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Water Quality: A vital dimension of water security

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1. Introduction

South Africa takes great pride in its achievement as a country that has undergone significant reform in adopting an approach of integrated water resources management (IWRM), where water security for growth and the alleviation of poverty features as a national priority. This reform has taken place through policy and legislative changes, as well as the restructuring of existing institutions and the establishment of new ones. Notwithstanding this achievement, South Africa has failed to develop the appropriate enablers to implement the legislation fully and to bring the policies and strategies into full operation.

South Africans have reason to be concerned. Public perception is that the quality of the country's natural and manmade water bodies is generally poor and deteriorating fast. It is widely believed that municipal drinking water is unsafe and that water occurring naturally in the environment is seriously polluted. Decision makers, investors and researchers share the view that the declining quality of water will have a negative impact on the South African economy, in both the short and the long term. Organised labour and civil society have warned that the breakdown of monitoring and reporting to the public could spell a national disaster, and they expect water contamination to reach catastrophic proportions.

While the Minister of Water Affairs and Forestry has stated that South Africa is not yet facing a water crisis, the national government is concerned about the state of river water quality and the status of wastewater treatment. Hearings during the 2008 Parliamentary sitting reflected the lack of clarity and certainty surrounding water quality and water infrastructure in the country. However, indications are that South Africa is coming to the end of its additional water supplies that can be harnessed economically, as well as of the "dilution capacity" of its water resources to remove waste.

With these aspects in mind and given the ever-increasing demands to prepare and plan for a water secure future, one fact is clear – South Africans are becoming increasingly concerned. Pertinent questions about the country's water resources and, specifically, the quality of the water, include the following:

- Are concerns about the quality of our water resources justified and informed?
- Is water quality a consideration in the water security equation?
- If so, why is water quality important and what are the tradeoffs if water quality is compromised?
- What are the links between water quality and the economy?
- Is investment in water quality sufficient, and is it necessary?
- Is it a cause for growth, a prerequisite to grow, or a consequence of growth?
- Where are we at this point in time?

Globally, analysts and decision makers are of the opinion that "good water quality co-enhances socio-economic development and growth" (SIWI, 2005). International and local experts agree that investment in water infrastructure and institutional capacity makes economic and social sense, and can be done with minimal environmental and other tradeoffs (WfGD, 2007). Perhaps we should be asking: "Can we afford not to invest in water quality and its enablers?"

2. The purpose of the paper

The objective is to provide a qualitative and strategic perspective on water quality and its relationship to the economy, urban challenges and sustainable productive capacity. It attempts to test the hypothesis that "good water quality is a vital component of good economic growth" and, if so, what the critical links and synergies in this relationship are and whether they can be "delinked", if necessary.

This document is not a research paper; neither does it offer technical detail or a comprehensive economic analysis or modelling. It seeks to present a range of selected, relevant and multidisciplinary viewpoints from leading South African experts. The conclusions aim to stimulate further debate and deliberation on the subject.

3. Water quality: a global snapshot and definitions

In September 2008, United Nations Secretary-General Ban Ki-moon's remarks at Expo Zaragoza in Spain set the scene for the water quality challenge for the "International Decade of Action, 2005-15". The following excerpt summarises the global challenges for water and sanitation (Nel, 2008):

> "We at the United Nations are strongly committed to protecting and properly managing the world's precious water resources. Providing access to safe drinking water and adequate sanitation are among the Millennium Development Goals agreed by United Nations Member States at the Millennium Summit in 2000. Today, we are taking every opportunity to raise awareness of the need to strengthen water resources management. We are encouraging governments to use the Integrated Water Resources Management framework. And we are relying on partners like you to show what can be done using the latest knowledge, science and technology …"

The fresh water resources of the earth are limited, as 99% of all water is saline (and becoming more so through the actions of humankind), and only 0.3% of all fresh water is fit for use. Due to rapid industrialisation in the developing world, food production, energy demands, population growth and climate change, it is estimated that half of the world's people will live with chronic water stress by 2025. Not only will the limited availability of fresh water lead to chronic water stress, but poverty, unequal access, wars, migration and unsustainable consumption patterns will also be major contributors to the water crisis.

Consensus has been reached on the vital role that water plays in human societies. It is a source of life, livelihood and prosperity, and also an input into all production in agriculture, industry and energy. Water can also be a force for destruction, through drought, floods, landslides, contamination and disease.

Food, water and energy security can all generally mean reliable access to sufficient supplies to meet the needs of individuals and societies. A striking difference is that, unlike food and energy, it is not only the absence of water but also its presence that can pose a threat. Furthermore, water security not only depends on an adequate quantity, but also on good quality. It is arguably the latter element that is becoming a critical element (and risk) in achieving water security.

In this context, it is useful to review some basic definitions of terms used (Bhagwan, 2008):

- Water quality: This is defined as the physical, chemical and biological characteristics of water in relationship to a set of standards. The primary uses considered for such characterisation are the parameters that relate to drinking water, safety of human contact, and the health of ecosystems.
- Anthropogenic water cycle: This cycle begins and ends in the water resources from where water is abstracted to be processed into drinking water. From the source, the raw water is moved through a collection structure (e.g. pipes and pumps) to the water treatment plant, where it is cleaned and disinfected as drinking water. It is then supplied to the consumer via a collection and distribution system (e.g. reservoirs, pipes and pumps). After use by the consumer, wastewater or sewage is discarded, collected and reticulated to a wastewater treatment plant. Here it enters another cycle of treatment before being returned as effluent to the river system from which it was taken.
- Pollutants and contaminants: These may be pathogenic and harmful to human, animal and/or plant health. Chemicals and microorganisms can be introduced into water resources by consumers or by creatures in the natural environment, where they remain in the water for undefined periods. Recent research has indicated that some of these pollutants may not be treatable by conventional technology. Many microorganisms are known to cause disease in humans, such as cholera, typhoid and shigellosis, while the effect of pollutants, such as microcystins, endocrine disruptors and partially metabolised medication, requires further research.
- Dilution capacity: This term refers to the ability of water bodies to receive and remove pollutants disposed in them by human activities, in a manner that protects other water users and does not harm the long-term environmental health of the water body itself (Turton, 2008).

4. South Africa and water quality

The security of a country's water resources is vested in its infrastructure – its bulk and retail networks – that takes the water from source to tap, as well as the institutions and regulatory framework that manage the overall delivery process. Most importantly, it is the regulatory, legislative environment that sets the tone for infrastructure and institutional performance and water quality compliance.

Figure 1 provides a useful perspective on how the management of water resource quality impacts on other water management activities and their outcomes (Nel, 2008).

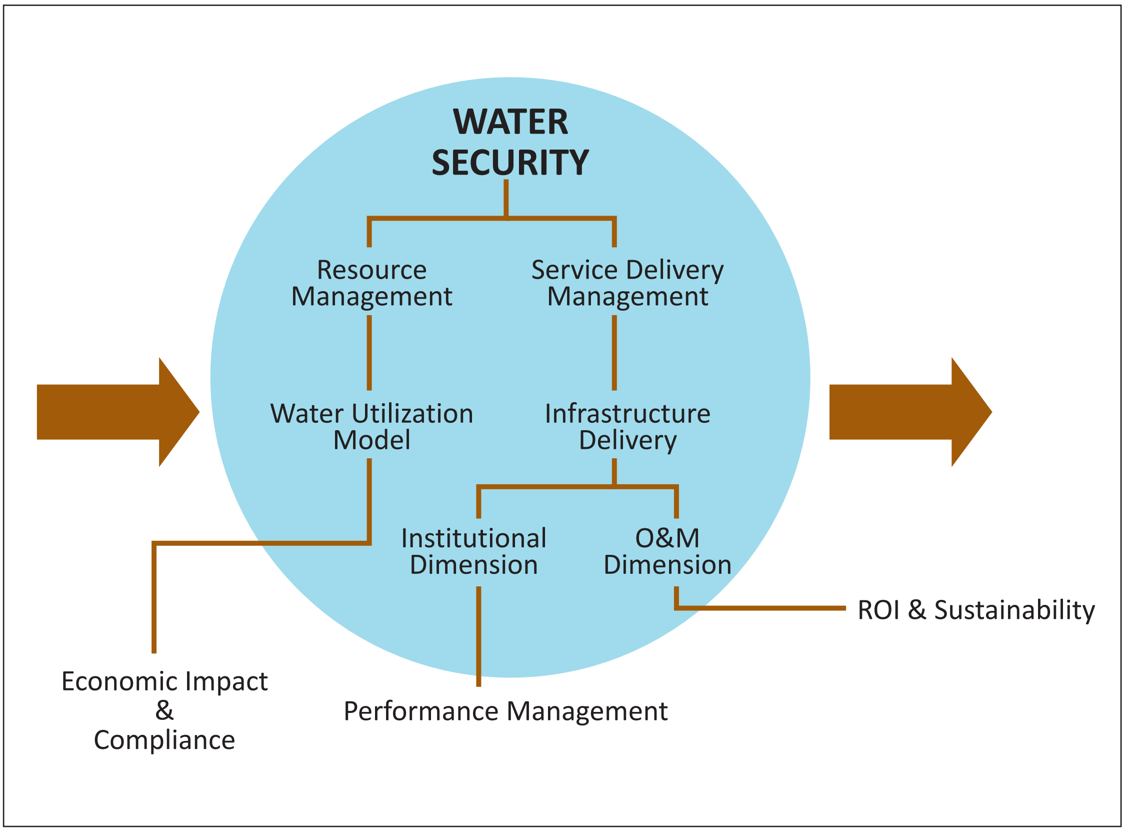

Figure 1: A water security model

In setting standards for water quality, the government makes political, technical and scientific decisions about how the water will be used. In the case of natural water bodies, it also makes some reasonable estimate of pristine conditions. Different uses of water in different contexts raise different concerns, and therefore different standards are considered (Heath, 2008).

In seven of the nine provinces of South Africa, more than half the water is provided by inter-basin transfers. This demonstrates the intensity with which the country's available resources are being used already. The current status of water quality varies substantially, with the most contaminated water resources being the Vaal River, Crocodile West (Limpopo), Umgeni and Olifants River systems.

The resultant challenges are well illustrated in the Vaal River system. Water investments were made in the past to ensure the economic resilience of large-scale commercial farming, mining and financial services in the nation's heartland, while the rest of the country had little water infrastructure. The Vaal system, situated in a semi-arid region with highly variable rainfall and runoff, includes inter-basin transfers with seven other river systems and 16 major dams (Figure 2). It also provides cooling water for power stations, which generate about 85% of the nation's electricity. The impact of pollutants on the Vaal River system is indicated in Figure 3. Deteriorating water quality, given as a value of total dissolved solids (TDS), can be seen at VS8 (the Vaal Barrage), the Vaal Dam and the Grootdraai Dam.

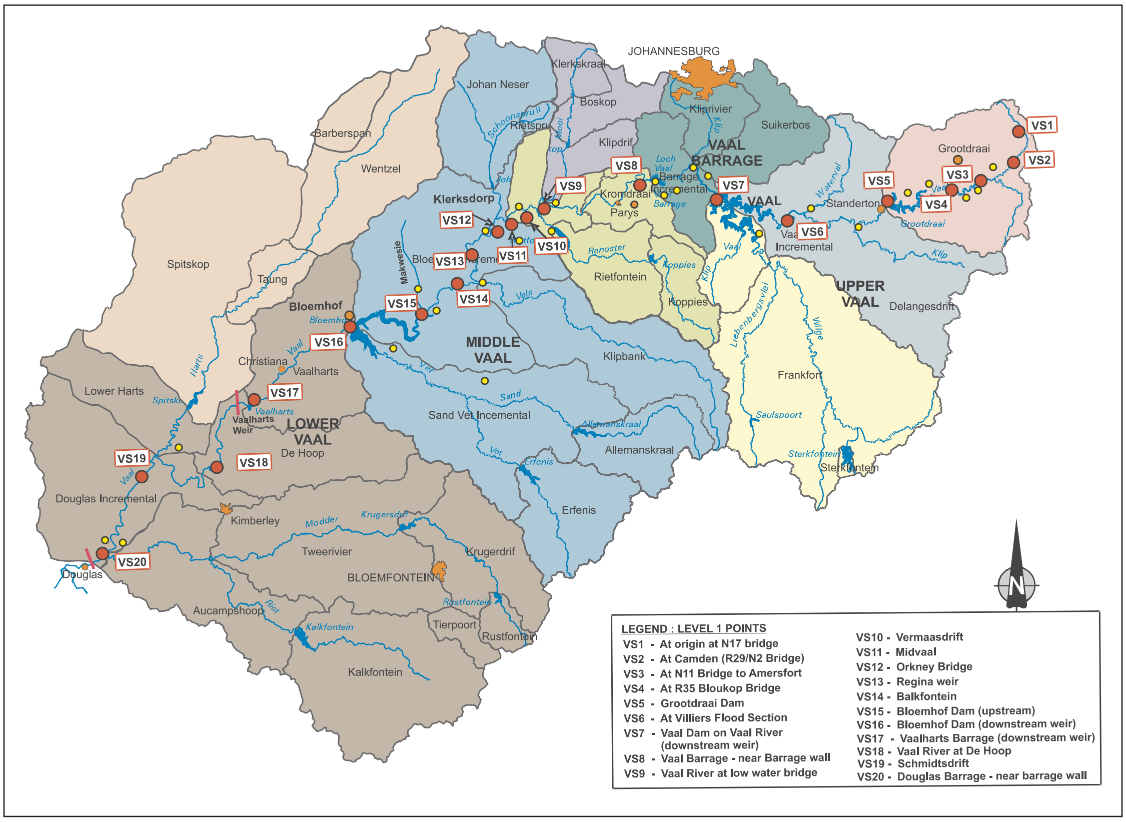

Figure 2: The Vaal River system

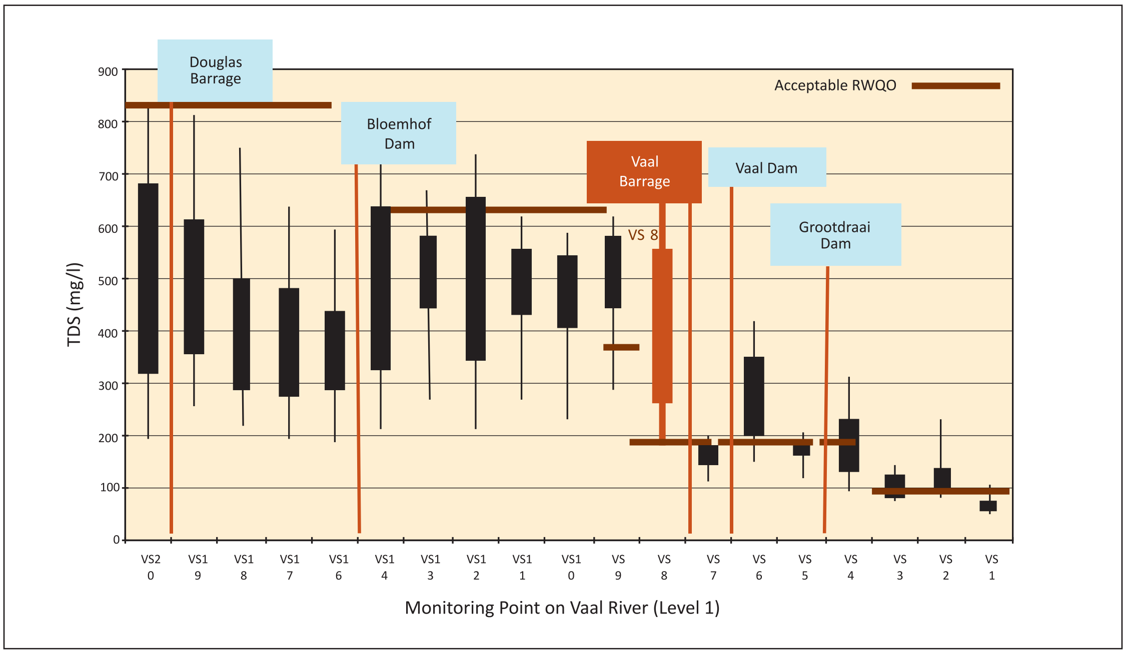

Figure 3: Total disolved solids values in the Vaal River system

Wastewater quality affects the system directly, in the same way that pollution from mining, agriculture and other industries have an impact on the resource. In Gauteng, for instance, 74% of the wastewater treatment works (WWTW) fail to comply with the standards of two or more parameters for effluent quality. Some 35 and 14% of WWTW operate at, or beyond, their design capacity, respectively, as seen in the green sections in Figure 4 (DWAF, 2008). As a consequence, the impact on water resource quality, demonstrated in terms of the increasing TDS concentrations of the Vaal River system, is threatening to reach unusable levels in the lower reaches.

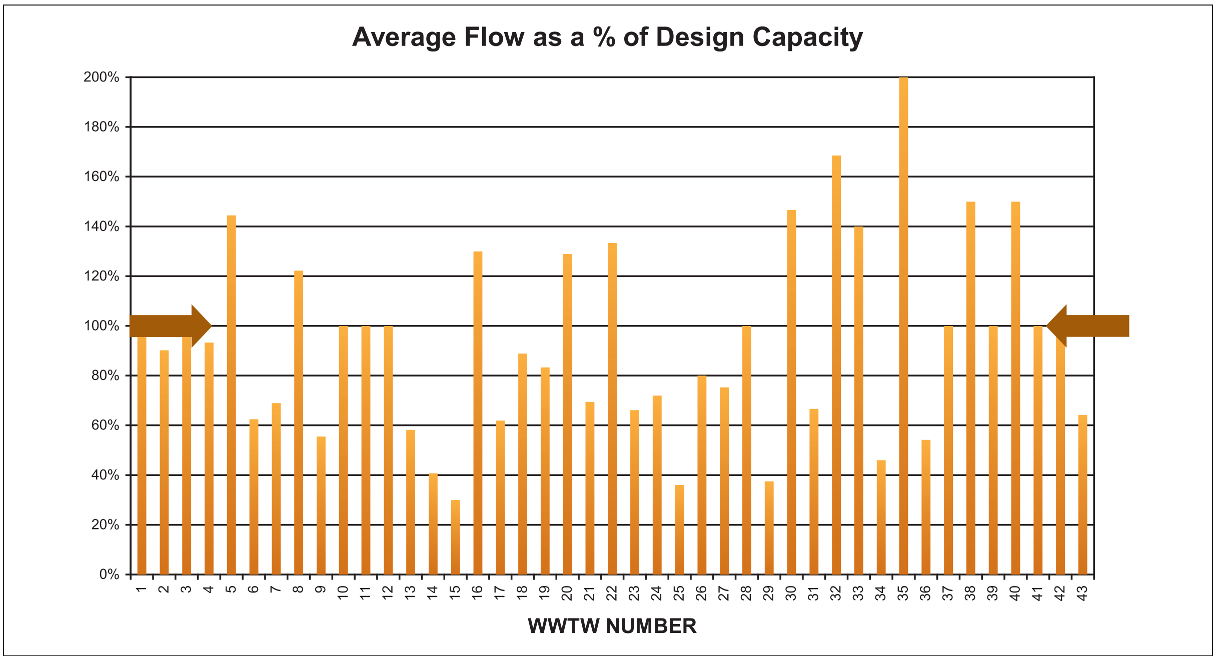

Figure 4: Licensing status of wastewater treatment

This background information demonstrates why values and priorities are changing, and why the mission of water managers is shifting from the construction and development of dams and major structures to good management and maintenance. Water resources management (WRM) increasingly needs to focus on improving, in an equitable way, the security, safety and efficiency of existing facilities, while meeting environmental obligations and maintaining the usability of precious water supplies. Water quality is a vital dimension of this process.

5. Key water quality indicators

When referring to water quality, available water resources in South Africa are sometimes described as being either "too little" (due to drought), "too much" (due to floods) or "too dirty" (due to pollution). More recently, the emphasis has shifted to water being dirty. Although this conjures up a picture of murky water with a high turbidity, it actually is about water being very salty, with high levels of nutrients and bacterial contamination.

In many South African water systems, the quality of the water is not fit for all possible uses. This situation is already incurring serious costs and requiring the application of new technology that will increasingly play a major role in the treatment of these water resources. Parameters for water quality that are of particular concern countrywide relate to the following issues:

- Salinity
- Eutrophication
- Microbial contamination
- Endocrine-disrupting compounds (EDCs)
- Microcystins
- Radionuclide and heavy metal contamination

5.1 Salinity

South Africa's national strategy for energy is currently based on coal as a feedstock. The dependence on coal is complex and not likely to change in the medium term. The increased costs of removing salts from the Vaal River system are well documented. These salts originate from the acid mine drainage (AMD) from gold and coal-mining activities in the Witwatersrand, as well as from agricultural runoff. The recent crocodile deaths in the Olifants River may be the result of contaminated water being released from the coal-mining areas in Mpumalanga. The deterioration of water quality will have continued impacts on aquatic biota and, ultimately, on biodiversity.

At a practical level, investigations into the use of the Vaal Barrage system as a "blending tank" are ongoing. Water with high levels of TDS is diluted through recirculation and transferred water to achieve the required TDS concentrations before being discharged from the Barrage. Because of pollution, water services authorities (WSAs) in the Midvaal area are experiencing increasing treatment costs and face the challenge of maintaining the most sophisticated WWTW in South Africa.

5.2 Eutrophication

Eutrophication is clearly observed in dams, such as the Hartebeespoort Dam in the North West province. Increased nutrient levels are brought about by the discharge of nutrient-rich effluents from WWTW, agricultural fertiliser runoff and urban runoff from underserviced areas. This leads to excessive algae growth, oxygen depletion, fish deaths and, ultimately, to deteriorating water quality. The situation will be aggravated as more people are connected to waterborne sewerage systems and discharge their waste into watercourses.

5.3 Microbial contamination

Microbial contamination is increasing due to the inability of WWTW to cope with larger loads, as well as to urban runoff from areas with inadequate sanitation services. Available microbiological monitoring data is too limited to follow trends, such as those seen in the Midvaal area (Figure 5).

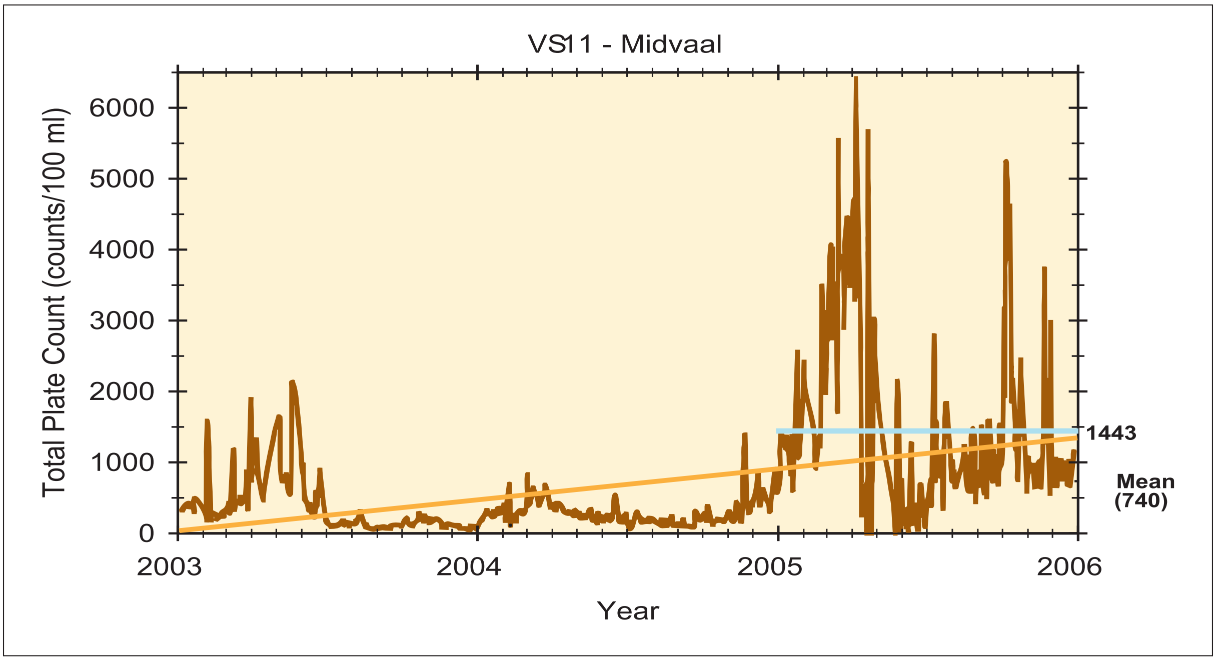

Figure 5: Microbial pollution at the Midvaal station

Microbiological pollutants are symptomatic of the non-compliance of WWTW and indicate inadequate disinfection of treated effluent.

The following three categories of pollutants, in particular, are being debated among water quality scientists. These are also the subject of the National Water Quality Science, Technology and Policy Support Programme currently being developed by the Council for Scientific and Industrial Research (CSIR).

5.4 Endocrine-disrupting compounds

The problem of EDCs is largely driven by the loss of dilution capacity. EDCs are being recycled without being removed by WWTW, which leads to concentration and bio-accumulation. The focus should therefore be on furthering research with international collaboration, and on understanding the pathways for designing proper interventions, technology and policy. South Africa can expect to be scrutinised and tested for these water-driven contaminants in international exports of the country's products.

5.5 Microcystins

Microcystin loads in water storage impoundments in South Africa are among the highest in the world (Turton, 2008). No high-confidence studies have been done yet. Views are that it borders on criminal negligence if national priority is not given to the potential cases of people being exposed to chronic doses of microcystins, especially in communities that are immune compromised. Scientists agree that microcystins produced by cyanobacteria can be toxic to humans, animals and plants (Oberholster & Ashton, 2008). In addition, direct links are made between cyanobacteria and climate change via the changing ambient temperatures in South Africa's water bodies.

5.6 Radionuclide and heavy metal contamination

Radionuclide and heavy metal contamination in South Africa is the legacy of more than a century of unregulated gold mining, coupled with high-density populations living in close daily contact with dust and sediment arising from mine tailings dams. Portions of Soweto and East and West Rand residential complexes are located on land that would be classified as contaminated sites in developed countries. This pollution also impacts on local water resources.

6. A water quality model

As is evident from the discussion thus far, the water quality agenda is complex, multidisciplinary and multidimensional. Although complex, a water quality system is, in fact, open and dynamic. To gain a better understanding of its nature and characteristics, it can be presented in the form of an integrated systems model. Figure 6 offers a simple categorisation of changes in water quality that result from both natural environmental processes and human activity (Wagner, 2008b). Policies, standards, parameters, criteria and guidelines for water quality need to be developed. These should consider factors such as people's needs, drinking water standards, agriculture, industry, mining and the natural environment.

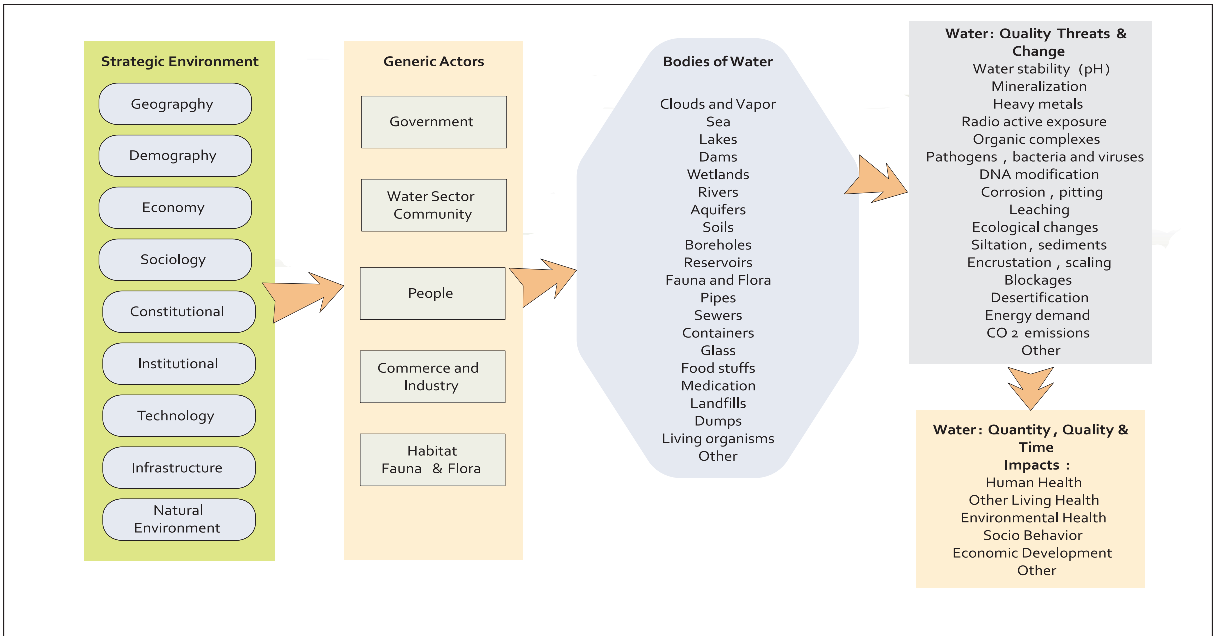

Figure 6: A water quality systems model

The model indicates a large number of "bodies of water" that need to be taken into account when considering the impact of changes in water quality on the South African economy. In an ideal world, each body of water would have a specific set of water quality parameters for it to achieve its purpose optimally and sustainably.

Wagner (2008b) presents in more detail the potential threats and actual changes as result of interaction with these water bodies. The composite effects of water quality changes can then be grouped together (as in the bottom right block in the figure). Seen collectively, it could be argued that the economy is actually a composite of all such impacts, as it could be used to measure their effects. It is important to give consideration to the various sectors of the economy and the way in which each sector will be affected by deteriorating water quality.

7. Water quality and the economy

According to recent key economic and financial data for South Africa, compiled by the South African Reserve Bank (SARB, 2008) in accordance with International Monetary Fund (IMF) standards, the water services industry accounts for about 1.3% of the South African economy (Table 1). However, the water sector affects *all* economic sectors directly, in the same way that energy does. It can be assumed that a national problem with water quality and quantity would affect the South African economy in the same way as the recent energy shortage, which resulted in a drop in economic growth of at least 2%, to the value of around R45 billion.

Table 1: Public sector budgets, 2007

GDP at current market prices (South Africa)	**1 765 305**
Total public sector	**737 619**
Total government	664 209
Central plus provincial	530 871
Central minus provincial	359 600
Provincial	171 271
Local	**133 338**
Metropoles	76 479
Local	445 516
District	11 343
State-owned enterprises	73 410
Water services budget (estimated cost)	23 094
Central government as a percentage of the GDP	**30.1%**
Total public sector as a percentage of the GDP	**41.8%**
Total local government as a percentage of the GDP	**7.6%**
Water services as a percentage of the GDP	**1.3%**

Note: All data in R million. Current costs of water services per model.

The monetary value of the impact of poor water quality can be determined by means of a high-level, socio-economic cost-benefit analysis, using social discount rates and discounted cash flow methodology. The following observations can be made in this regard:

- For potable water systems, the cost of the water quality component is about 30% of the total cost of ownership.
- For wastewater disposal and treatment plants, the cost of modifying water quality is approximately 70% of the total cost of ownership. It can then be assumed, very crudely, that the cost of providing water quality services in South Africa is approximately 0.65% of the gross domestic product (GDP). Reinstating water quality services to institutional compliance standards will require another 0.65%.
- However, improvements in water quality cannot be effected with the associated water supply services. The government is likely to have to increase its expenditure on water services by R25 billion per year in current terms.

It is also roughly estimated that the benefits of normalising South African water quality standards for priority water bodies could add as much as 2% growth to the GDP, resulting in a simple benefit-cost ratio of 1.8 (Wagner, 2008a).

8. Fundamental drivers of water quality: Key considerations for decision makers

Water security is determined by three main factors (Grey, 2007):

- Hydrologic environment: The absolute level of water resource availability, its inter- and intra-annual variability and spatial distribution;
- Socio-economic environment: The structure of the economy and behaviour of its actors, which will reflect natural and cultural legacies and policy choices; and
- Changes in the future environment: Considerable and growing evidence that climate change will play a major role in water security.

Against this broad framework, three fundamental drivers of water quality can be identified. These drivers cannot be changed, and failure to recognise them may make efforts at solution seeking redundant.

8.1 Dilution capacity

An important driver of water quality is the climate. It is generally recognised that water scarcity will be a fundamental developmental constraint to South Africa (Turton & Ashton, 2008). An important implication is that the country has very limited dilution capacity. This means that all pollutants and effluent streams will increasingly need to be treated to ever higher standards before being discharged into communal waters or deposited in landfills.

Climate change may prove to be an important driver in the longer term (Turton, 2008). Extreme hydrological events, such as severe storms, floods and drought, likewise have the potential to disrupt water supplies and cause damage to sanitation infrastructure. To the extent that there are declines in rainfall and river flow, the existing problem of limited dilution capacity will be substantially exacerbated.

8.2 Spatial development pattern

The unique spatial pattern of development in South Africa, and also the Southern African Development Community (SADC) region, presents an unusual case. All major centres of economic development, such as cities and urban conurbations, are located on watershed divides, where the global norm is for large cities to be located on rivers, lakes or the seashore. The significance of this is twofold:

- The development pattern requires major engineering and technology to supply the water needed to sustain these industrial and urban conurbations.
- Effluent return flows from major industrial and urban conurbations have a greater impact. This is because they are discharged at the top of catchments and the degraded quality of the water affects all downstream users.

8.3 Historic legacy

Having a highly unequal society means that the aspirations of the poor majority for a better standard of living, including higher levels of public services, are fuelled by daily exposure to the lifestyles of the wealthier minority. However, the financial resources to build, operate and sustain these services are often not available to all. This places extreme pressure on politicians, who are often not in a position to make what would appear to be rational choices, or to enforce policies.

The situation is compounded by the fact that poor education for the majority in the past has resulted in large sections of society not having the pool of skills required to understand and manage public services effectively. This, too, has contributed to the country's high levels of unemployment. The historic legacy creates pressure at the political level to appoint staff from previously excluded communities, even where they may lack the qualifications and experience necessary to carry out their functions efficiently. The required "demographic transition" was delayed by past policies, with the result that population growth continues to add pressure to a fixed resource (Johnston & Bernstein, 2007; Turton & Ashton, 2008).

9. The way in which these drivers impact on water quality: Cause and effect

The drivers identified above combine in specific ways to impact on water quality and the broader economic and social life of communities. Based on research and findings from related literature (Nel, 2008; Turton, 2008; Wagner, 2008a,b; DWAF, 2006, 2008; Nyathi, 2008; UNEP/GEMS, 2008), it is useful to list some of these ways, simply to demonstrate the importance of what might seem to be technical water quality issues.

1. There is a lack of ability, attitude, resources, skills and competency to comply with water legislation, standards and guides.
2. There is a lack of enforcement of legislation and standards due to the lack of ability, attitude, resources, skills and competency. (Note, in particular, the high turnover rate of appropriately skilled staff within the DWAF.) For example, there are serious bottlenecks in the implementation of the National Water Act (NWA) (DWAF, 1998), especially with regard to licence applications, the determination of reserves, the waste discharge charging system and the classification system for water resources.
3. Institutional design and deployments driven in terms of water resources and water services are poor.Ageing infrastructure creates major difficulties for operating and producing at the required levels of quality.
4. New infrastructure is often underspecified, poorly designed and constructed, and/or insufficiently integrated with existing infrastructure. For example, many wastewater treatment structures are in a good condition but are often non-operational due a lack of technical capacity. For instance, trickling biofilters and anaerobic digesters are replaced with costly, more advanced technologies, such as activated sludge plants and filter presses. This holds consequences in terms of the level of skill and financial maintenance required by these systems. The problem is compounded by the enforcement of effluent quality standards that may not necessarily justify the cost and resources required by state-of-the-art technology. In such cases, effluent standards should be reconsidered and weighted against cost-resource requirements.
5. Operating and maintenance practices at water and WWTW are poor due to a lack of resources, skills, attitude and competency, resulting in pollution of the water resources. This is particularly true for smaller works.
6. Poor operating and maintenance practices at water and wastewater distribution and collection systems result in leaks, blockages and spillages. This causes vector problems and the spread of pathogens.
7. Slow implementation is partially due to the high turnover of staff, the lack of institutional memory, immigration of skilled persons, poor retention of skilled staff in government, indiscretionary use of black economic empowerment (BEE) policies and, more recently, South African specialists competing successfully in the continental and global sector, which results a further loss of local competency and skill to the nation.

8. Insufficient access control, especially at wastewater plants, causes people to use alternative measures. For example, vacuum tank operators in some areas discharge untreated sewage into stormwater and river systems when access to treatment works is denied or restricted.
9. Poor practices in sludge handling result in a number of water quality changes, including the migration of heavy metals, phosphates and nitrates into the soil and groundwater.
10. Proper water quality monitoring, risk and safety management and response to adverse results are lacking. The analysis of contaminants in water quality monitoring is often insufficient.
11. There is an inability to translate data into practical information and action. For example, authorities ignore reports or are unqualified to interpret water quality data that may indicate the presence of heavy metals (such as lead, manganese, iron and zinc) or microbial contamination in drinking water.
12. Backup power supply is insufficient, causing WWTW and sewage pump stations to overflow with raw sewage and industrial wastewater to discharge into streams.
13. Because of poor municipal bylaws and weak enforcement of legislation, industrial and other polluters discharge waste into the receiving bodies, which affects water quality.
14. The rapid growth of urban slums is compounding the problem of pollution, as stormwater runoff from these areas is often highly polluted. This "diffuse pollution" is difficult to manage, creating a significant socio-economic burden.
15. The poor quality of water in rivers and dams inhibits both urban development and tourism. Investors perceive water quality incidents as part of their systemic risk in investing in South Africa.
16. Poor water quality affects private and public game lodges, as well as provincial and national parks, causing environmental damage and a decline in tourism.
17. Pollution of the South African coastline and territorial waters caused by inland rivers, marine outfalls and shipping is affecting marine life which, in turn, has an economic impact.
18. Agricultural practices, such as the use of pesticides, insecticides and fertilisers, are affecting water quality by releasing toxins, salts and organophosphates into the water environment.
19. Indiscriminate deployment of boreholes has resulted in the discharge of poor quality water to the surface, thus contaminating streams with fluorides, salts and heavy metals. It also lowers water tables, impacts on the vitality of trees, and interferes with the replenishment of groundwater.
20. The policy of indiscriminately removing so-called alien trees has caused changes in water tables, wind erosion and general ecological change. In some cases, this has brought about degradation of water quality.
21. Due to population growth and industrial development in a country where water is not plentiful, the available water resources are hard worked. Water therefore needs to be recycled, treated and well managed.
22. Constitutional change and the unpreparedness of local governments responsible for water services (burdened by the transfer of DWAF assets and staff to municipalities) have led to a downhill slide in water services management and delivery capacity.

23. Underinvestment in water infrastructure is a major cause of diminishing water quality.
24. Overambitious service delivery targets, especially for sanitation, have placed a huge burden on the infrastructure and ability of existing WWTW to treat additional loads. The result has been one service's "achievement" compromising that of another service, mostly with a detrimental effect on water quality.
25. Overreliance on grant and donor funding and freely deployed expertise has created a culture of dependency, which distracts from the focus on financial sustainability and accountability. Public utilities and local authorities are not financially sustainable, and private sector investment in the water sector is not forthcoming.
26. Providing water services is an economy-of-scale business that is best delivered over large regional areas. Demarcating local governments into numerous smaller councils, together with a two-tier system, creates further problems that make water quality compliance and management both costly and difficult. South Africa's 19 catchment management agencies (CMAs), which are responsible for WRM within the boundaries of the water management areas (WMAs), are unlikely to have the resources to execute their duties fully.
27. The coordination of programmes, projects, information and initiatives in the country remains inadequate, and information sharing imposes significant constraints on decision making. Duplication in effort and recycling of non-value-adding information, at some expense to the taxpayer, are generally observed.
28. The role of water management is fragmented among national government, regional implementing agents, local governments and CMAs.
29. In some areas, the mining industry continues to expose its workers and local communities to harmful radioactive-contaminated water.
30. Clouds and vapour in the air generally deliver water of good quality, containing nitrogen fixated through electric charges. However, over industrial areas with serious air pollution, many micropollutants will be returned to the surface in the form of acid rain, for example.

10. Back to basics: Integrated water quality management

The principles underpinning the conceptual model for integrated water quality management in South Africa remain valid and more necessary than before. However, the normalisation of water quality must be newly institutionalised (Heath, 2008; Bhagwan, 2008; Nel, 2008; Wagner, 2008b).

- *Water should be properly valued.* It is not only important to ascribe value to water based on its availability and increasing scarcity. "Value", in the context of water, should include the downstream costs of pollution, social and economic values, the value of wastewater, the significance of clean water in terms of public health, and even the price of not having water. The concept should, therefore, encompass an understanding of the different values of water and not be limited to the mere fact that there is not enough water.

- *Institutions responsible for managing water should be accountable for water quality.* Accountability is the obligation to demonstrate, and take responsibility for, performance in the light of commitments and expected outcomes. Accountability in respect of water quality is currently unclear because of the complex institutional framework that exists. As accountability implies that someone is accountable to someone else for something, it is important to ensure that responsibilities on all sides are clearly defined. Parties to whom institutions are accountable should clearly understand the standards at which water must be managed, in order for them to assess whether institutions are fulfilling their obligations with regard to water quality. Finally, commitment to management practices that will ensure good quality water should be evident at all levels, both within and across the spectrum of water management institutions.

- *Water quantity and water quality are inextricably linked.* It is important to ensure that this statement is consistently recognised in all aspects of water management. Poor quality water will reduce the quantity of water available for use, while having less water will increase the effect of contaminants on the water. While this seems to be stating the obvious, much of the documentation, legislation, regulations or research addresses either water quantity or water quality, instead of both.

- *The polluter pays principle should be applied to the true cost of water pollution.* This principle is well known and widely accepted in environmental policy that is applied internationally through various mechanisms. It does, however, raise the question as to what exactly the polluter should be paying. In the case of water pollution, there are always "downstream costs" to a pollution incident. This term should be understood in both its literal and figurative sense. There may be costs to water users physically downstream of a pollution incident, and there may be significant costs over time owing to environmental deterioration at the site and physically downstream of the incident. Furthermore, downstream costs could refer to indirect costs, such as the cost of a community not being able to develop as a result of the lack of clean water. It is important, therefore, that the polluter pays principle encompasses the expanded definition of "pays what?".

- *Short-term economic gain at the cost of increasingly deteriorating water quality is unacceptable.* This principle refers mainly to the practice where fees are levied on enterprises that discharge wastewater into sewers, the discharge which then has an impact on the WWTW and its capacity to operate optimally. It is unacceptable if the discharger simply pays higher fees when the downstream cost of discharging is creating a serious long-term impact on the water resource. The short-term economic gain received by levying charges should be balanced against the total cost of wastewater entering the resource. This principle is closely related to the need to value water appropriately.

- *Everyone should have access to water quality information, not data as such.* All who use water have some responsibility for the overall quality of water. Because water quality is largely a technical issue, most of the information disseminated about it is technical. While this is necessary at certain levels of responsibility, new and innovative ways to package information about water quality need to be found. It is important that there should be some understanding about water quality at all levels, and this will require a rolling-out of water quality data in more broadly understood formats.

All of these principles are part of the broader IWRM approach that is reflected in South Africa's overall policy and legislative framework. In the matter of water quality, as in the broader approach to water, the challenge is less about identifying new policies and approaches and more about implementing what has already been put in place.

11. Areas for strategic improvement and intervention

There is a range of areas in which intervention and improvement are required.

11.1 The value of water

More work is needed to understand the value of water (including wastewater), incorporating issues such as cost-benefit incentives and recycling initiatives. A cost-benefit analysis should be carried out for some of the scenarios (Wagner & Manus, 2008).

11.2 Documentation systems

The status and performance of South Africa's water and wastewater, in terms of both quality and infrastructure, are poorly documented, and limited real-time information and data are available. Systems such as the Electronic Water Quality Management System (eWQMS), the River Health Programme and water management systems are meaningful tools. A national water quality inventory and scorecard system will also add value. The development of the DWAF's Regulatory Performance Measurement System (RPMS) and the incentive-based Blue and Green Drop Certification Programme is noted. In these systems, performance and compliance scores will be produced (with dashboard visual technology) against weighted criteria aligned with the National Benchmarking Initiative for Water Services. This programme should be fast-tracked and released for public scrutiny.

11.3 Public awareness

Related to the above, public awareness and access to information are crucial. The DWAF's announcement (in September 2008 at the Municipal Indaba) in terms of the Blue and Green Drop Certification Programme is encouraging. In parallel, a campaign to raise awareness of water quality needs to be held and communicated to all South Africans. This communication programme should include key themes, such as water security, demand management, water quality, supply planning, capacity building, conservation, and the importance of water in a growing economy. These are issues that many consumers are unaware of. Unless a proactive plan is formulated to educate water consumers, even at the lowest levels, there will be insufficient awareness of the significance of water in the economic value chain.

11.4 Communication and accountability

Improved communication between water management institutions will strengthen cooperation and maximise outputs, while eliminating the duplication of efforts and disincentivising the recycling of non-value-adding products. This will leave much-needed resources, both human and financial, to tackle the remainder of the challenges.

Accountability needs to be strengthened, through measures such as the polluter pays principle, the enforcement of bylaws and other legislation, and the implementation of an effective government "watchdog" institution.

11.5 Institutional capacity

Improving institutional capacity remains high on the priority list. Suggestions from the sector include the establishment of regional, economy-of-scale and compliant water utilities. These would serve to regionalise, concentrate and mobilise all remaining capacity, as well as optimise operations and services delivery.

Also related to capacity building and support is the establishment of a national support and response centre for water quality management, which could take the form of a Water and Effluent Quality Innovation Centre. An all-hour professional service should be instituted to assist in matters such as problem identification, problem solving, improved methods, technology choices, and assistance to water services providers with capacity or complexity problems. The centre should be the embodiment of an innovation strategy for drinking water quality, which should include dedicated resources, funding, facilities, people and political support.

11.6 Regulation

The DWAF should reconsider its status as an agent and facilitator, and gear up its regulatory action and implementation. The matter of an independent regulator should also be considered.

11.7 Research

Research support should be increased, as the needs are plenty and the solutions few. Key research areas come to mind, such as alternative and appropriate technologies; reassessment of certain established parameters, such as resource quality objectives (RQOs); as well as issues pertaining to indirect costs, microcystins and radiation risks.

11.8 Water quality management framework

The implementation of an integrated framework for water quality management will require redressing certain strategic elements and taking new, pragmatic approaches. Ultimately, these should result in broad-based strengthening of the water sector and translate into improved quality of both water and effluent. A wide range of further detailed interventions could therefore be made.

Management options for improving water quality include the following:

- Effluent from WWTW and sanitation systems should be audited in terms of the current functionality of these systems. For instance, are they working according to specifications? Do they have appropriate technology and planned expansions? A plan of action or programme should be agreed with local municipalities and its implementation monitored. Repeated audits should be based on a predetermined schedule, while keeping compliance monitoring in place.
- Continual, routine monitoring of surface and groundwater resources is required to evaluate the salinity and eutrophication status of dams and rivers; to evaluate compliance with RQOs; and to detect early signs of deterioration in water quality.
- The salinity and eutrophication levels in major rivers and tributaries should be controlled as a matter of priority.
- The development of integrated water quality management strategies for the country should continue.
- The basis of the system should be the management of water resources in terms of the targets for integrated RQOs, which have been developed at a desired level of protection and sustainability.
- Mines and industry need to improve the management of water resources in their systems through more effective monitoring, assessment and reporting. They should be forced to supply a five-year forecast of volumes of water held in storage, discharge volumes and discharge qualities. Mine closure plans and closure funds need to be audited. A monitoring programme should be implemented for in-stream water, compliance and transfer water. Charges for waste discharge should be set for mines and industry in order to offset disadvantages.
- Ageing infrastructure should be replaced optimally, while working at remaining infrastructure backlogs. When considering infrastructure and technology options, the emphasis should be on robust structures that take scarce skills, attitudes and financial resources into account. This is important, as labour legislation makes it difficult and cumbersome to discipline negligent or obstructive staff. Current Sector Education and Training Authority (SETA) arrangements also make it difficult to develop and advance the right skills and competencies required to match the sophistication of the infrastructure and technology involved.

Sectoral, strategic and policy aspects to be considered include the following:

- Both the public and private sectors should add the matter of water quality to their development agendas and address it as a development issue. Important economic sectors include health, mining, process industry, agriculture, tourism, conservation and parks, water and energy (Gibbons, 1986).
- The introduction of creative water gaming at primary, secondary and even tertiary levels should be given serious consideration. These games can be used to aid water users and managers' understanding of the challenges associated with IWRM, water security and water quality. For example, they are led to recognise the effect that inadequate planning and poorly maintained infrastructure and treatment systems has on human and animal productive capacity. An example of such a game, called WATER ALERT!, can be found at www.unicef.org/voy/wes/.

- A strategic approach is required to monitor and react to global climate change and extreme events as part of an international grouping, if possible.
- Urban densification should be incentivised to help control urban sprawl, which is a major cause of problems with water quality. At the same time, close cooperation is needed between the technical units responsible for infrastructure planning and the local economic development units in municipalities responsible for spatial development.
- The South African Constitution should be amended to remove the power and duties from local government in respect of water services, and to make provinces or even the central government to serve as WSAs in the same way that they are responsible for water resources. If it is argued that provinces and the national government face the same constraints as local governments, then there would be no alternative but to ensure that local government is truly effective.
- In order to facilitate other management options, such as the privatisation of water services, institutional changes need to be made to the Water Services Act (DWAF, 1997) and its regulations, the Municipal Finance Management Act (MFMA) (DPLG, 2004) and the Municipal Systems Act (MSA) (DPLG, 2000). This would include changing the process in Section 78 of the MSA. In many cases, officials from the Municipal Infrastructure Grant Project Management Unit (MIG PMU) and other technical municipal officials have identified procurement and overly strict supply chain management policies to be a bottleneck in the quest for service delivery and adequate repairs and maintenance.
- If unclear, the various roles, responsibilities and accountability for service delivery should be clarified and assigned, and penalties for non-performance implemented. Although performance management systems are widely implemented, they are often not applied as intended or designed.
- The use of an assessment tool for evaluating performance may be useful. Annexure B presents such a tool for the systematic evaluation of the DWAF's performance, measured against European Union (EU) benchmarks. Ideally, such an assessment would be carried out with relevant stakeholders on a "360 degree" basis.
- The private sector needs to be actively engaged in the process of programme management, coupled with public sector support and political will and buy-in from the government to succeed. Civil society is not engaged optimally and its potential contribution to service delivery and water quality should be harnessed.

12. Concluding remarks

Both the quality and the quantity of water underpin water security in South Africa (Grey, 2007).

Emerging threats to water quality include waterborne and water-related pathogens, as well as chemical contaminants, such as industrial chemicals, pharmaceuticals and personal care products. These threats are driven by depleted dilution capacity, skewed spatial development, historic socio-economic legacies and, in the longer term, climate change.

It is clear that the state of water infrastructure, as well as the institutional capacity to underpin investments made in such infrastructure, is seriously affecting the country's ability to support sustainable economic and social development. Potential gains from investments are often constrained by the lack of ability to operate and utilise them effectively.

Since management requires measurement, much more effort is required to strengthen and maintain water quality assessment, management and audits. "Regulation with teeth" becomes an increasingly vital and necessary component, and is high in demand by municipal officials, the private sector and other key stakeholders. The challenge is one of strategy – prioritising and sequencing interventions so that the limited resources that are available can be deployed with maximum impact.

In responding to some of the opening remarks and questions, the following conclusions can be made:

- Yes, South Africa should be concerned about the state of the country's water quality. Feeding substandard and polluted water into water resources (whether dams, groundwater, rivers or storage areas) impacts on the quality of the receiving water resource. This environmental tradeoff affects the availability and cost of extracting the water for other uses, which again impacts on the cost and quality of water services. This, in turn, has further economic tradeoffs.
- Yes, a direct link exists between water quality on the one hand, and the water resource and water services on the other hand, which are critical elements of water security. A strong agenda for water quality is good socio-economic policy.
- Yes, improved drinking water quality contributes significantly to increased production and productivity within economic sectors.
- Yes, underinvestment in water services reduces the economy of scale; increases the ultimate cost of service provision; places demands on water storage; and is a major contributor to poverty and the national health burden.
- No, investment in water quality and its various enablers is not simply necessary, but is absolutely critical and non-negotiable if a water-secure country is envisioned.
- No, water quality as a critical dimension of water security cannot easily be delinked from growth and the economy – not without serious environmental and social tradeoffs.

"The era of procrastination, of half-measures, of soothing and baffling expedients, of delays, is coming to its close. In its place we are entering a period of consequences."

Winston Churchill, 1936

Appendix A

Proposed Self-Assessment of the South African water sector's performance as benchmarked against EU performance indicators

Table 1: Raising the policy profile

EU benchmark	Self-assessment of performance
Supply: Ensuring supply to every human being, especially the poorest, of sufficient drinking water of good quality and adequate means of waste disposal	
Management: Sustainable and equitable trans-boundary WRM	
Coordination: Cross-sectoral coordination to ensure fair and appropriate distribution of water among users of different kinds	

Table 2: Implementation of an integrated approach to water management

EU benchmark	Self-assessment of performance
Awareness and participation: Users should be aware of the importance of water as a resource and of their responsibilities in relation to sound management of this precious resource. Ownership is a key factor in the success of the policies, and the participation of actors at all levels is therefore essential.	
Institutional capacity building: The success of activities depends largely on the capacity, resources and expertise of the institutions concerned. Institutions responsible for water management should therefore be supported.	
Demand-based management: It is not enough to manage water distribution; supply should also be managed. The challenge is to reduce demand while increasing output through initiatives such as reusing water, protecting water resources, etc.	
Expansion of the knowledge base: The necessary knowledge and information are essential for drawing up effective policies.	
Coordination: Coordination is needed among all stakeholders, such as the DWAF, the Department of Provincial and Local Government (DPLG), non-governmental organisations, donors, etc.	

Table 3: Water-related actions for different uses

EU benchmark	Self-assessment of performance
Supply: Water supply and adequate sanitation should be secured for all. Emphasis is placed on the importance of sanitation.	
Agriculture: Where water is used in agriculture to ensure food security, the importance of saving water should be promoted, as well as healthy agricultural practices to avoid contamination of water sources.	
Resources and ecosystems: Water resources and ecosystems should be protected and restored to contribute to the long-term sustainability of water use.	
Energy: As water is also a source of energy and resource to industry, rational water use should be ensured and pollution reduced and prevented.	
Risk: Water-related risks relating to coastal areas, floods, droughts, etc. should be prevented and managed through the establishment of warning systems and rapid response capacity systems.	

Appendix B

SAICE rating in four key performance areas

In an article published in *Engineering News* dated 18 July 2008, Jacqueline Holman paints a rather gloomy picture of the state of water in South Africa (Holman, 2008). The concern about water supply systems was sparked by the country's power crises at the time. A summary of the observations made by Dr Chris Herold, chairperson of the South African Institution of Civil Engineering (SAICE), is presented below.

Table 1: Evaluation of key performance areas

Key performance area	State of the nation – South Africa	Comments
Demand management as a critical tool	There is increasing concern about the DWAF's water supply planning. Demand management is not being implemented by local authorities. The benefits of demand management are diminished where people do not have to pay for water. A behavioural change towards water use is necessary. Climate change can pose a huge threat to water supply.	Demand planning requires sufficient capacity at municipal level and sufficient political will to implement. If the pattern of water use is not changed, water supply shortages will be the outcome. A water supply system is not a binary on/off system and has to be managed accordingly.
Middle management gap	There is a lack of capacity and a huge loss of engineering expertise. The promotion of inexperienced personnel is demoralising for experienced staff.	Experienced personnel are feeling the brunt of the load and are either retiring or moving to the private sector. Employees at lower levels do not persist and readily move to positions in the private sector.
Education	There is a rapid decline in educational standards. Some 95% of students entering tertiary education are not eligible to study engineering. There is a lack of career guidance at schools. There is a problem attracting and retaining quality Mathematics and Science teachers.	More effort has to be made to advertise engineering as an attractive career.
Water engineering industry	The industry value is estimated at R14 billion per annum if all upgrades and refurbishments are carried out. The DWAF considers groundwater an important aspect of future water supply. Water quality is a growing concern, with more pollution and strain on resources that will intensify over time.	Water recycling can be useful in some industries, but is not the panacea to demand management. Recycling in coastal areas is cheaper than discharging sewage into the sea and then desalinating it.

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List of tables and figures

List of acronyms and abbreviations

AMD	acid mine drainage
BEE	black economic empowerment
CAGE	Conflict and Governance Facility
CMA	catchment management agency
CSIR	Council for Scientific and Industrial Research
DBSA	Development Bank of Southern Africa
DPLG	Department of Provincial and Local Government
DWAF	Department of Water Affairs and Forestry
EDC	endocrine-disrupting compound
EU	European Union
eWQMS	Electronic Water Quality Management System
GDP	gross domestic product
GEMS	Global Environment Monitoring System
IMF	International Monetary Fund
IWRM	integrated water resources management
MFMA	Municipal Finance Management Act
MIG PMU	Municipal Infrastructure Grant Project Management Unit
MSA	Municipal Systems Act
NWA	National Water Act
RPMS	Regulatory Performance Measurement System
RQO	resource quality objective
SADC	Southern African Development Community
SAICE	South African Institution of Civil Engineering
SARB	South African Reserve Bank
SETA	Sector Education and Training Authority
SIWI	Stockholm International Water Institute
TDS	total dissolved solids
UNEP	United Nations Environment Programme
WfGD	Water for Growth and Development
WISA	Water Institute of Southern Africa
WMA	water management area
WRC	Water Research Commission
WRM	water resources management
WSA	water services authority
WWTW	wastewater treatment works

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Water quality: A vital dimension of water security	Paper prepared by: Marlene van der Merwe-Botha (The Water Group)
Water resources management, rural redress and agrarian reform	Paper prepared jointly by: The International Water Management Institute (IWMI) and the Institute for Poverty, Land and Agrarian Studies (PLAAS), with contributions by Barbara van Koppen and Hilmy Sally (IWMI) and Michael Aliber, Ben Cousins and Barbara Tapela (PLAAS)
Challenges for human capital development and technological innovations in the South African water sector	Paper prepared by: Eiman Karar (Water Research Commission) and Kevin Pietersen (Water Geosciences Consulting)