are not doing so adequately. We need to look elsewhere to explain why. Evidence suggests that there are governance failures in water resource management in multiple spheres and at multiple levels. While, in most instances, policy and legislation that guides management is clear, effective management is not happening. These governance failures appear to be a consequence of a range of factors acting independently and in concert. These include lack of technical and administrative capacity, lack of understanding, lack of political will, poor strategic leadership, poor or confused accountability, insufficient investment, incorrect pricing and perverse incentives, poor revenue collection systems, general lawlessness and lack of compliance, lack of compliance enforcement, and corruption. These governance failures are not confined to government but also occur within and between all spheres of society. We have a mess.

Social tension

A consequence of all of the above is a growing sense of frustration amongst stakeholders who are observing and experiencing a deteriorating situation. This manifests itself as ongoing destructive criticism of all and anyone who is perceived as being responsible and accountable for the mess. Criticism by civil society of government is particularly strident. While government needs to account to society, the impact of the criticism results in the opposite. Government officials withdraw from forums of discussion becoming increasingly inaccessible and unresponsive.

Research and monitoring

There is a considerable body of research on the uMngeni, particularly on biophysical aspects such as its hydrology and ecology, and applied research related to infrastructure planning and development. There is also a growing body of social science research informing governance issues. However, much of this research is fairly inaccessible and there is no common platform for sharing. As a specific example, simply to compile the very basic information in this document required locating information in a range of repositories and ongoing interaction with a number of organisations, some of which failed to respond at all. Also, there remains a significant gap between research and practice and it appears that, while research is informing policy it is not being carried forward into practice.

As it relates to monitoring and given the importance of water resources to the socio-economic development of the river basin, investment in monitoring is completely inadequate. In many cases too few biophysical, social and economic parameters are being measured to determine causal relationships and the intensity of monitoring is insufficient to account for episodic events.

SASS is an important and cost-effective monitoring tool   Duncan Hay

Responding to the challenges:
a few ideas

Identifying problems is easy.
Developing solutions is more difficult.

Identifying problems is easy. Developing solutions is more difficult. This section does not pretend to solve problems. No individual and no individual organisation can solve these problems – it requires an integrated collective approach. This simply provides the strategic direction we might follow to arrive at solutions.

Changing the way we think about water resources

A paradigm shift in how we think about water resources is required. Currently our focus is on the storage, transport and delivery of water but we pay very little attention to the full value chain that is involved. On the supply side we think of a dam as the producer of water. It is not; it is simply the equivalent of a storage shed or pack-house. The agent of production is the upper catchment and rainfall itself. On the demand side we waste it because its financial value is so low.

The second shift we need to make is to appreciate and start working at scale. While pilot and demonstrations projects are useful learning exercises they, in themselves, do not solve the problems. The scale of our thinking and doing involves the river basin so our level of investment needs to match this. In some instances this means investments in the billions of rands will be required to fix certain problems.

Then, and specifically in the context of the uMngeni, we need to stop thinking about water resource management as a constraint to development and rather think of it as an opportunity for development, as an enabler. We alluded to this in the introduction. If we do this we explicitly link water resources to socio-economic development and we enhance its value. We have to go beyond the mind-set of simply trying to supply more water to more people through more dams and more pipes. It is not sustainable.

If our water resource is to be an enabler it needs to be resilient – the water resource system needs to be stable and it needs to be able to resist and recover from various stresses. The stress might be disease, drought, flood, or any number of combinations of these and other factors. As I sit here writing there is little to no water supply to certain areas of Pietermaritzburg. The stress is a combination of drought, poor planning, insufficient capacity and aged infrastructure. Water resource security is compromised and with it the resilience of, particularly, our economic and social service systems – factories can't operate, people are being sent home from work, schools have closed and hospitals are only handling emergencies.

A single stressor operating on its own is unlikely to compromise the resilience of a system. Obviously extreme events such as tropical cyclones and tornadoes do, but as the example above illustrates it is often several stressors which compound the impact.

In our context the concept of resilience has taken centre stage as we become increasingly aware of the impact we are having on our earth and its systems and the consequence of system failures for ourselves and society as a whole. The fundamental question is: how do we build the resilience of both society and the ecosystems that sustain us to ensure that both endure, that both are secure? Specifically, how do we build resilience into water resource management in the uMngeni system and so improve security?

These ideas are based on principles developed by the Resilience Alliance:

Diversify:
diversifying, particularly our sources of freshwater, reduces risk. With energy we are already doing this – mixing solar, wind, coal, hydro-electric and nuclear. With water we can mix bulk supply with more rainwater harvesting, recycling and groundwater usage. If one source fails there is a back-up. It also applies to managing waste water – at a waste water treatment works build a wetland so that if the works fails there is a back-up system. A word of caution is required. Our focus is on water resource security. Even in diverse systems most components will be directly and/or indirectly reliant on water resource integrity. So, as much as one diversifies, if the integrity of the water resource fails the entire system can collapse.

Appreciate and manage connectivity and change:
everything is linked in space and time particularly when it comes to water – water sustains our economy, our economy sustains us – simple. So, we need to understand that when sewage leaks into the Msunduzi River in Pietermaritzburg, water hyacinth will proliferate in the upper reaches of Inanda Dam and the cost of treating water from Inanda Dam will increase.

Managing complexity:
complexity and complicated are different. Flying a jet is complicated – there are many things to do but the response of the jet is predictable. Managing a natural system is complex – there are many things to do

and the responses are unpredictable. So, we should recognise that we are dealing with complex systems, that establishing cause and effect is difficult, that there are high levels of uncertainty, that many decisions are value-laden and contested but that we need to act. It means planning, acting, reflecting on the results of our actions, and refining or modifying our actions based on these reflections.

Learn and broaden participation:
we have already focused on learning but building on the point above, we are working within and dealing with complex adaptive systems. Because they are constantly changing we need a process of continuous learning. Within our context, particularly with culturally heterogeneous communities and huge disparities of wealth and education, we also need to create platforms where those who have been previously excluded from participation in learning and decision-making are acknowledged, accepted and listened to.

Promote cooperative governance systems:
cooperative governance is where multiple governance agencies (governing organisations which include government, business and civil society), each with their own particular mandate, work together to achieve a particular objective. As an example, a municipality, instead of trying to fix a water quality issue on its own, partners with NGOs, researchers, other state agencies and the business sector to resolve the issue. This creates the requisite depth and breadth of capacity that is required to address the issue.

Cooperative planning & management - essential for success   Duncan Hay

In engaging a new paradigm there are six areas where we might invest – our capacity, our built infrastructure, our green infrastructure, pricing, compliance, and research and monitoring. Simply stated we develop and harness our capacity, establish effective pricing mechanisms and enforce compliance to ensure that the green and built infrastructure work together for optimal societal benefit. And, in doing this, we research improved methods and measure our performance.

Developing capacity

Capacity is the realisation of the need to act combined with the desire, will, freedom, ability and opportunity to act. Practically it includes people; their labour; their education, expertise and experience; institutions of governance and management; organisation; political will; investment – in short, every attribute that gives people the ability to operate effectively.

Why do we stress capacity? As described previously, we are observing governance rather than technical failures as a root cause of a number of the challenges we face, and even those challenges that do not originate as governance failures will require capacity development to manage. As an example, while climate change might not constitute a governance failure at our local level, we are going to have to develop significant capacity at local level to meet the challenges it presents.

Building capacity - a foundation for changing behaviour   Duncan Hay

A fundamental foundation of capacity developing, and one that speaks to our core values, is caring – caring for each other and caring for the earth. Without a caring society it will be extremely difficult to establish a healthy river basin. Caring arises out of the growing appreciation of the value of someone and/or something. Achieving this appreciation arises out of ongoing education and interaction.

Educating and raising people's awareness on water resource management alone is unlikely to change behaviour but it is an important foundation in the capacity development process. In the short term we cannot educate everyone so we might focus initially on those whose decisions fundamentally impact on what priorities are established and where resources are allocated. These include our political leadership, particularly councillors and officials in local government and Amakhosi (chiefs) and IziNduna (headman) in traditional government. It also includes our large land-owners – our commercial farmers and foresters. But, what type of education? It should be education that is an active and experiential learning process that engages the specific context that people find themselves in; responds to specific needs; builds on prior learning and on strengths; encourages the sharing of knowledge and practice, and the application of this learning should be immediate.

Engineered infrastructure

In the short term massive improvements can be made by fixing and maintaining the existing engineered infrastructure. Using eThekwini as an example – it is the largest consumer so here is where we might secure the most gains. If one was to halve the water lost through leaks (from 30% to 15%) this translates into 47 million cubic metres of water that would not need to be purchased; a saving of R282 million. If one was to halve the lost revenue from illegal connections (from 10% to 5%) that would translate into increased revenue of R312 million. Together this would give eThekwini more than half a billion rand annually to invest in infrastructure development and maintenance.

New Darvill WWTW will be commissioned next year **Umgeni Water**

Quantifying the specific financial benefits of repair and maintenance to sewer and stormwater systems is a little more difficult but the argument is no less compelling. Re-establishing system stability of a waste water works every time it is flooded during a rainfall event; clearing water hyacinth that thrives on the high nutrient loads; lost productivity of hundreds of paddlers who contract gastro-intestinal infections; clean-up of industrial effluent discharges that escape from sewer systems; processing water of poor quality to potable standards – all these factors attract considerable socio-economic costs that might be avoided. As priorities the waste water treatment works and associated reticulation systems of Howick (including Mpophomeni) and Pietermaritzburg require urgent attention.

While we might criticise the engineering-driven supply-side approach it is a harsh reality that if the Spring Grove transfer scheme had not been commissioned in April 2016 Midmar Dam would have been almost completely empty by December 2016. (One could also argue that if eThekwini fixed all its leaks we would not need Spring Grove at all!) In the future economic development is likely to remain concentrated along the Durban – Pietermaritzburg access so more water will be required. In this context a planned dam on the uMkhomazi with a transfer scheme to this area makes sense. But it only makes sense if the rights of downstream users (including the environment) on the feeder catchment are accounted for and if the water tariff from the scheme includes provision for ecological infrastructure conservation and rehabilitation – securing the source of water – in both catchments.

Conserving wetlands helps sustain water yield

Duncan Hay

Green Infrastructure

It has been calculated that it would cost about R 260 million to remove all the invasive wattle from the uMngeni River Basin. This would generate an increased yield of 7.2 million cubic metres of water annually. Engineers use a crude estimate to determine the approximate cost of securing yield through engineered infrastructure – it is R 100 million for 1 million cubic metres. So, through investing in alien invasive plant removal one might secure the same yield at about one-third of the price.

The same research that determined this yield improvement also informs us where in the river basin we should invest in restoring ecological infrastructure particularly to improve water yield and reduce sedimentation. Also, there is an investment of about R 35 million annually being made by the Department of Environment Affairs NRM programmes in the uMngeni so we have an excellent foundation of research, planning and implementation.

Going forward we might focus on two priorities. First, let's work with the major landowners and land managers to upscale the investment in alien invasive plant removal and ecological restoration. In the short term this might be funded by the Green Climate Fund and in the long term by catchment management charges embedded in the water tariff system. Second, again working with major landowners and land managers, reduce nutrient loading and so protect existing ecological infrastructure. This would include a more comprehensive implementation of buffers systems, reducing nutrient loads at source and converting various waste streams into fertilizer and biogas.

Buffers can reduce sediment and nutrient loads **Donovan Kotze**

Pricing

The Department of Water and Sanitation has revised the National Water Pricing Strategy and published this strategy for comment early in 2016. It is not perfect but it moves towards pricing water at its true value. It also makes provision for a catchment management charge as part of the overall tariff. This is ground-breaking as it creates a sustainable revenue stream for, amongst others, habitat restoration, alien invasive plant removal, soil conservation and improved biodiversity conservation. Unfortunately, it appears to be stuck in some bureaucratic or political process and has not, as yet, been finalised. As a first step the strategy needs to be finalised and implemented as a matter of urgency and secondly, in the context of the strategy, fundamental price reform needs to take place and perverse financial incentives need to be reversed.

Linked to pricing is revenue collection. eThekwini manages to collect 90% of its water revenue which is admirable. uMgungundlovu only collects 69% and Msunduzi 75%. Significant improvement in these levels of collection will provide much needed resources for rehabilitation and maintenance of the water and sewage reticulation infrastructure.

Compliance

We know levels of compliance are low – farmers abstract and discharge without licenses; industries discharge waste illegally into streams and sewer systems; municipalities themselves discharge illegally; land is developed without authorisation and without following due diligence; sand-mining is largely unregulated – it is an anarchic free-for-all.

One of the reasons for this is that the risk of being caught and successfully prosecuted is very low. The systems are not being effectively policed. Improved

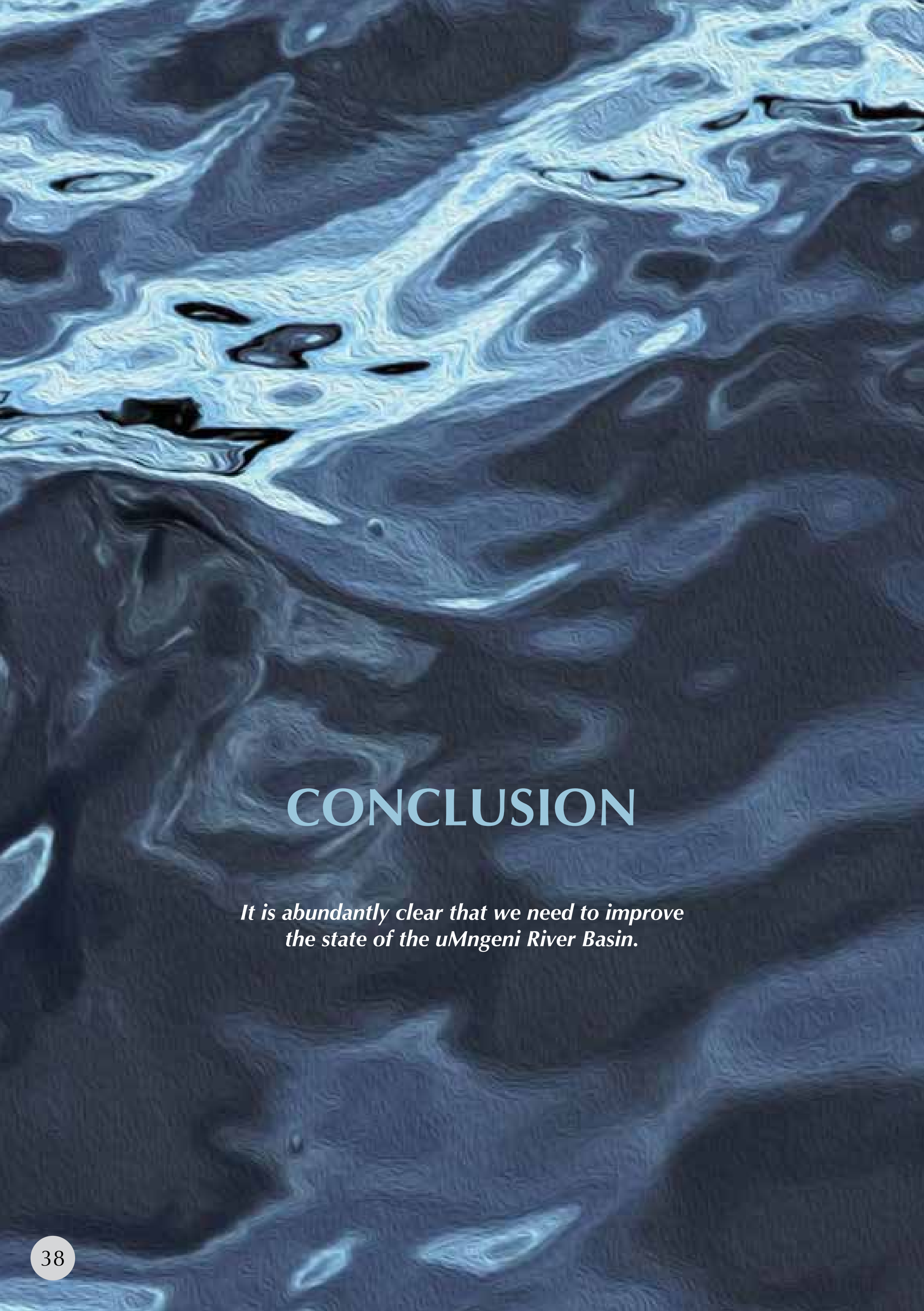
Sand-mining is largely unregulated **DUCT**

compliance will come from improved policing at two levels. The first and probably the more important is internal policing within business, government and societal sectors – self-regulation needs fundamental strengthening. The second level is state policing – more capacity in both enforcement and prosecutorial arms of the state. We need to make examples of the criminally delinquent and make people think twice before they transgress.

Research and Monitoring

We have great research institutions in the river basin – University of KwaZulu-Natal, Durban University of Technology, CSIR and a number of NGOs. We might increase investment in them so that they can act as repositories of pertinent research information, direct further research needs and act as 'knowledge brokers' between research organisations and between these organisations and planners and implementers.

At the time of writing Umgeni Water and UKZN are designing a comprehensive water monitoring system for the uMngeni River Basin. Once the design is complete, it will require investment from a range of interested parties.



CONCLUSION

It is abundantly clear that we need to improve the state of the uMngeni River Basin.

It is abundantly clear that we need to improve the state of the uMngeni River Basin. Until recently I thought that with some well-directed interventions – collect the trash, fix the leaks in the freshwater and sewer systems, cut down the alien invasive plants, turn waste into fertilizer and energy, conserve some wetlands and grasslands, stop discharging industrial pollutants – we could clean up the system in no time. None of this is rocket science. How difficult could these interventions be?

Now I am having a crisis of faith in technical solutions. Over the past 10 to 20 years, despite dedicated effort by many people, we have failed miserably in our quest to deal with most of these issues. What I have come to realise is that it is not the state of the river basin that needs attention; it is the state of society that resides in the river basin that needs attention. The state of the basin is simply a consequence of the state of society that lives, works and plays here.

Currently we, through our collective and individual actions, are subjecting the basin to what colleague Jim Taylor refers so aptly as 'slow violence'. What is also apparent is that the basin is responding and, in turn, is visiting 'slow violence' on us – economic options and service levels are declining and human health is impaired.

So what should we be doing? Perhaps a 'social revolution' might help; a shift in the paradigm that regulates our behavior; a movement from violence to care. We need to build a caring society – people who care deeply for each other and for the natural systems on which we depend.

Caring does not just happen; it starts with people being included, having a stake in the system. If people perceive that they are part of the system, that they will materially benefit if the system improves or they improve the system, and that they will lose materially if they degrade the system or steal from it, then people are more likely to care. It also starts with understanding; providing residents with the opportunity to learn about and appreciate the ecological and social wonders of the basin that stretches from uMngeni Vlei to the coast. Lastly, while caring is a fundamental value it is also an action. You can't just think 'caring', you have to do 'caring'. Small considered acts of caring will rapidly take us to our intended destination.

I am aware that with lots of money, some detailed planning and effective implementation we will deal with some of our challenges; we will win some battles. But if we do not combine these interventions with a social revolution towards a duty of care, these victories will come to naught and we will lose the war.

A basin resident surveys uMngeni's headwaters **Duncan Hay**

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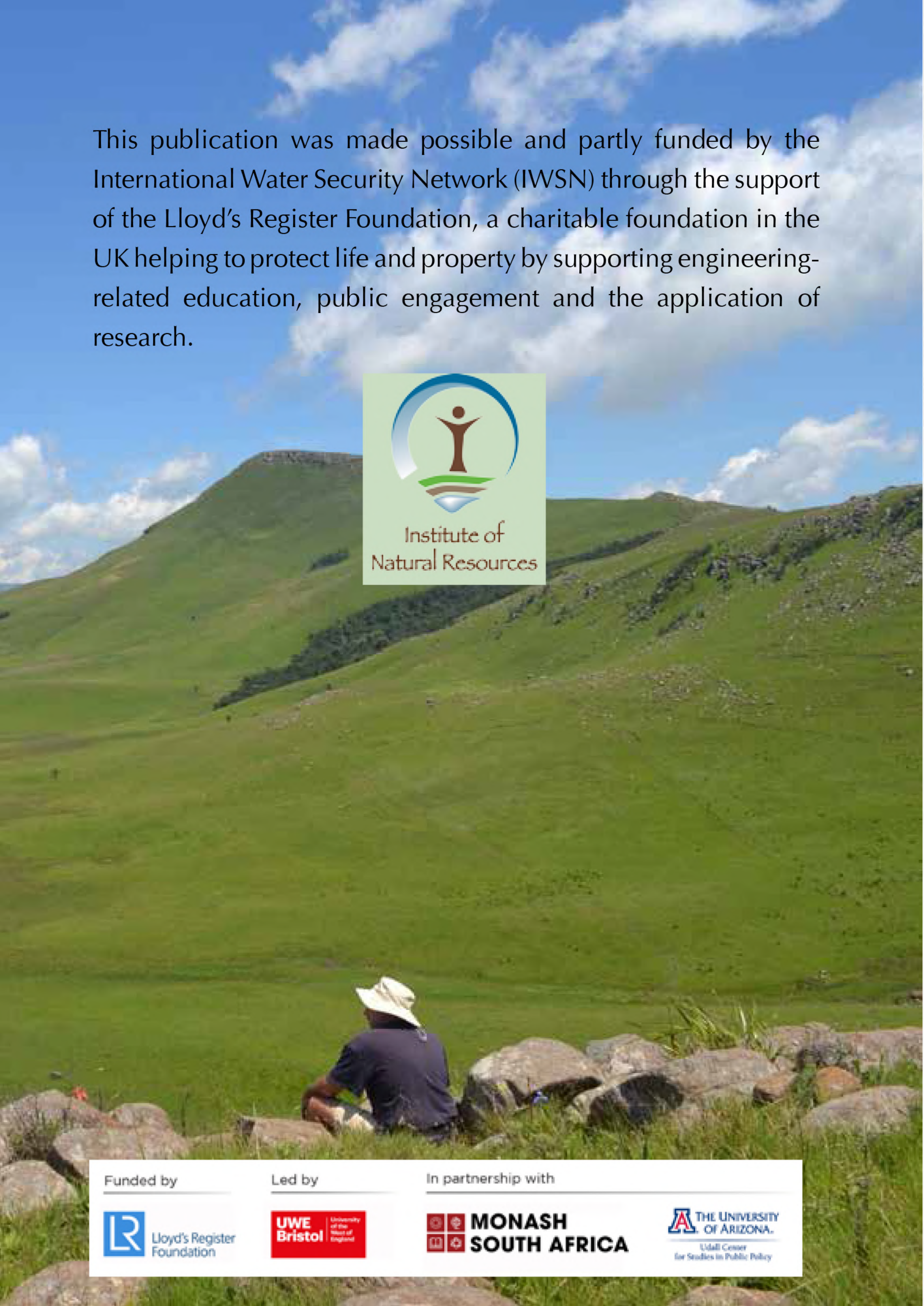

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