Water safety planning and implementation: lessons from South Africa

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ABSTRACT

Water Safety Planning is an innovative way of attaining high quality of water service provision through embracing a risk-based approach to service provision. This paper describes the water safety planning journey of Ugu District Municipality, which manages 19 formal water supply systems. The municipality adopted the Pareto 20/80 rule of targeting 20% of the areas with 80% impact in the first iteration of the WSP by targeting the systems with the greatest impact while incorporating system knowledge from all other systems and the use of an extensive hazards database. The efforts received national recognition and built teams with improved understanding of the business resulting in improved water quality management. Operationalization of the plan was the most difficult task as it requires institutionalizing best practice amidst challenges that include limited funding, lack of support from critical stakeholders, staff shortages and attrition. A dedicated champion who will be an advocate for change management, proactive stakeholder engagement and senior management commitment with corresponding financial resources, are seen as prerequisites for success.

Undeniable, progressive regulations and policies set the tone and foundation and are, in most instances, the drivers for water safety.

Key words | risk management, Ugu district municipality, water safety planning

INTRODUCTION

Drinking Water Quality Management in South Africa has, in recent years, been undergoing critical reforms. Noteworthy is the introduction of incentive-based regulation in the form of the Blue Drop Certification programme in 2008 (DWA 2012), where municipalities are recognized for their excellent drinking water management through the Blue Drop Awards. These incentive-based regulations have generally been the key drivers in the adoption of risk-based management of water supply systems through the application of water safety plans as part of compliance requirements. Furthermore, in the latest edition of the South African National Standard for drinking water, SANS 241:2011, water safety planning is a key requirement of drinking water quality management, a step further from the previous purely health-based target regulations.

A Water Safety Plan is an improved comprehensive risk management tool designed to ensure delivery of safe drinking water to the consumer by preventing contamination of source waters, treating water to reduce or remove contamination in order that water safety targets are met and preventing re-contamination during storage, distribution and handling of water (World Health Organization 2005). These plans are extensively documented in literature, examples of which include Godfrey & Howard (2008), Thompson & Majam (2009), Bartram et al. (2009) and World Health Organization (2011).

This paper describes the water safety planning journey of Ugu District Municipality, a small to medium-sized municipality located in the southernmost end of the KwaZulu Natal Province of South Africa. Its jurisdiction encompasses what is commonly referred to as the South Coast of KwaZulu Natal. It extends approximately 5,866 km² with a spectacular coastline of 112 km forming its eastern border, and has a population density of 76–312 persons per km².
for the six local municipalities that comprise the district. The average population density is 140 persons/km², which is relatively sparse. Ugu is predominantly rural with an estimated population of 878,000, of which 10% is urban, 10% reside on commercial farms and the remaining 80% live in rural areas.

The municipality manages 19 formal water supply systems comprising 19 conventional water treatment works with a combined capacity of 106 Ml/day and reticulation networks of over 4,000 km of water reticulation (bulk and distribution) with supporting infrastructure of 150 reservoirs, 120 pump stations and about 300 telemetry outstations. Figure 1 summarizes the bulk water infrastructure within the municipality. The majority of the water treatment works are run-of-the-river systems subjected to highly variable water quality and quantity through the year. The spatial distribution of the infrastructure over a thousand hills and the remoteness of some of the waterworks compound the operation and maintenance challenges.

The formal water systems only cover about 70% of the population and the remainder get their water through the extensive municipal tankering programme, which consists of up to 20 water trucks (between 8 and 18 kl each) traversing the district on a daily basis. An additional much smaller proportion gets its water from protected springs and boreholes.

**PREPARATORY WORK**

Water safety planning was initiated within the municipality early in 2008 with the main objective being to adopt best practice and a proactive management approach of anticipating and avoiding drinking water quality failures, which were problematic for some of our water works. Compliance was, therefore, not a critical issue at that point but has over the years become as important as, if not more important than, Blue Drop regulation.
and the revised SANS 241, whose implementation is imminent.

Assembling the team

A decision was taken to utilize internal resources and skills as opposed to the use of consultants as was the typical choice for unfamiliar activities. The main reason for this decision was to embark on a learning journey to enable staff members to internalize the process and be able to do their respective tasks differently upon realizing the inherent and possible risks of doing business in certain ways. Furthermore, it is believed that the teams, consisting of engineers, technicians, scientists, operators and artisans, albeit fewer than would have been preferred, were not only competent enough but were the people most familiar with the systems and were able to identify and articulate the risks. In keeping with best practice, other external stakeholders and experts were invited to be part of the process and a senior manager responsible for operations was appointed as the team leader.

Initial workshops explaining what a water safety plan is and the process of compiling one were done to ensure that everyone had an understanding of what was required. Although these workshops were useful, it was realized after a while that even though the majority of the concepts were not necessarily foreign and are aspects of daily work for some, an adaptation of the terminology used in reference material to local common terms would have been far more beneficial.

The main challenges relating to assembling a team included convincing other departments within and external to the municipality and other stakeholders that did not really see their contribution to water safety to be part of the team; the commitment of team members once they were officially part of the team; and finding time for key resources to work on this project while carrying out their daily activities, particularly in resource-starved areas. The lack of commitment meant that there were different people in different meetings, particularly in the internal municipal departments and external institutions on which the team leader had no direct influence.

SYSTEM ASSESSMENT

The goal of system assessment was to systematically evaluate the capability of the various drinking water supply chains from catchment to consumer to deliver acceptable quality of water in compliance with the health-based targets of the SANS 241 WQ standard. What became an immediate challenge was the number of the supply systems that needed to be visited, assessed and analysed. To put it into context, travelling time to some of the water treatment works from the head office in Port Shepstone can take four to six hours in total, leaving only about two to four hours of actual work within the works and the catchment. Against a background of commitment issues with the technical team, it was almost impossible for the first iteration of the water safety plan to have time to carefully assess all the systems individually. This led to an important departure from standard practice where it was opted to comprehensively assess the system that had the greatest impact in terms of population and treatment capacity whilst at the same time involving staff and operators from other systems to give their perspective and input from those systems. To further compensate for this choice, tools were chosen that were believed to assist in the consideration of the widest variety of hazards in all systems. A literature review on this subject led to the comprehensive TECHNEAU hazard database (Beuken 2008) and a locally developed tool for assessing water supply systems by the Thompson & Majam (2009). Subsequent reviews of the water safety plan have, however, been done per system using the baseline derived from the first edition.

Documenting the systems

Works managers and their supervisors were given the task of mapping the processes of each of their plants in line with the template provided by the Thompson & Majam (2009), particularly for the smaller systems that were not part of the initial site visits. These were shared with the teams followed by brainstorming sessions to fill in the gaps, together with available GIS and CAD drawings. A brief overview of the TECHNEAU hazard database was also discussed as part of the preparation for a detailed site visit on the selected Bhohboyi/UMzimkhulu system, which supplied up to 60% of the water in the district, and
subsequent smaller team visits to the Umtamvuna system, which supplied an additional 20%. These site visits served as verification of the systems description and also for hazard identification.

In general, the catchment land use of the municipality is broadly composed of 12.7% urban, 22.3% forest, 35.5% grassland and 29.5% sugarcane plantations and forestry plantations. The main activities in the catchment that have a negative influence on the water quality include:

- Effluent discharge from wastewater treatment facilities
- Forestry and agriculture activities
- Settlements with inadequate sanitation
- Discharges from industries (sweet factory, soap factory, cement factory) – industrial activity is, however, very limited within the municipality
- Seawater intrusion during low river flow periods in the winter months
- High sediment loading and turbidity in the rivers towards the coast.

However, the source of all the water is more or less in a predominantly pristine rural environment or sugarcane plantations with the exception of Umzinto, KwaHlongwa and Hlokozi systems, which are downstream of the settlement areas and suffer higher E. coli counts in the raw water from time to time. Another environmental challenge was the flood events that happened from time to time and destroyed both water and sewer infrastructure.

The majority of the plants have a design capacity of less than 0.6 Ml/day and consist of modular package plants with conventional water treatment processes, with a number of pressurized filters. The bigger plants all have conventional treatment processes with a combination of pH correction, coagulation flocculation, settling/clarification, filtration and disinfection with chlorine gas or HTH. Compliance levels with respect to the quality of the water produced against the SANS 241 standard are at 100% for about 40% of the systems as per the 2012 Blue Drop audit. The treatment plants also have comprehensive standard operating procedures in place, including both compliance and operational monitoring of water quality.

With the exception of a number of pockets where no information exists, the distribution network is largely documented, with house connections in the urban areas and mostly communal stand pipes in the rural areas and a few house and yard connections. Due to the rugged terrain, pipelines transverse through a number of valleys with river crossings, the majority of which are under the river. Coupled with high water tables in some parts of the municipality, negative pressures together with on-site sanitation facilities such as septic tanks and conservancy tanks (aka cesspits) are some of the imminent threats to water quality. The condition of the reticulation network was largely unknown, particularly within the coastal strip, but the higher burst frequency was indicative of a relatively poor condition in some areas. Intermittent supply was a challenge for a number of the rural schemes and certain sections of the urban systems mainly related to capacity constraints.

Catchment management was one of the areas where there were no active roles and responsibilities and remains a challenge to this day. However, through the water safety planning activities, key contacts for industries with an impact on the water supply were established and the good working relationship is beneficial.

**Hazard identification and risk assessment**

The TECHNEAU hazard database (Beukin 2008) was used as the baseline document for collecting information and was used together with other information collected during site visits and brainstorming sessions. A number of lengthy workshop sessions of going through the database noting relevant hazards and scoring both the likelihood and consequences were done according to the matrix shown in Table 1 derived from Thompson & Majam (2009). Risk ratings of very low, low, medium, high and very high were given scores of ≤5, 5–10, 11–15, 16–20 and >20, respectively.

The ranking of the likelihood was a purely qualitative ‘gut-feel’ exercise as there were no historical data on occurrences and, as such, much emphasis was placed on operator and field staff. Surprisingly, there were no hazards with a risk rating of ‘very high’, although there were quite a number that were in the high region.

There were also a number of interesting high ranking hazards that were unearthed such as lack of registered servitudes (aka wayleaves) and access roads to critical infrastructure that were accessed through private land and roads. Challenging and questioning current assumptions
and norms was an invaluable tool during the exercise as was viewing daily operations through a risk lens.

**CONTROL MEASURES**

For each of the relevant hazards with a high and medium risk rating, control measures, critical limits, monitoring details (what, when, who), corrective actions and verification of the efficacy of the control measures were compiled. The remainder of the lower ranking risks were placed on a watch-list.

The control measures ranged from easy and highly cost effective quick fixes, such as improving access control to reservoirs and treatment works sites to the rather costly measures such as the training of the available operators, recruitment of critical staff and operators particularly for unmanned plants, making adequate provisions for maintenance and implementing pipe replacement programmes. Because of the capital intensiveness of some of the control measures, they were packaged into programmes to be carried out over a few years. Budgetary constraints were, however, a reality that negatively impacted progress.

Validation of control measures for the quick-wins was mostly centred on the already well-established control and monitoring points in the systems consisting of raw water sampling points, treatment works process and effluent monitoring and the monitoring of critical areas within the distribution systems. Furthermore, uniformity was introduced at all manned plants to reinforce the hourly operational monitoring of water quality. Reassessment of the control measures that are not quality related has remained elusive with the lack of maintenance and incident management data as the commissioning of the maintenance management system has been fraught with difficulties.

Ownership and implementation of some of the control measures, particularly those falling outside Water Services Operations, was also a challenge as it was not seen as a priority by supporting departments nor was it part of their KPIs. The adoption and understanding of water safety planning by entire municipal staff, particularly non-core functions, remains a challenge, although significant inroads have been made.

**IMPROVEMENT PLANS AND SUPPORTING PROGRAMMES**

A number of control measures necessitated the development of programmes and improvement plans to ensure that the identified risks were appropriately mitigated. Some of these improvement plans included:

- **Water treatment plant refurbishment and reconstructions.** Major work done to date includes the replacing of filter media in the two largest treatment works, the addition of a sedimentation basin in one plant and the refurbishment of various other plants.
- **Reconfigurations of the organizational structure within Operations to form a dedicated treatment function that minimized dual reporting and travelling times to treatment works.** While this structure has been supported by senior management, its implementation has been unsuccessful due to on-going embargos on filling new posts.
- **Utility mapping exercise to improve the operation and maintenance of reticulation infrastructure.** The utility mapping exercise was completed in 2011 for the two major water supply systems and will be rolled out to the rest of the systems when funds are made available.
- **The implementation of a maintenance management system to help achieve maintenance objectives and other water safety plan imperatives.** The functional design of the system was completed in 2010 and, although the system has been commissioned, it has a number of challenges that render it non-functional.
- **The establishment of a technical control centre to coordinate all work while supporting a reconfigured**

### Table 1 | Hazard assessment matrix

<table>
<thead>
<tr>
<th>Likelihood</th>
<th>Rating</th>
<th>Consequence</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost certain (once a day or permanent feature)</td>
<td>5</td>
<td>Catastrophic (death expected from exposure)</td>
<td>5</td>
</tr>
<tr>
<td>Likely (once per week)</td>
<td>4</td>
<td>Major (population exposed to illness)</td>
<td>4</td>
</tr>
<tr>
<td>Moderately likely (once per month)</td>
<td>3</td>
<td>Moderate (large aesthetic impact)</td>
<td>3</td>
</tr>
<tr>
<td>Unlikely (once per year)</td>
<td>2</td>
<td>Minor (small aesthetic impact)</td>
<td>2</td>
</tr>
<tr>
<td>Rare (once in five years)</td>
<td>1</td>
<td>Insignificant (no impact)</td>
<td>1</td>
</tr>
</tbody>
</table>
customer call centre. These two centres started operating in 2010 on a skeletal basis, but have been fully functional since 2012.

In addition to the improvement plans, the following are some of the supporting programmes initiated to improve our ability to deliver safe water to the consumers:

- Online Drinking Water Monitoring of all plants to measure the key parameters such as residual chlorine, turbidity, conductivity and pH. The installation of online meters was completed in 2011 but, due to funding shortfalls, a number of the rural plants that are unmanned at night are yet to be connected to the telemetry network.
- Infrastructure Replacement and Refurbishment Programme for the dilapidated infrastructure, the elimination of dead ends in the network that were highly susceptible over time to poor water quality and the replacement of corroded GI pipes that compromised the quality of the water delivered to some consumers. This was an extension of planned off-channel storage dams meant to improve water quality and short-term quantity assurance. This programme has been done annually since 2007 and has relatively the biggest share of funding, albeit still insufficient.
- Information Management Systems and Integrated Telemetry as opposed to the use of spreadsheets on individual PCs that made integration and contextualization of the information a challenge with another critical risk of losing critical performance data. The telemetry system also required upgrading to remove poor configuration and security vulnerability. The information management system was rolled out in 2009/2010 whilst only the master planning of the telemetry systems has been completed to date and the implementation is dependent on financial resources.
- The establishment of a Quality Management System has been one of the elusive targets, particularly for the treatment and call centre function. The main challenge has been the failure to allow the identified and trained champions to work on developing the system entirely due to staff shortages in other activities that form part of their core duties.

A number of management procedures were also created to support the water safety plan and include an Emergency/Peak Season Preparedness Plan and an Incident Management Protocol. The former document has particular significance to the municipality as it is largely a tourism destination and it is of paramount importance that the peak demands experienced during holidays and long weekends are met and are also at the right quality.

LESSONS LEARNT

The benefits of the water safety planning as applied and derived by Ugu District Municipality cannot be overstated. Not only did the water safety plan receive national recognition in 2010, but the journey itself helped build a team that is not only confident in its ability but made the team members understand their business better and the hazards inherent in the business and helped them achieve water quality management that has been rated good, very good and excellent. This came with the corresponding improvement in operations and maintenance and improved water quality. The source to sink approach advocated by the water safety plan approach has also tremendously changed the way operators and other technical staff see and carry out their daily operations in other areas that are normally not thought to have an impact on water quality such as planning and design. As such, water safety planning provided a new unifying and clearer perspective to the many different activities that were traditionally performed without consciously considering the impacts on water quality. This clarity of purpose created an enabling environment for staff buy-in, which had previously been inadequate.

However, operationalizing of the plan was by no means an easy task as internalizing the plan took more effort and time than simply ticking the boxes on a compliance checklist. A sponsor who not only is senior enough to account for most of the areas covered by the plan but also will consistently serve as the advocate for use of the plan in all daily operations was seen as a critical prerequisite as people tended to gravitate toward old practices and habits. Change management and proactive stakeholder engagement were also identified as other key components required in implementing change to align with the adopted risk-based approach. This facilitates an understanding of the role of all stakeholders in the delivery of safe, clean water to consumers, thereby increasing the likelihood of obtaining their buy-in. The foregoing becomes easier when water safety
planning is harmonized with other municipal risk assessment exercises resulting in an inclusive corporate risk register. Failure to do so renders water safety risks unimportant and is hypocritical at best, particularly for municipalities whose core business is water provision.

The progressive Blue Drop regulations have been one of the key enablers of political and senior management support for water safety planning, which Ugu still enjoys to date. The role of progressive regulation is therefore undeniably necessary, particularly for utilities that do not willingly adopt best practice and only approach water safety planning to score compliance points. Most importantly, as was in Ugu, it raises the profile and importance of water safety planning as an integral part of the public sector. This improves the prioritization of the resourcing of water safety requirements that tend to take a back seat to some political expedient grandiose activities.

However, adequate financial resources to implement the required control measures to guarantee water safety remains the greatest of enablers of water safety planning as all other efforts can only go so far. This has been a major limiting factor in Ugu that has also influenced the ability to attract and retain suitably qualified staff in the right numbers.

CONCLUSIONS

Water Safety Planning is an innovative way of improving and maintaining high quality of water service provision through the transformation of the way those services are delivered. As demonstrated in Ugu District Municipality, a dedicated approach to water safety planning brings about unifying paradigm shift in daily operations resulting in improved water quality management. Legislation is a necessary prerequisite in setting a foundation and enabling an environment for water safety planning, as is the case in South Africa, but lasting benefits are only possible when water safety planning is more than just another compliance issue. A disciplined, resourced and sustained adoption of best practice supported by senior management and stakeholders aimed at institutionalizing water safety planning will go a long way in achieving the required objective of delivering of safe drinking water.

The challenges were many, and still remain, ranging from limited funding, sporadic support and buy-in from some stakeholders, staff shortages and attrition, amongst other issues. In spite of these challenges, much has been accomplished to date and the water safety planning journey still continues in its quest for sustained improvement in water services.

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REFERENCES


