Guidelines on using the refined and translated web-enabled Water Safety Plan Tool (2013 version)

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WATER RESEARCH COMMISSION
TT 581/13

Guidelines on using the refined and translated web-enabled Water Safety Plan Tool (2013 version)

Report to the
Water Research Commission

by

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on behalf of
Emanti Management (Pty) Ltd

WRC Report No. TT 581/13

January 2014

Obtainable from

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The publication of this report emanates from a project entitled: *Refinement and Translation of Spreadsheet-based and Web-enabled Water Safety Plan Tools* (WRC Project No. K8/1006//3)

ISBN 978-1-4312-0495-3

PRINTED IN THE REPUBLIC OF SOUTH AFRICA

ACKNOWLEDGEMENTS

The following organisation is thanked for their contribution to this project:

Financial Support
Water Research Commission

ABBREVIATIONS

BDC	Blue Drop Certification
BDS	Blue Drop System
DEAT	Department of Environmental Affairs and Tourism
DoH	Department of Health
DWA	Department of Water Affairs
eWQMS	electronic Water Quality Management System
IMESA	Institution of Municipal Engineers of South Africa
IWA	International Water Association
SALGA	South African Local Government Association
WHO	World Health Organisation
WRC	Water Research Commission
WSAs	Water Service Authorities
WSI	Water Service Institution
WSPs	Water Service Providers
WTW	Water Treatment Works

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GLOSSARY OF TERMS / DEFINITIONS

Acceptable Drinking Water Quality – water deemed to have an acceptable health risk as defined by SANS 241, i.e. water that is considered to be safe for lifetime consumption implying an average consumption of 2 L of water per day for 70 years by a person that weighs 60 kg

Acute Health – 1 – routinely quantifiable determinand that poses as immediate unacceptable health risk if consumed with water at concentration values exceeding the numerical limits specified in SANS 241

Acute Health – 2 – determinand that is presently not easily quantifiable and lacks information pertaining to viability and human infectivity which, however, does pose immediate unacceptable health risks if consumed with water at concentration values exceeding the numerical limits specified in SANS 241

Aesthetic – determinand that taints water with respect to taste, odour and colour and that does not pose an unacceptable health risk if present at concentration values exceeding the numerical limits specified in SANS 241

Chronic Health – determinand that poses an unacceptable health risk if ingested over an extended period if present at concentration values exceeding the numerical limits specified in SANS 241

Contracted bulk provider – water services authority that receives water in bulk from a water services provider

Critical control point – step at which control can be applied and that is essential to prevent or eliminate a water safety hazard (biological, chemical or physical), with potential to cause a health effect or reduce it to an acceptable level

Determinand/Parameter – micro-organism, physical or aesthetic property or chemical substance of which the risk posed is classified under either acute health - 1, acute health – 2, aesthetic, chronic health, or operational

Disinfection Residual – disinfection that remains in solution after disinfection

Distribution area – specific area supplied from a borehole, treatment system, reservoir or tower

Hazard – determinand with the potential to cause an adverse health effect or to affect the quality of the water

Operational – determinand that is essential for assessing the efficient operation of treatment systems and risks to infrastructure

Risk – likelihood and consequence of the presence of an identified hazard in the final water at values that exceed the numerical limits in this part of SANS

Risk assessment – process of identifying and documenting all potential hazards and risks within the water supply system

Routine Monitoring Programme – ongoing monitoring programme intended to validate the effectiveness of control measures at critical control points and to assess the quality of water based on the location of routine sampling points, sampling frequency and determinands

Routine sampling point – identifiable sampling point within the routine monitoring programme where a representative sample is collected to determine water quality

Sampling frequency – time interval between consecutive sampling events at a specific sampling point or the number of samples taken over a given period

SANS 241 – South African drinking water quality standards (South African National Standard 241)

Verification of Water Quality – assessment of compliance with the numerical limits specified in SANS 241

Water Safety Planning – systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery

Water Services Authority (WSA) – any municipality that has executive authority to provide water services within its area of jurisdiction in terms of the relevant national legislation or the ministerial authorizations made in terms of the relevant national legislation

Water Services Institution (WSI) – water services authority or water services provider or both

Water Services Provider (WSP) – a person who has a contract with a water services authority or another water services provider to sell water to that authority or provider

OR

a water services authority that provides either both of the services described above itself

OR

any person who has a contract with water services authority to assume operational responsibility for providing water services to one or more consumers (end users) within a specific geographic area (retail water services provider)

Water Supply System – geographically defined area within which water intended for human consumption may come from one or more sources and within which the water quality may be regarded as being approximately uniform

Water Treatment System/Works/Plant – process or combination of processes undertaken to render intake water acceptable for drinking as defined in SANS 241 that includes conventional treatment plants, disinfection of groundwater or any other process used for treating water to an acceptable drinking water quality

1 INTRODUCTION

Past and recent studies in South Africa have shown that it is apparent that for a significant proportion of municipalities, sustained provision of service and quality are under threat due to failing infrastructure. The Department of Water Affairs (DWA) reported that there has been significant improvement in terms of water quality monitoring within Water Service Authorities, however there still needs to be improvement until all Water Services Authorities are monitoring as per current SANS 241 requirements (DWA, 2010).

In order to take proper action, the existing situation has to be analysed and required corrective measures must be identified and implemented.

The Water Research Commission (WRC) project K5/1993//3 "*Web enablement of a water safety plan and incorporation of existing similar supply system assessment tool*" aimed to establish a methodology to identify and manage the risks of water services infrastructure and the means by which Water Services Institutions (WSIs) are better able to identify and manage these through use of a Water Safety Planning.

During the course of project K5/1993//3 and after, the project team continuously received feedback from tool users (which includes municipalities, consultants and water boards) and this has led to a need to continuously review and refine or enhance the tools. The project K8/1006/3 "*Refinement and Translation of spreadsheet and web enabled Water Safety Plan Tools"* emerged as a result of this. The project aims to ensure that the methods used to develop Water Safety Plans are in line with the sector requirements and also support the water safety planning process as much as can be. The urgent need to review and refine the tools is compounded by:

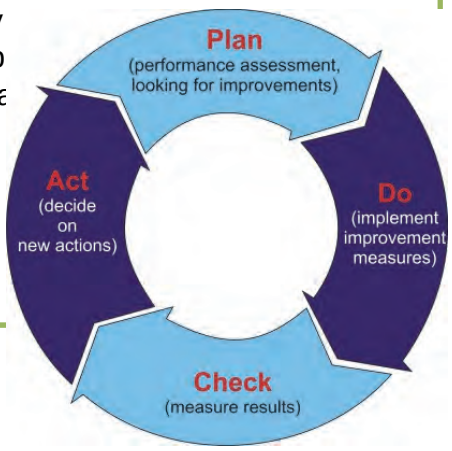
1. The on-going annual modification of the Blue Drop Certification (BDC) process requirements (which have progressively become stricter since implementation thereof).
2. The recent introduction of new drinking-water quality standards in South Africa (i.e. SANS 241-2011 replacing SANS 241-2006).
3. On-going water sector initiatives encouraging WSAs to proactively adopt typical management principles (PLAN-DO-CHECK-ACT).

The Water Safety Planning tools were created in both Excel and web based formats because some of the municipal officials that the tool is aimed at are comfortable using a spreadsheet-based tool. The updates and reviews were done in both these formats so that whether the user prefers the Excel or the web, they are the same version and follow the same process. The use of the web tool is recommended over the Excel based because of its advantages that are discussed in section 5.1.

The tools assist in developing a Water Safety Plan. Implementation thereof (e.g. taking required actions, implementing corrective actions, developing and implementing management and communication procedures) of the Water Safety Plan depends on the Water Services Institution (WSI).

Top Tips

Water Safety planning is a process of identifying and implementing possible and known risks in the water supply system. The process aims at ensuring acceptable drinking water quality through all stages of the water supply system. The Water Safety Planning process in turn assists the user in developing a Water Safety Plan which is a guiding plan with respect to managing, avoiding, minimising/reducing chances of water contamination in the water supply system. The process requires development of the p implementation of the plan, review of performance a amendment or modification to the plan to ensure that it remains relevant. The entire process is demonstrated in the figure.



Note

The Water Safety Plan tool developed through this study is a desktop electronic based tool that requires detailed knowledge of the water supply system. Some of the required information is available within the municipality, whereas other information can only be obtained via site visits. Site visits are therefore an essential part of the process and should be conducted prior to using the tool. The tool should also be used in conjunction with the current SANS 241 water quality requirements (i.e. link current SANS 241 determinands to identified risks). This is explained further in the guide.

PURPOSE OF THIS MANUAL

The purpose of this manual is to:

- Introduce Water Safety Planning to the reader.
- Highlight key steps to be considered when developing a Water Safety Plan.
- Provide step-by-step guidance as to how to use the Water Safety Plan Tools currently hosted on the electronic Water Quality Management System (eWQMS)/Emanti.

IN THE PIPELINE

The tool is also available on the WRC website. www.wrc.org.za

This manual is intended for use by:

- Managers of drinking water services within a WSI
- Water quality managers
- Environmental health practitioner
- Department of Water Affairs staff
- South African Local Government Association (SALGA), Institution of Municipal Engineers of South Africa (IMESA), Department of Health (DoH) and Local Government and Housing (LGH) departments
- Water resources people
- Any person responsible for drinking water services status

2 INTRODUCTION TO WATER SAFETY PLANNING

Water Safety Planning is a systematic process that aims to consistently ensure acceptable drinking water quality that does not exceed the numerical limits in SANS 241 by implementing an integrated water quality management plan, which includes a risk assessment and risk management approach from catchment to point of delivery. In so doing the process allows for better understanding of water supply systems. Once the risk has been identified, control measures can be put into place to mitigate these risks. The process also needs to identify systems by which these measures are implemented and monitored. Management plans describing actions taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes, should be included. Key components of a Water Safety Planning (WHO/IWA, 2009; Thompson and Majam, 2009) include:

- **System assessment** – determine whether the supply system (i) can deliver safe water, and (ii) is meeting SANS 241 targets. This should be undertaken for both current and planned new systems.
- **Identifying control measures** – conduct a risk assessment to collectively control identified risks and hazardous events and ensure that SANS 241 targets are met. For each control measure identified, an appropriate means of operational monitoring should be defined that will ensure that any deviation from required performance is rapidly detected in a timely manner.
- **Management plans and risk management** – to develop plans describing actions to be taken during normal operation or incident conditions and documenting the system assessment (including upgrade and improvement), monitoring and communication plans and supporting programmes.

The approach adopted when developing a Water Safety Planning typically comprises the following sequential steps:

1. Assemble project team
2. Document and describe the present Water Supply System
3. Assess the Water Supply System
4. Undertake a hazard/risk assessment
5. Identify control measures
6. Verify that the Water Safety Plan is operational
7. Draft management procedures
8. Develop supporting programmes
9. Establish document and communication procedures
10. Review the Water Safety Plan

IDENTIFICATION OF TYPICAL WATER SUPPLY SYSTEM

In order to understand what needs to be monitored and protected, a detailed understanding of a water supply system management (that is from source to point of use) is required. A typical conventional water supply system comprises the following (Figure 1).

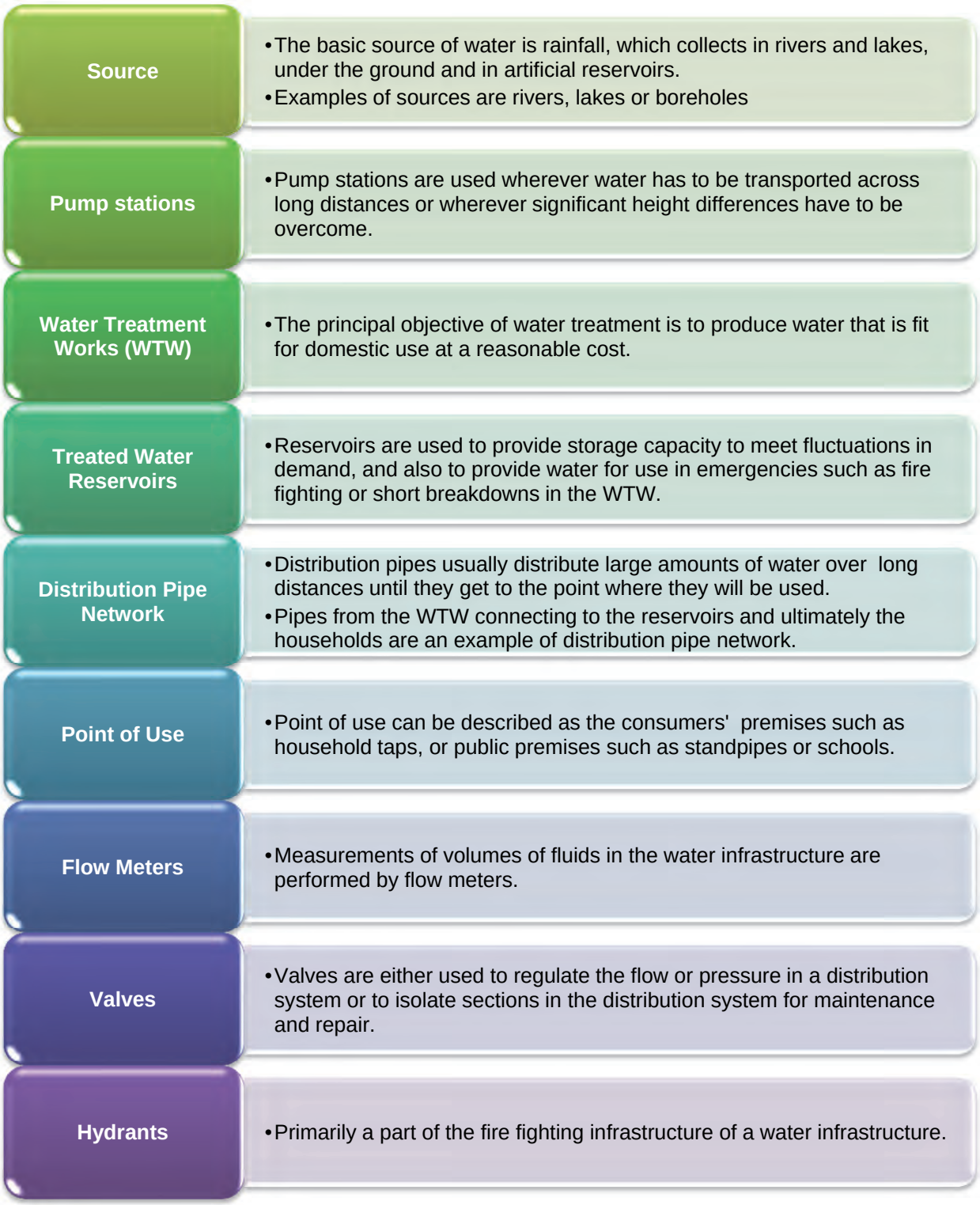
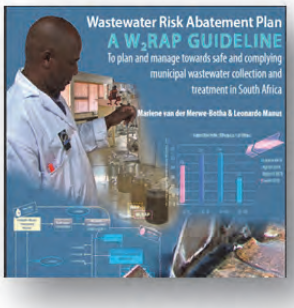


Figure 1: *Typical water supply system components*

Small systems typically comprise of a groundwater source (normally a borehole), storage (where treatment by disinfection is normally practised) and distribution network to the consumer.



Drinking water supply system covers from source to point of use or consumer, however wastewater has an impact on the source that brings consideration of wastewater system in the concept. Wastewater risk management (which is closely linked to Water Safety Planning) is covered in the Wastewater Risk Abatement Planning (W_2RAP) process discussed in the W_2RAP Screenshot of this guideline is shown here.

3 COMMONLY UTILISED WATER SAFETY PLANNING GUIDES AND TOOLS IN SOUTH AFRICA

3.1. General steps and consideration

Most literature sources utilise a similar methodology for Water Safety Planning. The two most commonly utilised methodologies in South Africa are those presented by IWA/WHO (2009) and Thompson and Majam (2009) through WRC. These guides highlight the following:

Top Tips

- A Water Safety Plan cannot be done solely as a desktop study. It must involve site visits to confirm the knowledge, information and schematics available to the WSI. Site visits need to include inputs from those who work at the sites and/or within catchments and have detailed local knowledge.
- The WSI should take lead in the Water Safety Planning approach but it is advised not to do this in isolation.

The following stepwise approach is used:

1. Assemble the Project Team and Key Stakeholders – responsible people making up the water safety planning team.
2. Document and Describe the present Water Supply System – components of each and specific water supply system are documented and described.
3. Assess the Water Supply System – identify possible hazards and hazardous events for each component of the water supply system.
4. Undertake a Risk/Hazard Assessment – determine risks associated with hazards and hazardous events identified.
5. Identify Control Measures – identify corrective actions and/or ways to control hazards and hazardous events identified.
6. Verify that the Water Safety Plan is Operational – ensure that the Water Safety Plan is implemented and effective.
7. Draft Management Procedures – develop procedures such as indication of responsibilities, operational and maintenance procedures, etc.

8. Develop Supporting Programmes – develop programmes such as emergency protocols to respond to failure, safety procedures, etc.

9. Establish Document and Communication Procedures – develop documents indicating procedures such as communication protocols, community consultation, etc.

10. Review Water Safety Plan – evaluate the implementation of the plan, any adjustments to be made.

3.2. World Health Organisation (WHO) / International Water Association (IWA) 2009 Water Safety Planning

3.2.1 Water Safety Plan Manual: Step by step risk management for drinking water suppliers

World Health Organization (WHO) manual (WHO, 2009), continues from the Third Edition of the WHO Guidelines for Drinking-water Quality (2009) that describes the principles of the Water Safety Planning approach. The aim of the WHO manual is to provide practical guidance to facilitate Water Safety Planning development focusing particularly on organized water supply systems managed by a water services institution. The water quality standards used in the guide are WHO drinking water standards. The manual includes case studies on developing Water Safety Planning in different countries.

Different approaches, that is quantitative or semi quantitative and simplified qualitative approaches are introduced in this manual. Quantitative or semi quantitative approach is based on estimation of likelihood or frequency and severity or consequence. Examples of this kind of approach are presented in Figure 2 and Figure 3.

Process step	Hazardous event (source of hazard)	Hazard type	Likeli-hood	Severity	Score	Risk rating (before consideration of controls)	Basis
Source (groundwater)	Cattle defecation in vicinity of unfenced wellhead causing source of potential pathogen ingress in wet weather	Microbial	3	5	15	High	Potential illness from pathogens from cattle, such as *Cryptosporidium*
Source	Cocktail of pesticides from agricultural uses	Chemical	2	4	8	Medium	Potential introduction of toxic chemicals which could lead to concentrations in finished water above national standards and WHO Guideline values
Source	Potential for informal solid waste disposal	Microbial and chemical	1	1	1	Low	Potential for hazardous waste plus rainfall event causing contamination to water supply is low
Storage tank	Unroofed reservoir allows birds to congregate and defecate in treated water	Microbial	2	5	10	High	Potential illness from pathogens such as *Salmonella* and *Campylobacter*
Treatment	No back-up power supply	Microbial and chemical	2	5	10	High	Potential loss of treatment and pumps/pressure
Distribution	Leaks on trunk main and distribution system	Microbial	5	3	15	High	Leaks are a potential source of microbial pathogens and contribute to high % of unaccounted for water

Figure 2: *Example of hazard and risk assessment using semi quantitative approach*

High risk ≥20 Medium risk 10-19 Low risk <10				Consequence				
				Wholesome water Insignificant 1	Short term or localised, not health related non compliance or aesthetic Minor 2	Widespread aesthetic issues or long term non compliance not heath related Moderate 4	Potential long term heath effects Major 8	Potential illness Catastrophic 16
Likelihood	Has not happened in the past and it is highly improbable that it will happen in the future	Most unlikely	1	1	2	4	8	16
	Is possible and cannot be ruled out completely	Unlikely	2	2	4	8	16	32
	Is possible and under certain circumstances could happen	Forseeable	3	3	6	12	24	48
	Has occurred in the past and has the potential to happen again	Very likely	4	4	8	16	32	64
	Has occurred in the past and could happen again	Almost certain	5	5	10	20	40	80

Figure 3: *Example of hazard and risk assessment using quantitative approach*

A simplified qualitative approach is based on expert judgement of the Water Safety Planning team. An example of such approach is presented Figure 4.

Descriptor	Meaning	Notes
Significant	Clearly a priority	The risk should be considered further to determine whether additional control measures are required and whether a particular process step should be elevated to a key control point in the system. It is necessary to validate existing control measures before defining whether additional control measures are required.
Uncertain	Unsure if the event is or is not a significant risk	The risk may require further studies to understand if the event is really a significant risk or not.
Insignificant	Clearly not a priority	Note that the risk will be described and documented and will be revisited in future years as part of the WSP rolling review.

Figure 4: *Example of hazard and risk assessment using simplified qualitative approach*

3.2.2 WHO/IWA Water Safety Plan Quality Assurance Tool (2009)

The Water Safety Plan Quality Assurance tool is an excel based tool which is intended to assist WSIs managing organised/formal water supply systems to assess the completeness of their Water Safety Planning and the effectiveness of its implementation. The tool is closely aligned with the WHO/IWA manual. The major benefits in applying the tool (as indicated within the tool) are highlighting of:

- Areas where progress is being made with the Water Safety Planning implementation, and
- Opportunities for improvements

A screenshot of the hazard/risk assessment part of the tool is presented Figure 5.

	Name of water supply system	
5.1	Have stakeholders been identified? a. Catchment b. Treatment c. Distribution d. Consumer premises	
5.2	Have stakeholders been contacted and are they engaged in the WSP process? a. Catchment b. Treatment c. Distribution d. Consumer premises	
5.3	Number of stakeholder groups identified a. Catchment b. Treatment c. Distribution d. Consumer premises	
5.4	Number of stakeholder groups contacted regarding water safety responsibilities a. Catchment b. Treatment c. Distribution d. Consumer premises	
5.5	Has hazard identification been conducted? a. Catchment b. Treatment c. Distribution d. Consumer premises	
	Were site visits made for visual inspection and was local input obtained to inform the hazard identification?	

Figure 5: *Hazard/Risk assessment section screenshot on the WHO/IWA Quality Assurance tool*

3.3. WRC Guides and Tools

3.2.3 The Development of a Generic Water Safety Plan for small community water supply

This guide has incorporated the World Health Organization manual basic principles as well as additional information obtained during a literature review of various other Water Safety Plans that have already been established in other countries. This guide focuses on the methodology that can be used to develop a Water Safety Planning for small community water supply in South Africa. SANS 241 standards is drinking water quality standards considered in determining hazards. The guide includes common hazards and hazardous events that can be considered for each component of the system and a list of possible control measures that can be considered.

3.2.4 WRC Water Safety Planning Tools

The purpose of the tools is to:

- Highlight key steps to be considered when conducting Water Safety Planning
- Provide step-by-step guidance as to how to develop and implement a Water Safety Plan and
- Manage to rate the identified risks as high, medium or low

- Check the status of implementation of Water Safety Plan

An example of risk matrix used is presented in Figure 6.

Shortcut	Likelihood	Rating	Shortcut	Consequence	Rating
A1	Almost Certain Once a day or Permanent Feature	1	A2	Catastrophic Death expected from Exposure	100
B1	Likely Once per Week	0.8	B2	Major Population exposed to significant illness	70
C1	Moderately Likely Once per Month	0.5	C2	Moderate Large Aesthetic Impact	20
D1	Unlikely Once per Year	0.2	D2	Minor Small Aesthetic Impact	2
E1	Rare 1 in 5 Years	0.1	E2	Insignificant No Impact	1

Likelihood is determined by "how often' or 'how likely" a hazard or a hazardous event occurs. It must take into account hazards that have occurred in the past and their likelihood of re-occurrence and must also predict the likelihood of hazards and events that have not occurred to date.

Consequence looks at the severity of the results of the hazard/hazardous event and the seriousness or intensity of the impact of the hazard. When dealing with impact we are concerned with human health only.

RISK RATING = LIKELIHOOD X CONSEQUENCE

Risk Rating	Range
Low	0-10
Medium	11-56
High	57-100

Figure 6: *Risk Assessment Matrix*

A comprehensive checklist for conducting a Water Safety Plan has also been included to ensure the proper development and maintenance of a Water Safety Planning (Figure 7). The checklist assists in terms of identifying where one is in terms of developing and reviewing a Water Safety Planning.

		YES ✓	NO ✗
1.	Has a multi-disciplinary team of experts been assembled to carry out the water safety plan?	☐	☐
2.	Has the team been informed of their duties and commitment?	☐	☐
3.	Has the water treatment system been described? (i.e. has each step in the system been considered for range and magnitude of hazards that may be present and the ability of existing processes and infrastructure to manage actual or potential risks)	☐	☐
4.	Following the description of the system above, has all the information been documented?	☐	☐
5.	Has a flow diagram of the entire water supply system been constructed using the symbol chart?	☐	☐
6.	Have existing as well as potential hazards in the system been identified?	☐	☐
7.	Have these hazards been prioritised using the hazard assessment matrix provided?	☐	☐

Figure 7: *Checklist on how for conducting a Water Safety Plan*

This checklist has been reviewed and enhanced in this study to a tool rather than a checklist. This tool considers typical steps of the Water Safety Planning status process and asks 5 key questions per step. A colour coded “spider diagram” output is an indication of the status. Screenshots are presented below.

1. Water Safety Plan Team		
1.1	A multi-disciplinary team of experts has been assembled to carry out the WSP	4
1.2	The WSP team has been informed of their duties and is committed to the process	4
1.3	A WSP methodology (e.g. steps 1 - 10) has been defined and agreed by the WSP team	4
1.4	The WSP team regularly meets to discuss issues, review progress, etc	4
1.5	WSP development and implementation is funded and supported by top management	4

2. Water Supply System Assessment		
2.1	The water supply system has been described from catchment to consumer	4
2.2	The wastewater system has been described from collection to discharge	2
2.3	A flow diagram of the entire water and wastewater system has been developed using the symbol chart	4
2.4	The water & wastewater system description has been confirmed by site visits, interactions with stakeholders, etc	3
2.5	The water & wastewater system description information has been documented	3

Scoring Rules	
Strongly disagree or don't know	0
Disagree	1
Neutral or not applicable	2
Agree	3
Strongly agree	4

Figure 8: *Water Safety Planning status Checklist questions*

What will Water Safety Planning tools not help you with? The limitation of these tools is that they do not provide answers to what the user does not know; however need to be provided with information themselves. The tools however provide guidance to possible hazards and control measures to be considered. The hazards and control measures presented in the tool are not the only existing hazards and control measures, therefore the user should consider what is applicable in their own situation and include those for assessment.

Figure 9: *Checklist Water Safety Plan Status*

Top Tips

When using Water Safety Planning tools, and in particular when conducting risk assessments, it is important that the same methodology be used throughout the WSI (i.e. all supply systems within that WSI are assessed using the same tool/risk rating methodology).

Note

The tool has been continuously reviewed and updated; therefore the user should make sure that the recent tool at that time is used. The tool presented in this report was developed through that process, therefore is an update of the original version.

4 CONDUCTING WATER SAFETY PLANNING

The steps presented below are followed for English, Afrikaans and Zulu Water Safety Plan Tools that are available as Excel and web enabled formats. Presented in this document is the updated tool that was refined and translated after the feedback received from the sector through the use of the originally developed tool.

Step 1: Formulate a Water Safety Planning team

In this step, the WSA identifies people who should form part of the team. It is recommended that, if possible, the Water Safety Plan team consist of the following persons: (1) water services managers, engineers and technicians, (2)operational staff of treatment plants (if applicable), (3) water quality managers/specialists, (4) catchment managers, (5) Water Service Providers, (6) environmental, public health or hygienist professionals and (7) consumer representatives.

Top Tips

- Choose a Leader for the process.
- Consider location (who is impacting, who are the users)

Step 2: Document and describe all water supply systems within your area of concern

Define each water supply system by identifying all its components starting from source to point of use. Each water supply system has different components and/or design of the system. It is important to identify and describe each component of each water supply system. This includes capacities (e.g. plant, reservoirs, etc.), process/es used (e.g. flocculation, filtration, etc.), material of construction (e.g. PVC pipes, cement tanks, etc.), age, etc.).

Note

In some cases, treated bulk water may be provided by a water service provider; therefore the area of responsibility starts at the reservoir (inclusive or exclusive) to the point of use.

Top Tips

In such cases, a Service Level Agreement (SLA) between the water service provider and water service authority should be drawn indicating responsibilities, area of provision and service quality expected. Communication, inclusion of the Water Service Provider and Water Services Authority in the team is essential.

A flow diagram indicating each component of the assessed water supply system could be drawn. An example of a flow diagram is presented in Figure 10.

Top Tips

Things to consider:

- Source (type, yield, quality)
- Water Treatment Works (processes, capacity)
- Reservoirs (types, capacity)
- Network (pump stations, valves, pipes, etc)
- Refer to as-built drawings, documents, etc
- If don't know, find out (and improve record keeping)

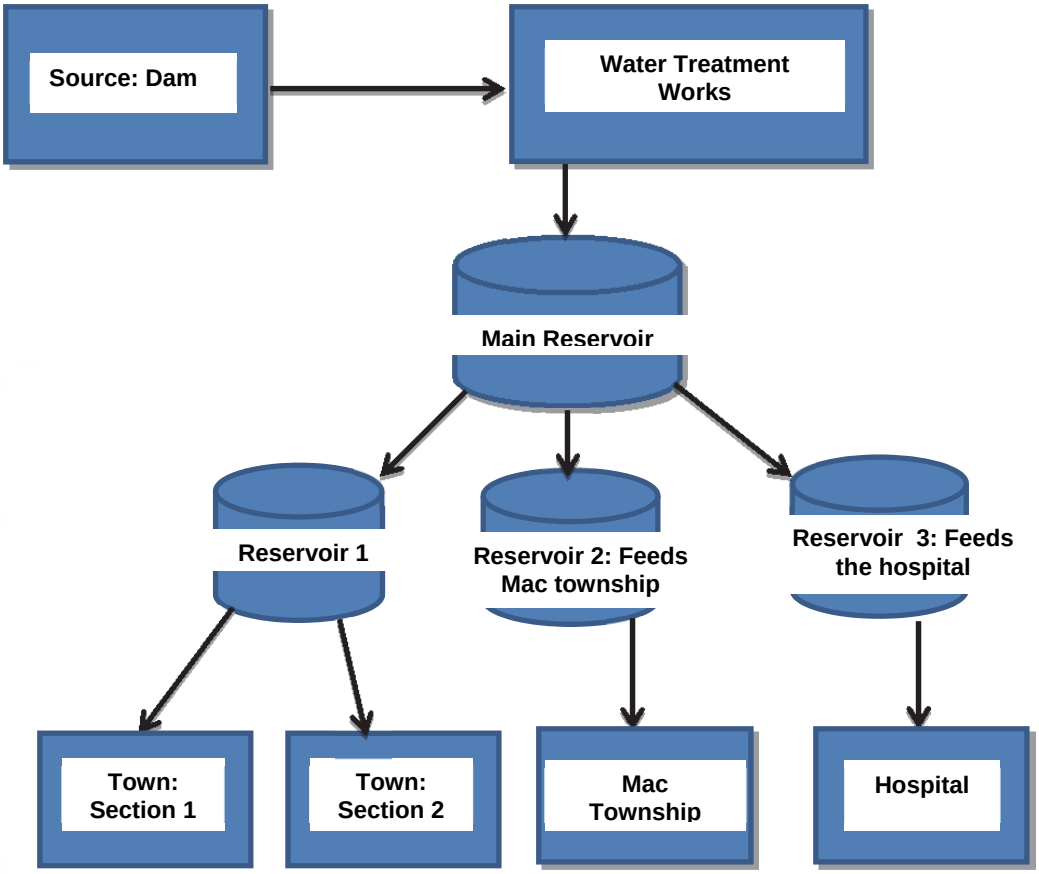


Figure 10: *Example of system description*

Note

Always take into consideration valves, hydrants, meters as part of the water supply system.

Though a photo diary (as evidence of site visits and issues identified on site) was noted as an advantage by some users, the inclusion of photos within the web enabled due to (i) prioritization of needs vs. "nice to haves" and associated limited budget for IT developments, (ii) security concerns regarding posting photos of vulnerabilities (iii) technical IT aspects including limiting file size to be uploaded/viewed and associated system usability; it was decided to not presently implement this feature on the web based version and re-consider this again in the future. However, provision to upload system photos has been made in the Excel based tool as evidence of site visits and issues identified on site as shown below. Photos can be uploaded on the spreadsheet and the user can choose the required photo from the list.

Figure 11: *Excel based photo diary*

Step 3: Assess the water supply system

Evaluation of water supply system is conducted to obtain an idea of the typical hazards/hazardous events faced at each component. This will assist with completing the risk assessment. Assessment of the water supply system includes:

- Identification of potential pollution sources at each component (e.g. livestock, human activities at water source).
- Identify the hazards associated with the pollution source (e.g. if there are livestock, human activities at the source; *E. coli* / faecal content is likely to be experienced).
- Treatment processes at each component (e.g. pre-treatment at source, chlorination at reservoirs, etc.).

This should be aligned with known challenges and risks associated with each component (e.g. water treatment works operating above design capacity). Any size drinking water treatment system should be assessed whether low or high technology system.

Note

Assessment may be conducted by a team or information obtained from a team that works from different components of the water supply system.

Step 4: Conduct site visits

The information could be easily available within the municipality (as as-built drawing, charts, etc.), however in some cases the records are not available. Investigations should be conducted (whether by consulting retired people, physically going out to the field following every lead) to gather the information.

Note

Site visits should be conducted, GPS co-ordinates gathered for each component of the water supply system, photos for any issue identified.

Top Tips

Identified hazards should form part of the water supply system monitoring programme. That is, identified hazards should be monitored.

Step 5: Undertake Hazard/Risk assessment

Determine the risks associated with the hazards identified by considering the likelihood (probability) (e.g. has it happened in the past, is it likely to happen) and consequence (impact should it happen) of a potential hazardous event.

Characterisation of likelihood of the hazardous event to occur is normally based on historic experience and /or recent observations. Determining the consequence or impact should the hazardous event happen needs understanding of health, physical and chemical categorisation of SANS determinands. Therefore the SANS limits for hazardous determinands should be understood so as to associate them with frequency of monitoring and developing preventative measures.

Top Tips

When conducting this hazard/risk assessment, it is important to understand the current SANS 241 standards.

It was deemed necessary to identify the hazard (in terms of SANS 241 determinands) and link those with the identified hazardous event. This was seen as assisting in developing a risk based monitoring programme and is also (in line with Blue Drop requirements). This feature has been included in the refined web enabled tool as indicated in Figure 12.

Note

It is recommended to have the team of all the people involved in water services to collectively identify potential hazards and discuss likelihood and consequence of the identified hazards. This allows for different views of analysing the risks and therefore agreeing on the most appropriate rating.

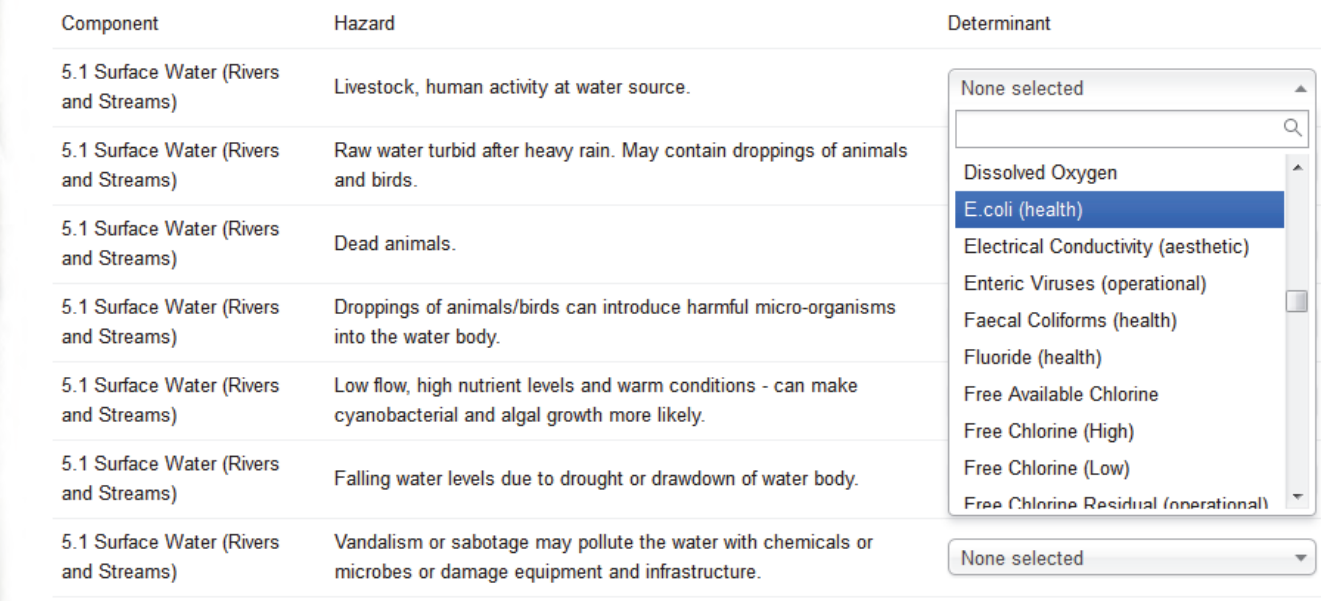


Figure 12: *Linking hazards/hazardous events with SANS 241 determinands*

There are a number of tools (e.g. WHO/IWA, WRC) available that can be used to calculate and rate the risks identified. The user should understand the concept and use of the tool used. As indicated earlier, it is important that the same methodology be used throughout the WSI (i.e. all supply systems within that WSI are assessed using the same tool/risk rating methodology).

Step 6: Identify control measures

For each and every hazard/hazardous event, control measures should be developed (e.g. redundancy, alternatives, back-ups, etc.). Control measures include consideration of what needs to be done to rectify the situation and also identifying measures of preventing, minimising and/or eliminating the situation. It could be noted that there are existing control measures for some situations, however not implemented. There also could be control measures in place, however not effective.

If the control measures were identified to be ineffective, a review should be conducted to identify if a new measure replacing the existing is required or the existing measure should be strengthened.

A list of possible control measures is provided in appendix B. These are just examples; therefore the user should identify control measures applicable to their own situation.

It would be a good practice to also collectively discuss suggested control measures as a team.

Step 7: Implement control measures

Considering the summarised findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be addressed by ranking the risks. It is suggested that this be limited to high and medium risks, and have short, medium and long term action period (e.g. immediately, 3-6 months, 3 years). A plan to monitor low risks should be considered. It is essential that appropriate budget and responsibilities are assigned to address the highest risks identified.

Implementation of newly developed control measures is required whilst review of the effectiveness of existing control measures should be conducted. Assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. Sign off by management is necessary to ensure that control measures are implemented.

Consider (1) quick wins, (2) Cost: Risk Reduction, (3) social impact/consumer confidence, (4) environmental impact (5) Commitment and funding

Effectiveness of newly implemented control measures and monitoring the effectiveness of existing control measures can be reviewed by calculating residual risk after the implementation of a new control measure or as a way of assessing the effectiveness of the existing control measure. The outcome will provide the user with an updated risk calculation. The calculation of residual risk is important because risk rating does not consider the effectiveness of existing control measures. Therefore, understanding of the effectiveness of each implemented control measure will enable the user to calculate the residual risk. The newly implemented control measures will also be reviewed and their effectiveness measured by going through the same process (for example, when the Water Safety Plan is being reviewed, preferably annually) providing the user with an updated risk calculation. An example of this is provided in the figure of the web enabled tool below.

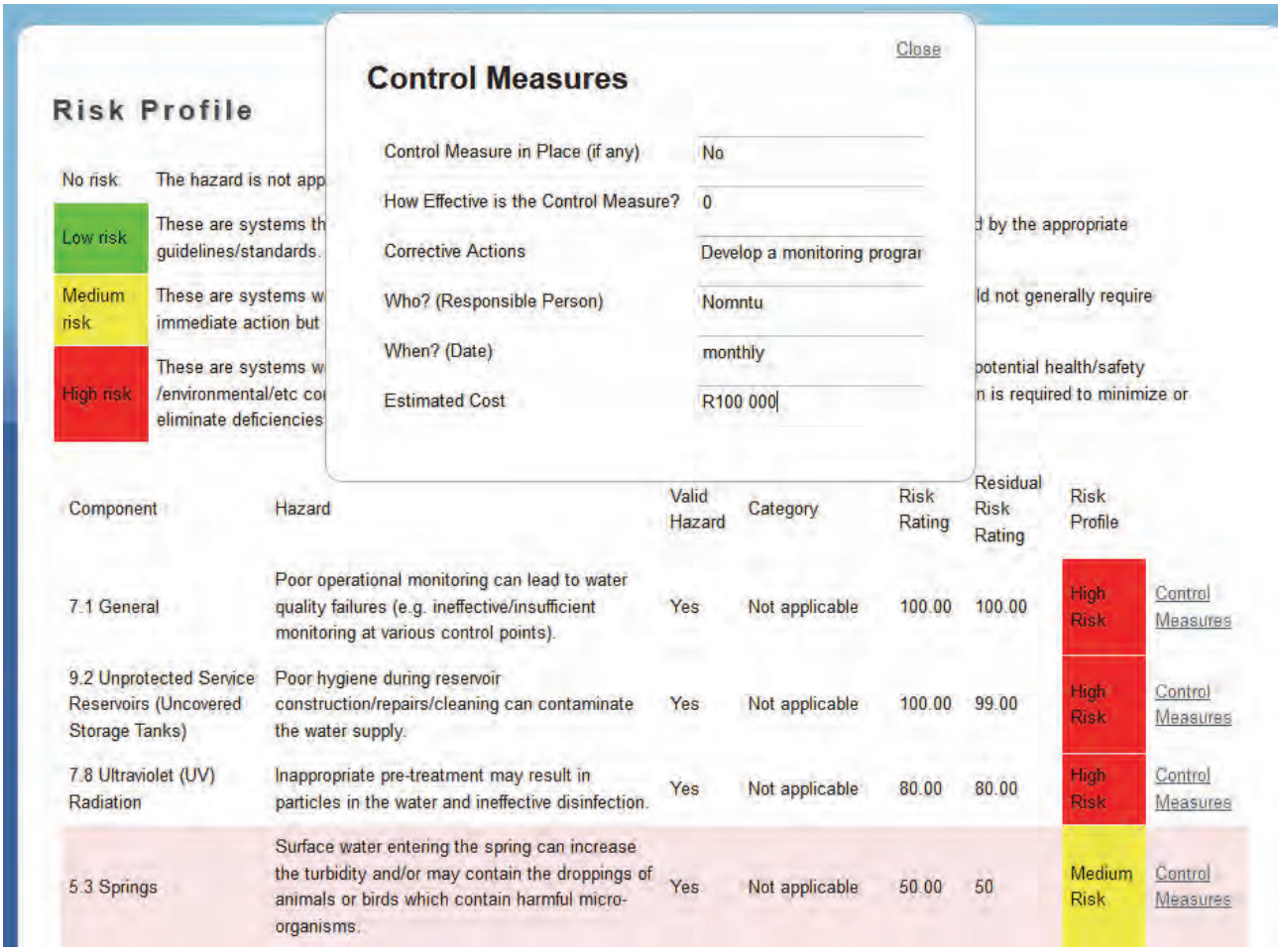
The formula used to calculate the residual risk is:

Residual Risk Rating (RR) = original Risk Rating X (100% - control measure effectiveness %)

For example, if the effectiveness of the implemented control measure is estimated to be 60% and the original risk rating was 80% (high risk), the residual risk will be calculated as follows:

RR = 80 x (100% – 60%)
OR
= 80 x (1-0.6)
= 32 (low risk)

An example of this is provided in the following screenshot.



Close

Control Measures

Control Measure in Place (if any)	No
How Effective is the Control Measure?	0
Corrective Actions	Develop a monitoring prograı
Who? (Responsible Person)	Nomntu
When? (Date)	monthly
Estimated Cost	R100 000

Risk Profile

No risk	The hazard is not app
Low risk	These are systems th guidelines/standards.
Medium risk	These are systems w immediate action but
High risk	These are systems w /environmental/etc co eliminate deficiencies

d by the appropriate

ld not generally require

otential health/safety
n is required to minimize or

Component	Hazard	Valid Hazard	Category	Risk Rating	Residual Risk Rating	Risk Profile	
7.1 General	Poor operational monitoring can lead to water quality failures (e.g. ineffective/insufficient monitoring at various control points).	Yes	Not applicable	100.00	100.00	High Risk	Control Measures
9.2 Unprotected Service Reservoirs (Uncovered Storage Tanks)	Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply.	Yes	Not applicable	100.00	99.00	High Risk	Control Measures
7.8 Ultraviolet (UV) Radiation	Inappropriate pre-treatment may result in particles in the water and ineffective disinfection.	Yes	Not applicable	80.00	80.00	High Risk	Control Measures
5.3 Springs	Surface water entering the spring can increase the turbidity and/or may contain the droppings of animals or birds which contain harmful micro-organisms.	Yes	Not applicable	50.00	50	Medium Risk	Control Measures

Figure 13: *Residual risk calculation: web*

Summary Status and Ranking

Component	Hazard	Risk Profile	Control Measure in Place (if any)	Control Measure Effectiveness (%)?	Residual Risk Rating	Residual Risk Profile	Corrective Actions	Who? (Responsible Person)	When? (Date)	Estimated Cost?
Source	Livestock, human activity at water source.	Low Risk	0	80%	0.2	Low Risk	New fence	P Smit	2010/12/01	R 10 000
Source	Raw water turbid after heavy rain. May contain droppings of animals and birds.	No Risk	Effective monitoring & treatment	0%	0	No Risk	Not required	-	-	-
Source	Dead animals.	Medium Risk	0	50%	8	Low Risk	0	0	1900/01/00	R 0
Source	Droppings of animals/birds can introduce harmful micro-organisms into the water body.	High Risk	0	30%	56	Medium Risk	0	0	1900/01/00	R 0

Figure 14: *Residual risk calculation: Excel*

Step 8: Verify that the Water Safety Plan is operational

Verification is necessary to ensure that the Water Safety Plan is implemented and effective. Verification process requires assessment of a range of performance indicators. Verification includes both operational audit water quality analyses using a range of indicators (e.g. operational monitoring programmes). Operational audit should include the systematic review of operational procedures and documentation to ensure that the Water Safety Plan is working. A key element of the audit process is to identify when monitoring results show deviation from critical limits and what operational shortcomings may have been the cause. The audit should identify short comings in the overall Water Safety Plan and identify modifications and improvements required for the Water Safety Plan (Thompson and Majam, 2009).

Top Tips

In the process of verification, the following should be considered and understood:

- What should I be checking on a regular basis to make sure my control measures are effective?
- Development of risk based monitoring programme.

Step 9: Draft Management Procedures

For a plan to be implemented successfully, it is of utmost importance to set out all the required steps needed to achieve the desired end results, the order in which they ought to take place, and the necessary resources (e.g. both the people and material involved).

Step 10: Develop supporting programmes

Supporting programmes are activities that ensure the operating environment, equipment used and people themselves do not become an additional source of potential hazards to the drinking water supply (Thompson and Majam, 2009).

Top Tips

Supporting programmes could include:

- Operation and maintenance manuals
- Protocols to respond to failure
- Safety procedures
- Emergency procedures

Step 11: Establish document and communication procedures

Documentation of all aspects of drinking-water quality management is essential. Documents should describe activities that are undertaken and how procedures are performed. They should also include detailed information on:

- assessment of the drinking-water system (including flow diagrams and potential hazards and the outcome of validation);
- control measures and operational monitoring and verification plan;
- routine operation and management procedures;
- incident and emergency response plans; and supporting measures, including:
    - training programmes
    - research and development
- procedures for evaluating results and reporting
- performance evaluations, audits and reviews
- communication protocols
- community consultation.

Step 12: Review Water Safety Plan

The Water Safety Plan should be reviewed annually. Reviewing a Water Safety Plan include identifying any changes that have happened in that period (e.g. hazards that could be as a result of new developments, new activities, climatic changes, etc.), reviewing effectiveness of control measures, management programmes, documents and communication procedures. Identify if there are any improvements required.

- Site visits are essential in conducting Water Safety Planning
- Municipal management ownership and sign off is necessary
- Implementation of control measures is vital
- Having strategies documents, procedures in place that are properly used is necessary
- Improving on existing methods is a good practise
- Taking ownership, budgeting and having supporting programmes and responsible management are as important.

Have regular meetings to check the following…

- Where are we?
- What have we done?
- What must we still do?
- Renewed management commitment!
- Required actions, responsibilities, sign-off, money!!

5 USING THE ENGLISH WATER SAFETY PLANNING TOOLS

5.1. Introduction

Both Excel and web based tools are available on eWQMS. The aim of the project was to web enable the tool, however it was deemed necessary to have both. Key advantages identified from using the web-based Water Safety Plan tool (in favour of the spreadsheet tool) include:

1) Enhanced sharing (parties can access/edit a database at the same time)
2) Enhanced security (sensitive information can be easily protected and users can be protected from making mistakes - e.g. deleting information, loading incorrect information)
3) Efficiency and cost effectiveness (minimize duplication, economies of scale - enhancements rapidly available to all),
4) Enhanced reporting (format the same data many ways in various reports create more interactive features/outputs),
5) Ease of maintenance and lowered downtime (less likely to break than spreadsheet),
6) Repository of information (hold much greater numbers of records than spreadsheets),
7) Ability to conduct strategic analysis if sufficiently adopted (e.g. identify key threats/hazards/risks on a national basis),
8) Less duplication (duplication of existing information in a new spreadsheet or creation of copies of existing spreadsheets which is the latest/correct version?).

Although the web-tool has numerous advantages over the spreadsheet tool, many municipalities continue to use the spreadsheet. Although the focus has been on keeping the web-tool up-to-date, a need therefore exists to also ensure that the spreadsheet tool is also up-to-date.

The web tool does not need to be filled in once and completed at the same time, that is, the user can stop any time, save the information and continue later by clicking ‘continue later’ button at the bottom of each page:

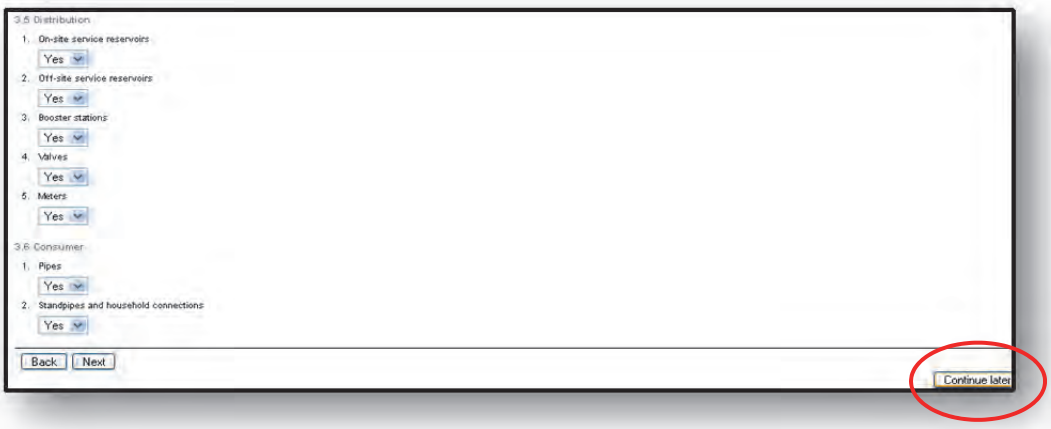


Figure 15: eWQMS *continue later function*

As mentioned earlier, the tool will be continuously reviewed and updated, therefore the user should make sure that the most recent version is utilised.

The current steps below form part of the WRC Water Safety Planning tool on the electronic Water Quality Management System (eWQMS):

5.2. Accessing and Using the English Water Safety Plan Tool

Users who do not have eWQMS login details can access the tool via Emanti website: www.emanti.co.za. Users will be provided with a unique username and password to be able to access the web tool.

The steps presented below do not necessarily follow the traditional steps of developing and implementing Water Safety Plans. However, these are the steps followed when using the Excel and web Water Safety Plan tools developed through this study.

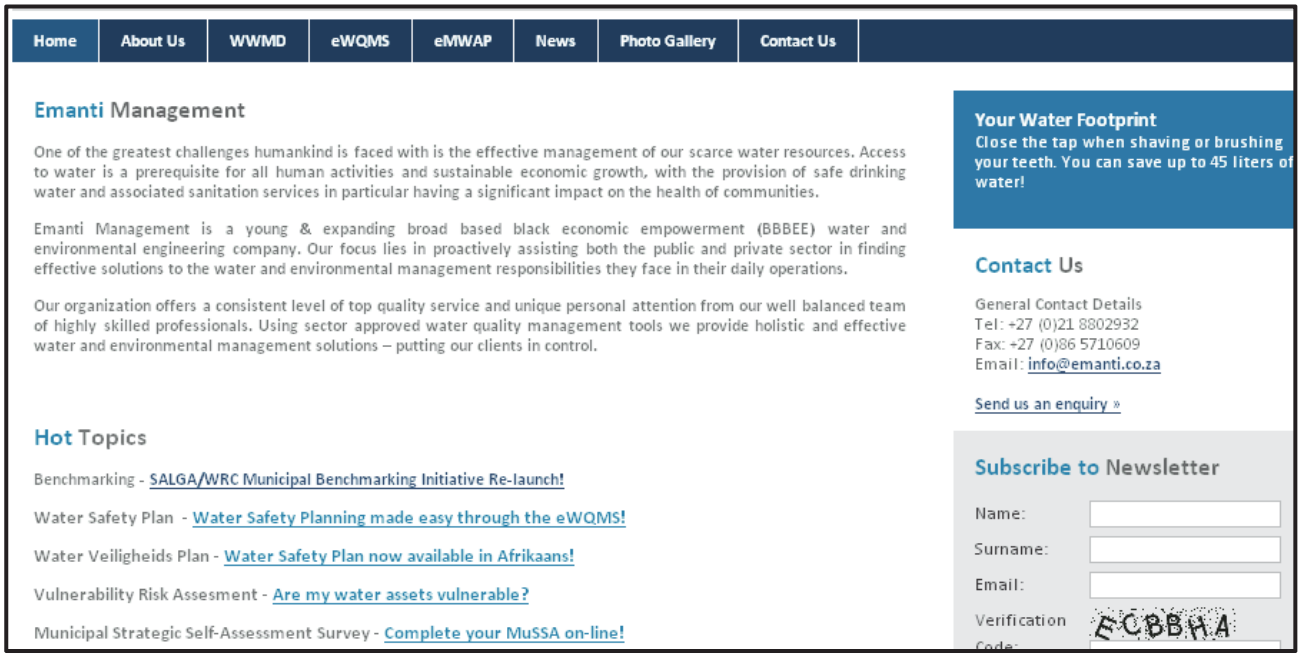


Figure 16: *Emanti home page*

Users who have eWQMS login details can access and use the tool through the steps explained below.

Step 1: Login to eWQMS

- Go to www.wqms.co.za
- Complete your username and password.
- Click “Login” (Figure 17)
- Once logged in, the Dashboard will open (Figure 18)

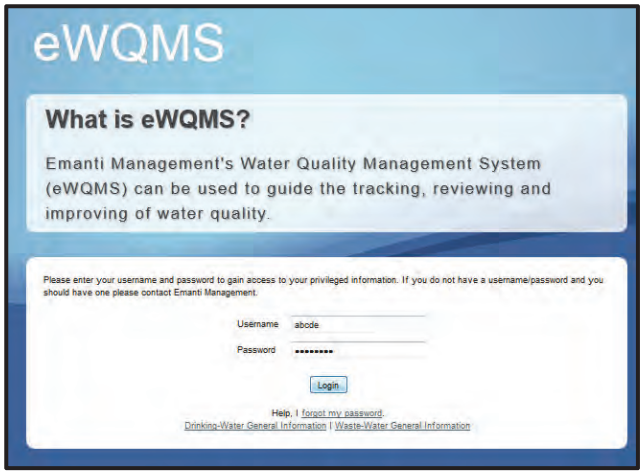


Figure 17: *eWQMS login page*

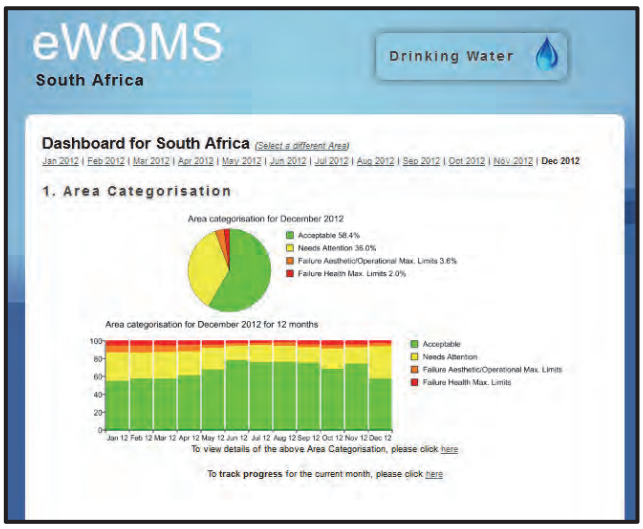


Figure 18: *eWQMS Dashboard page*

Go to Risk Toolbox and access the Water Safety Plan tool

- Using the tabs, go to “Risk Toolbox” (Figure 19)
- Select WRC Water Safety Plan Tool (Figure 19)

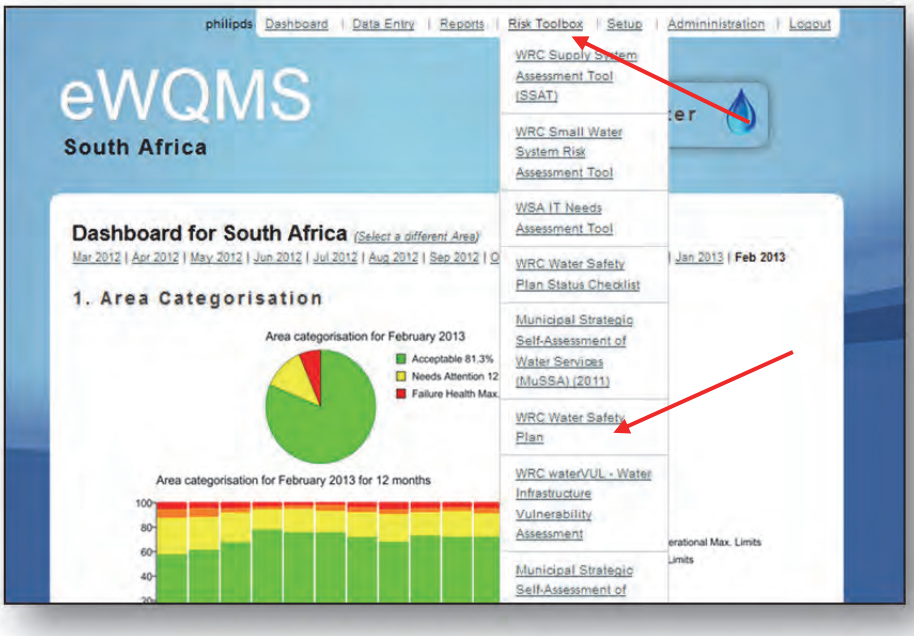


Figure 19: *eWQMS Risk Toolbox options*

Fill in the Water Safety Plan questionnaire

- Click “fill in questionnaire”
- All present systems within the area of jurisdiction of the user should be registered separately (i.e. as individual water supply systems).

To download the Excel tool via eWQMS, after selecting "Risk Toolbox":

- On the bottom left corner click on "additional resources"
- A message box will ask if you want the spreadsheet file to be saved.
- The spreadsheet can be saved to a suitable location and opened from there, as shown in Figure 20 below.

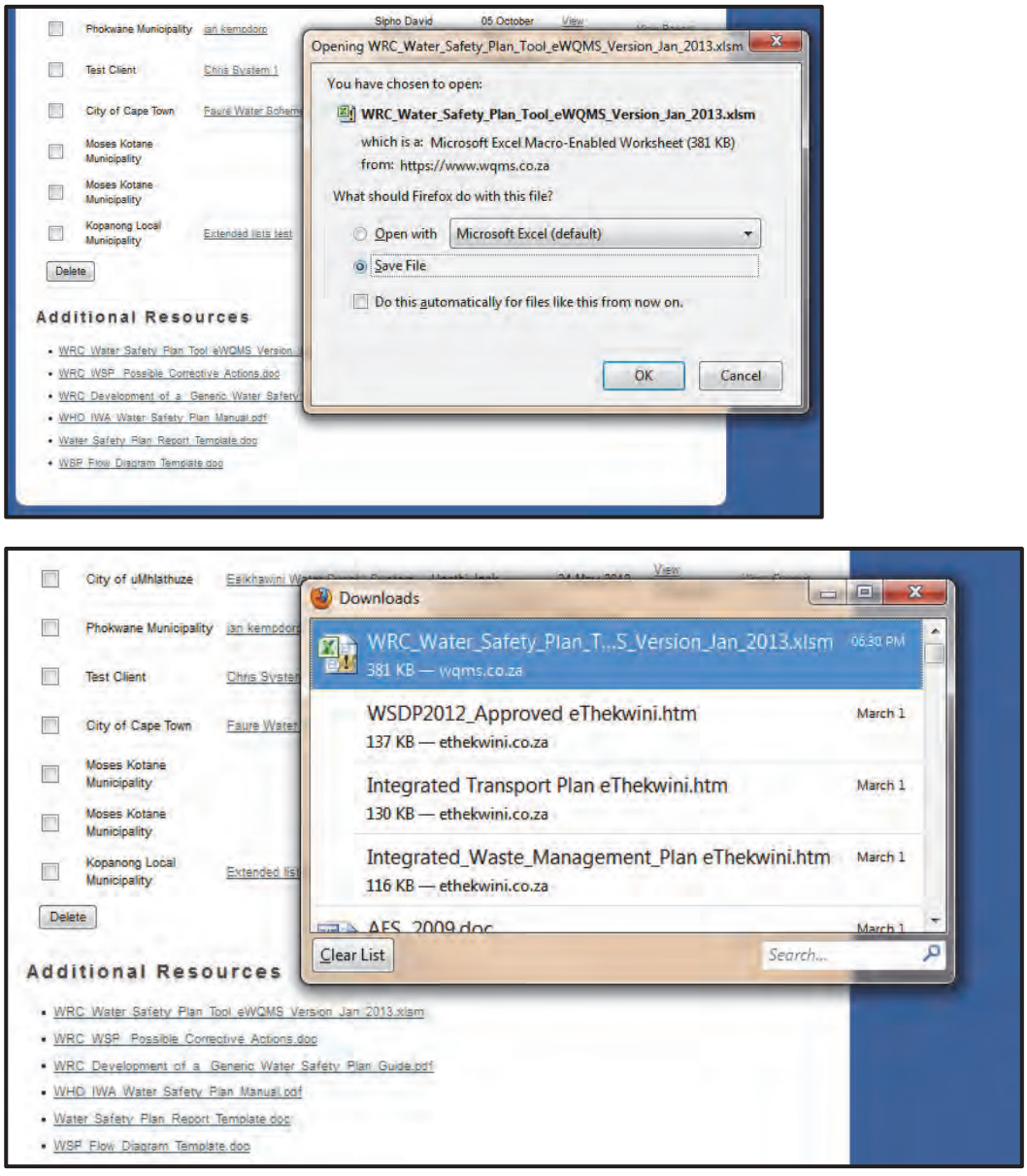


Figure 20: *eWQMS selecting and saving the tool*

Whether the Water Safety Plan is filled in through the spreadsheet or directly on to the web, eWQMS, the same steps to develop a Water Safety Planning are followed and are indicated in this section with screen extracts from the tool as indicated below.

Step 2: Capture the name of the system

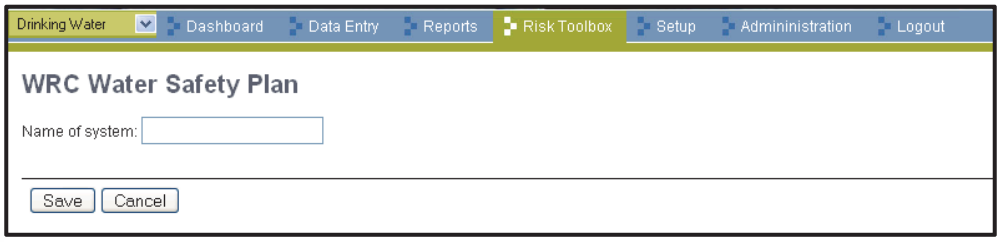
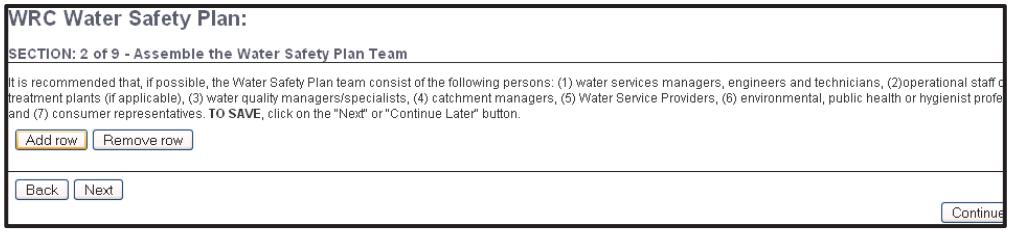


Figure 21: *eWQMS capturing the name of the system*

Step 3: Capture Project Team and Key Stakeholders

Using the Water Safety Planning tool, capture the details of the individuals making up the Water Safety Planning team, including appropriate roles and responsibilities, and associated contact details as shown in Figures 22 and 23 below.

- Click 'add row' to create as many rows as the number of the people making up the Water Safety Planning Team. More rows can be added or removed when there are changes to be made.
- Capture details of the team as according to the fields required.



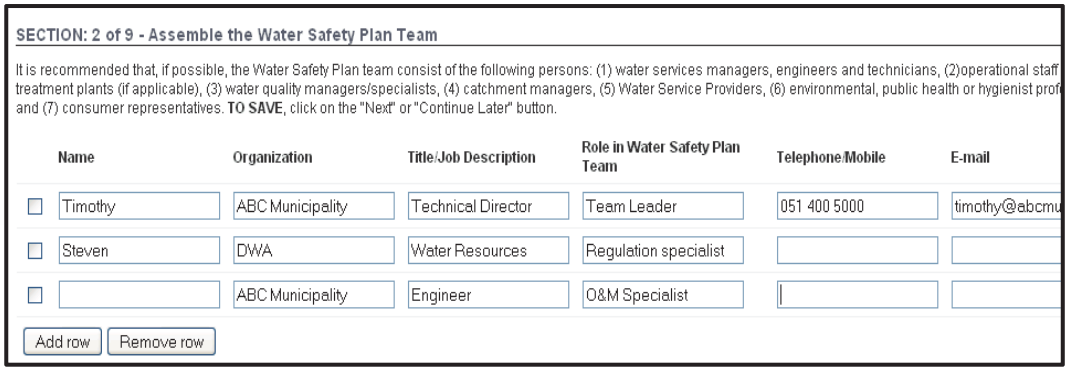


Figure 22: *Capturing Water Safety Planning Team: web*

Water Safety Plan Tool
Step 2 of 11

Assemble the Water Safety Plan Team

This step is: Incomplete

Capture the details of the WSP team. It is recommended that, if possible, the Water Safety Plan team consist of the following persons: (1) water serv managers, engineers and technicians, (2)operational staff of treatment plants (if applicable), (3) water quality managers/specialists, (4) catchment managers, (5) Water Service Providers, (6) environmental, public health or hygienist professionals and (7) consumer representatives.

	Name	Organisation	Title/Job Description	Role in WSP Team	Tel	Fax	Mobile	E-mail
1	Mr Thabo Smit	ABC Municipality	Technical Manager	Team Leader	+2742123456	+2742123456	+2783456789	tsmit@abc.gov
2	Ms ABC	ABC Municipality	Water Quality Manager	Water quality specialist	etc	etc	etc	etc
3	Mr DEF	ABC Municipality	Engineer	O&M specialist				
4	Ms XYZ	DWA	Assistant Director	Regulation specialist				
5	Mr IJK	IJK River Catchment Management Agency	Manager	Catchment Management specialist				
6	etc	etc	etc	etc				

Figure 23: *Capturing details of Water Safety Planning Team: Excel*

Step 4: Capture the details of the individual responsible for providing information of the Water Safety Planning

It is important to fill in a record of completion indicating who filled in the tool and the period. This would assist the WSI in determining the need to revise the tool and check if there are any updates required to be made. It is recommended that the information is completed by the individual responsible for conducting the assessment or the Water Safety Planning team leader. An example of record of completion is provided below.

SECTION: 1 of 9 - Record of Completion

TO SAVE, click on the "Next" or "Continue Later" button.

1. Name: Mfoba
2. Title/Job Description: Water Quality Manager
3. Locality: Venterstad
4. Address: 16 Church Street, Venter
5. Province: Eastern Cape
6. Telephone: 04735647899
7. Fax: 086 0001111
8. Mobile: 083 123 4567
9. E-mail: mfobane@venterstad.g

Figure 24: *Capturing details of person responsible for providing information of the Water Safety Plan: web*

The following information should be completed by the individual responsible for conducting the assessment and/or any additional revisions.	
Name	Thabo Smit
Title	Technical Manager
Water Services Authority	ABC Municipality
Water System Name	Town D
Address	32 Main Road
Province	Eastern Cape
Postal Code	7500
Telephone	+2742123456
Fax	+2742123456
Mobile	+2783456789
Email	tsmit@abc.gov.za

Figure 25: *Capturing details of person responsible for providing information of the Water Safety Plan: Excel*

Step 5: Document and Describe the present Drinking Water Supply System

First identify which components of the water supply system are applicable to the particular system by using examples below.

- Using the down arrow keys, choose yes or no indicating which components are available or not for that particular water supply system.

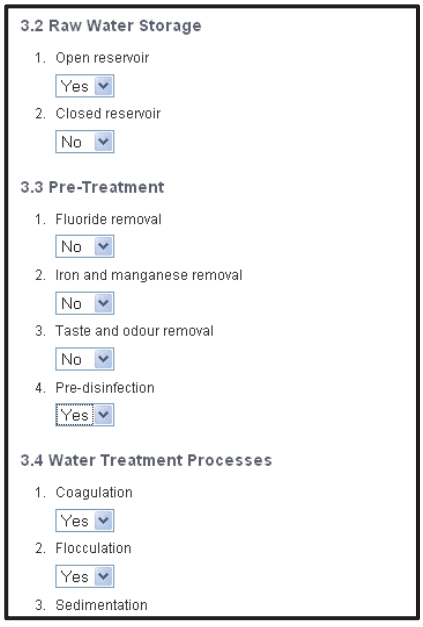
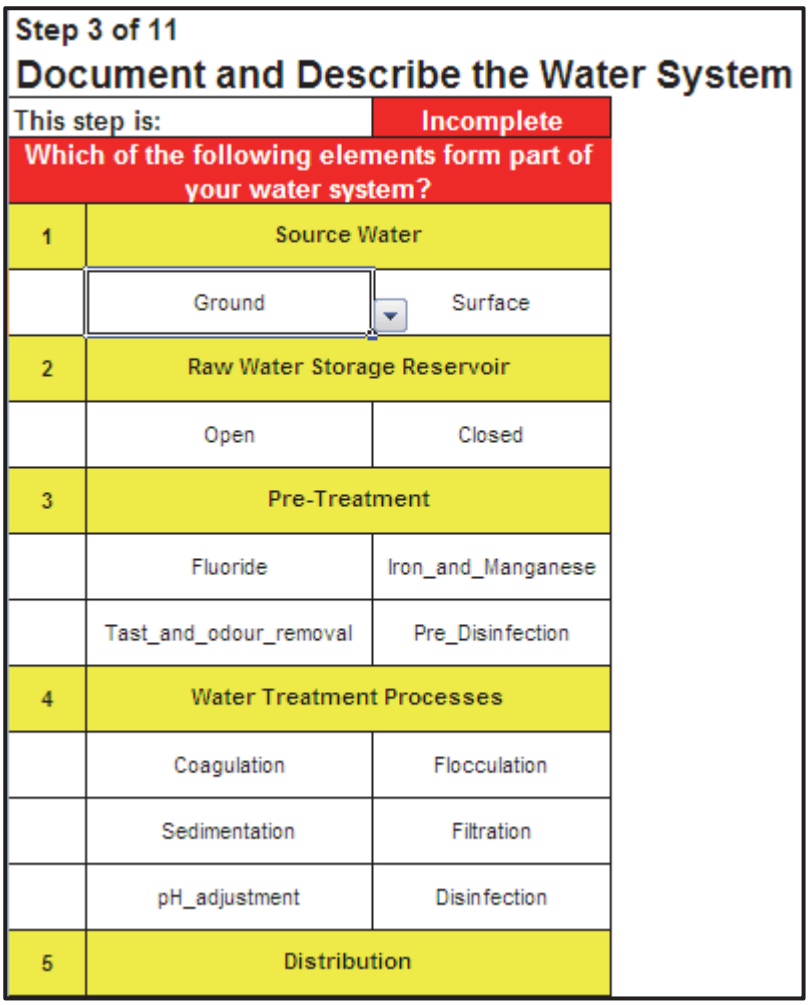


Figure 26: *Documentation and description of water supply system: web*



Step 3 of 11

Document and Describe the Water System

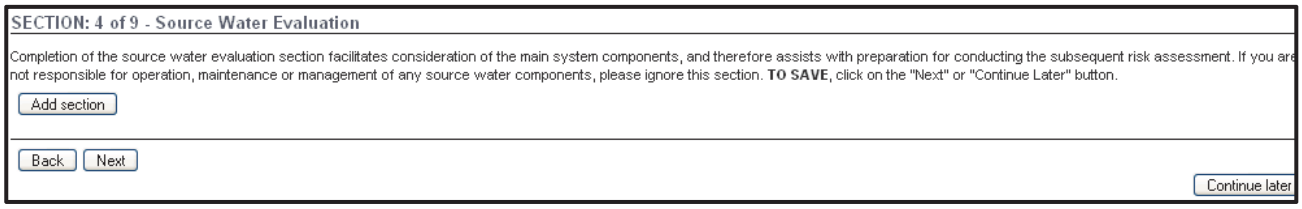
This step is:	Incomplete	
Which of the following elements form part of your water system?		
1	Source Water	
	Ground	Surface
2	Raw Water Storage Reservoir	
	Open	Closed
3	Pre-Treatment	
	Fluoride	Iron_and_Manganese
	Tast_and_odour_removal	Pre_Disinfection
4	Water Treatment Processes	
	Coagulation	Flocculation
	Sedimentation	Filtration
	pH_adjustment	Disinfection
5	Distribution	

Figure 27: *Documentation and description of water supply system: Excel*

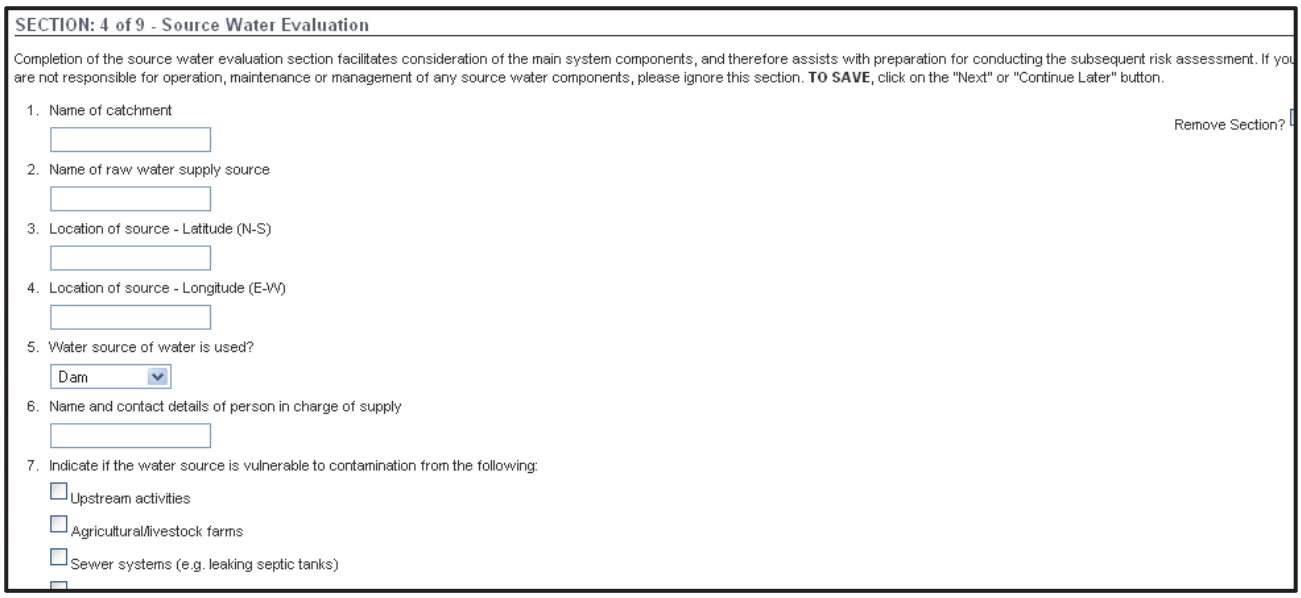
Step 6: Assess the Water Supply System (from source to consumer)

Using the tool, assess each component of the water supply system to obtain an idea of the typical hazards/risks faced.

On the tool, start with source assessment. If bulk water is received, this sectioned can be skipped.



- To fill in the information on source assessment, click add section
- Fill in the information according to the required fields



- If source assessment is not applicable for the system, click ‘next’ without clicking ‘add section’

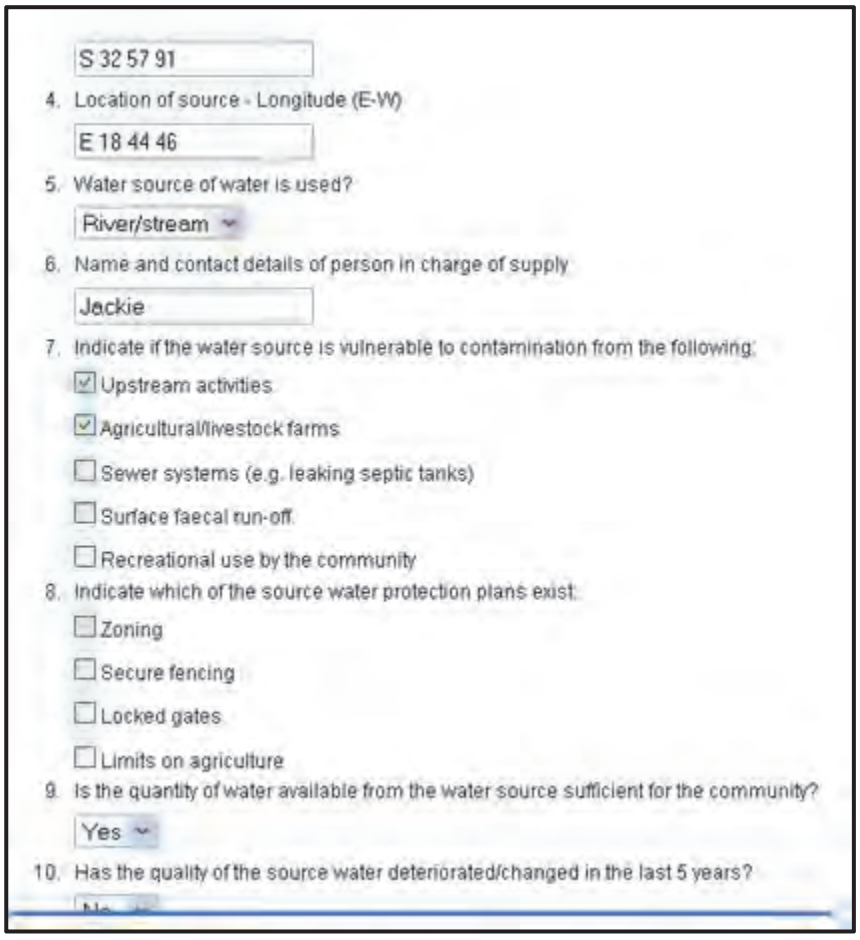


Figure 28: *Assessing source water: web*

Possible source related hazards (which are also included in the tool are listed in Appendix A.

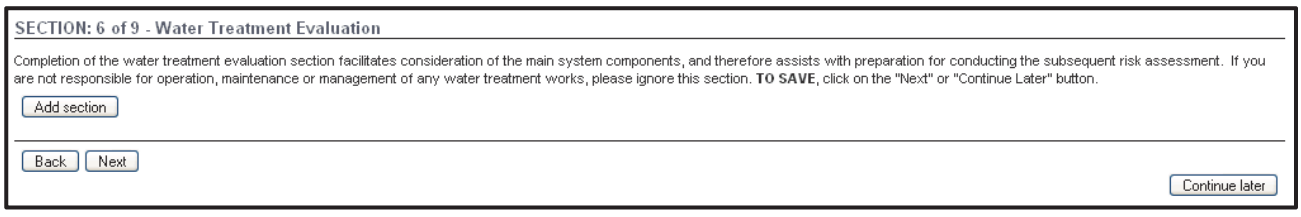
Evaluation of Catchment and Raw Water Source			
	Aspect	1	Comments
	Date of Assessment		
1	Name of catchment		
2	Name of raw water supply source		
3	Location of the source (GPS)		
4	What source of water is used?	River/Stream	
5	Name of person in charge of supply		
6	Contact details of person in charge of supply (phone, email, address)		
7	Is the water source vulnerable to contamination from the following?		
	- Upstream industries	Yes	
	- Agricultural/livestock farms	No	
	- Sewer systems such as leaking septic tanks, etc	Yes	
	- Surface faecal run-off	Yes	
	- Recreational use by the community	Yes	
	- Other (specify)	No	
8	Indicate which of the source water protection plans exist?		
	- Zoning	No	
	- Secure fencing	No	
	- Locked gates	No	
	- Limits on agriculture (e.g. phosphorous, pesticides)	Yes	

Figure 29: *Assessing Source Water: Excel*

Drinking Water Treatment Assessment

This section should be filled in by users who have a water treatment system, whether it is a system that use conventional treatment methods or a simple small treatment system. Using the tool, assess each unit of the drinking water treatment system to obtain an idea of the typical hazards/risks faced. If there is no water treatment system, this section can be skipped.

- To fill in the information on water treatment system, click add section (Figure 29):



- Fill in the information according to the required fields (Figure 30):

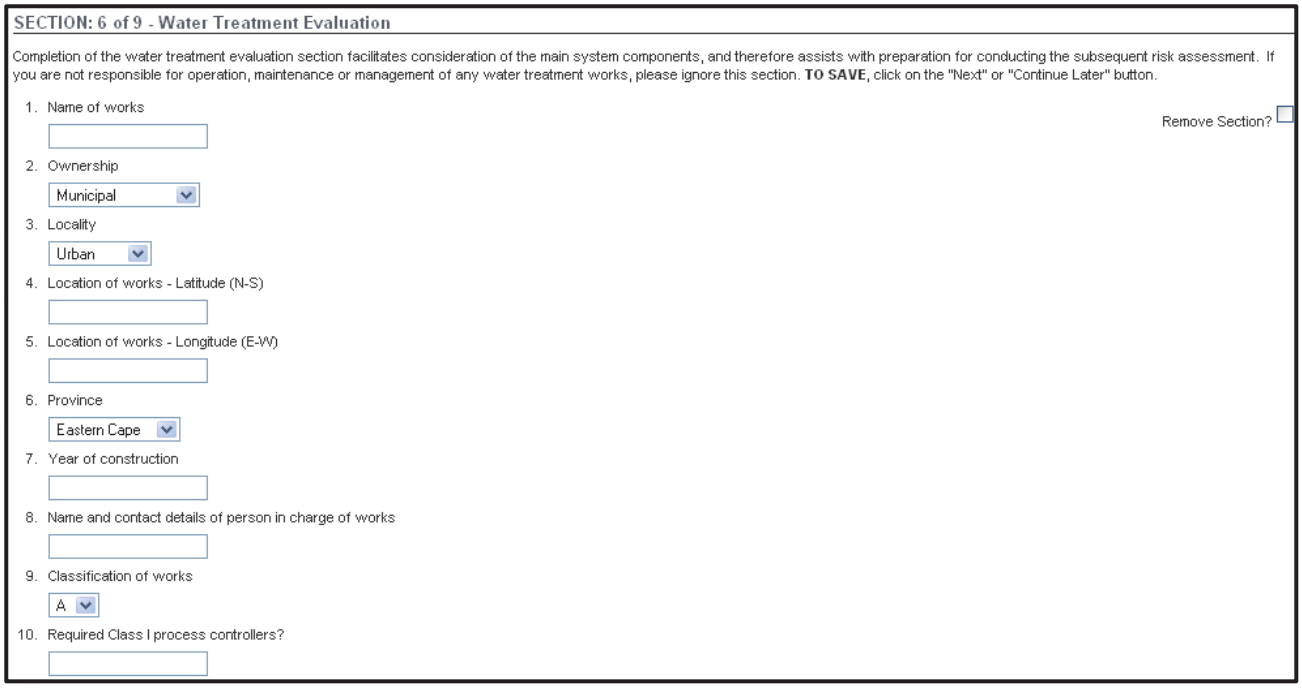


Figure 30: *Assessing Drinking Water Treatment system: web*

- If water treatment assessment is not applicable for the system, click 'next' without clicking 'add section'

Possible drinking water treatment related hazards (which are also included in the tool) are provided in Appendix A.

Evaluation of Waterworks Treatment, Design and Operation			
	Aspect	**1**	**Comments**
	Date of Assessment		
1	Name of works		
2	Ownership	DWA	
3	Locality	Urban	
4	Location of the works (GPS)		
5	Province	Free State	
6	Year of construction		
7	Name of person in charge of works		
8	Contact details of person in charge of works (phone, email, address)		
9	Classification of works	A	
	- Required class of process controller/operator (per shift)	Class IV	
	- Required class of supervisor (need to be available at all times)	Class V (on-site)	
10	Number of required process controllers/operators		
	- Full time	1	
	- Day time	2	
	- Part time	1	

Figure 31: *Assessing Drinking Water Treatment system: Excel*

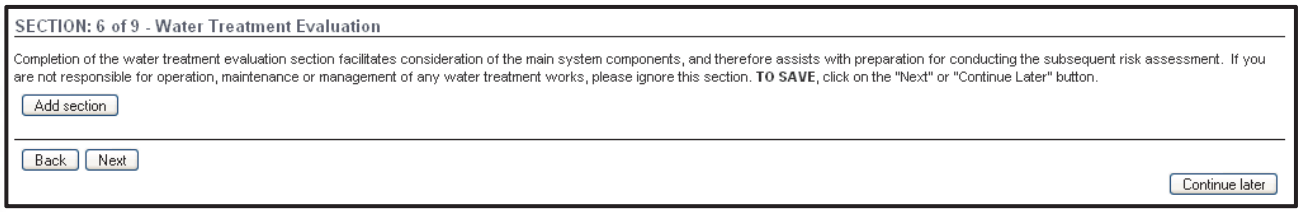
Drinking Water Network Assessment

Network includes bulk mains, network distribution pipes, on site and off site reservoirs, booster stations, valves, standpipes and house connections. Assess the drinking water network to obtain an idea of the typical challenges/risks faced.

Using the tool, assess each unit of the drinking water network to obtain an idea of the typical hazards/risks faced.

Possible drinking water network hazards (which are also included in the tool) are listed in appendix A.

- To fill in the information on drinking water network system, click add section



- Fill in the information according to the required fields

Using the tool, drinking water network information should be documented and hazards applicable for that drinking water network should be identified by selecting the appropriate answer. Examples of treatment evaluation are shown in the figures below.

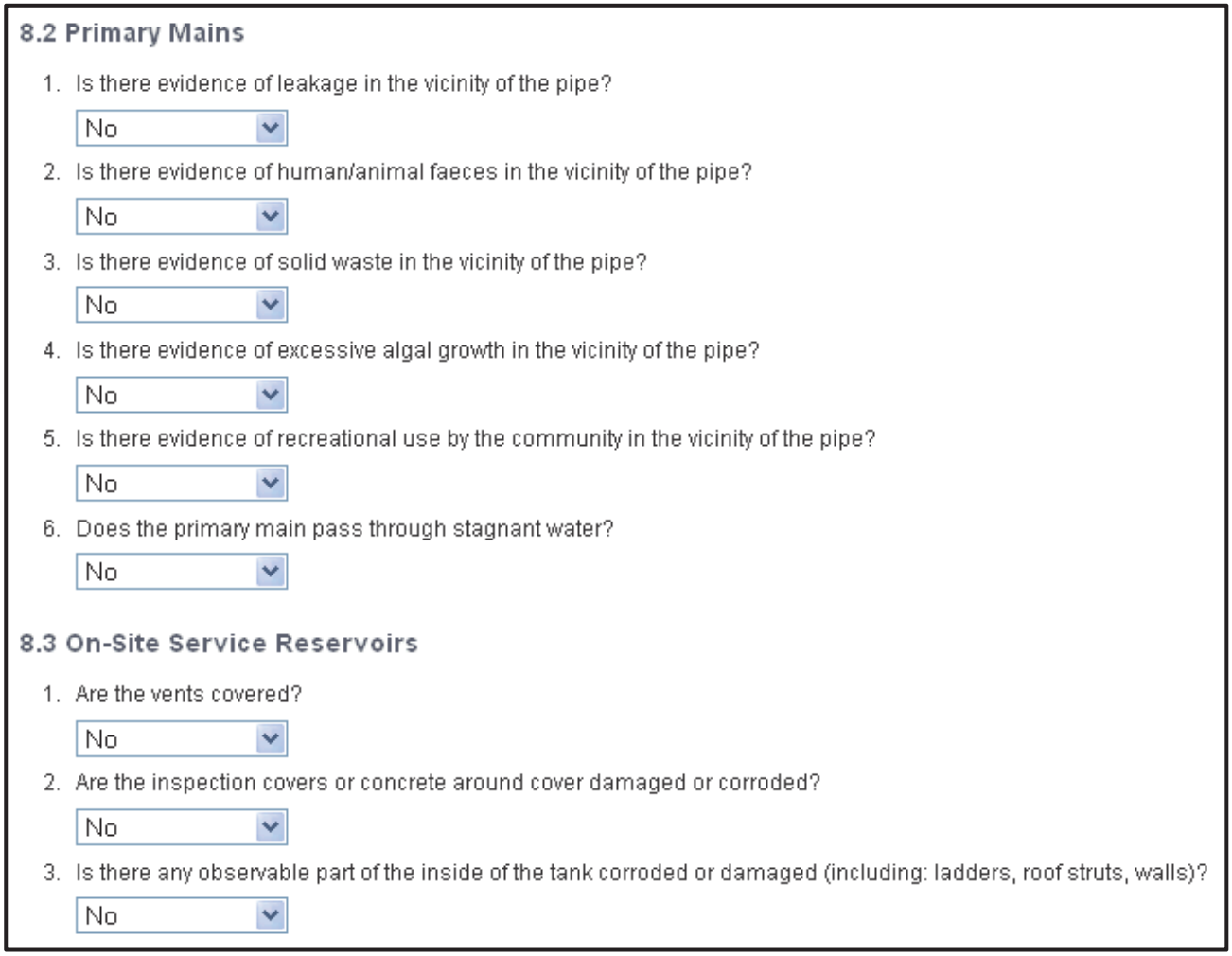


Figure 32: *Assessing Drinking Water Network: web*

Evaluation of Distribution Network			
	Aspect	**1**	**Comments**
1	Safety policies and procedures are in place and adhered to (as per Occupation Health and Safety Act requirements) distribution network.	Yes	
2	Appropriate safe work procedures, permit to work systems and lock-out procedures are available and implemented	Yes	
	Primary Mains		
1	Is there evidence of the following in the vicinity of the pipe?		
	- Leakage	Yes	
	- Human/animal faeces	Yes	
	- Solid waste	Yes	
	- Excessive algal growth	Yes	
	- Recreational use by the community	Yes	
	- Other (specify)	Yes	

Figure 33: *Assessing Drinking Water Network: Excel*

Step 7: Undertake a Risk assessment

From the hazards identified for each water supply system component, determine the risk associated with them. On the tool it would be already indicating by a yes or no if the hazard is valid or not (if the assessment page has already been filled in). Focus should be given on those hazards already indicated as valid.

- Select the option under likelihood indicating the likelihood of that hazard to happen as shown in Figures 34 and 35 below.
- Once the likelihood has been determined, determine the consequence should that hazard happen.
- Select the option under consequence indicating the impact the hazard would have, as shown in Figure 36 below.
- If the valid hazard is not on the available list, the user can add the hazard/s by going down the page of risk assessment and click “add row” under “User defined hazards” category, as shown in Figure 37. Fill in the valid hazard in the evaluation item block and indicate likelihood and consequence. The user identified hazards will be included in the summary report.

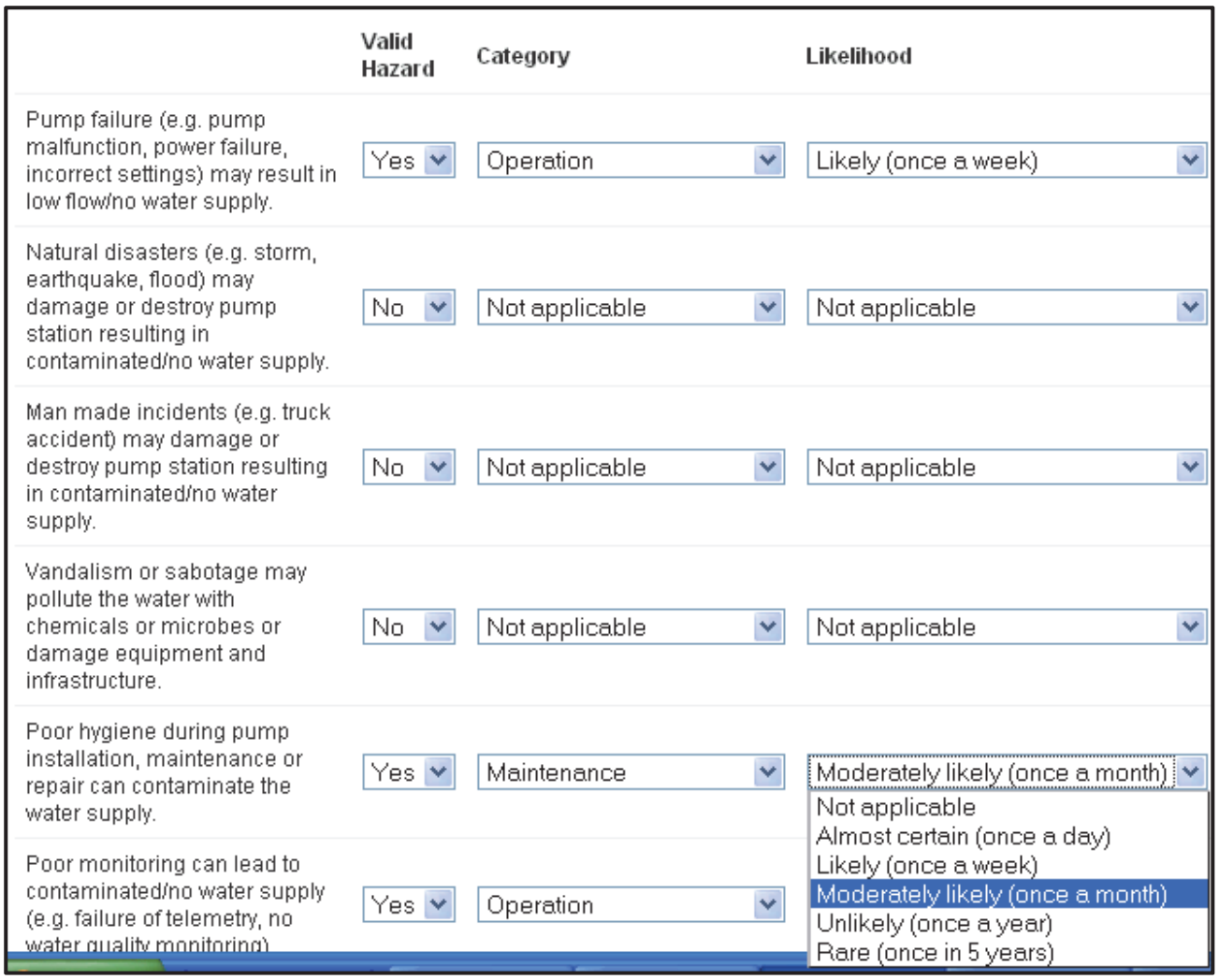


Figure 34: *Determining Likelihood of a valid hazards: web*

Source Water

	Potential Hazards or Hazardous Events	Valid Hazard	Category	Likelihood	Rating	Consequence	Rating	Risk Rating	Risk Profile
	Surface Water (Rivers and Streams)								
1	Livestock, human activity at water source.	Yes	Operation	Moderately likely	0.5	Minor	2	1	Low Risk
2	Raw water turbid after heavy rain. May contain droppings of animals and birds.	Yes	Design	Not applicable	0	Not applicable	0	0	No Risk
3	Dead animals.	No	Maintenance	Almost certain Likely Moderately likely Unlikely Rare Not applicable	.8	Moderate	20	16	Medium Risk
4	Droppings of animals/birds can introduce harmful micro-organisms into the water body.	Yes	Design		.8	Catastrophic	100	80	High Risk
	Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal								

Figure 35: *Determining Likelihood of valid hazards: Excel*

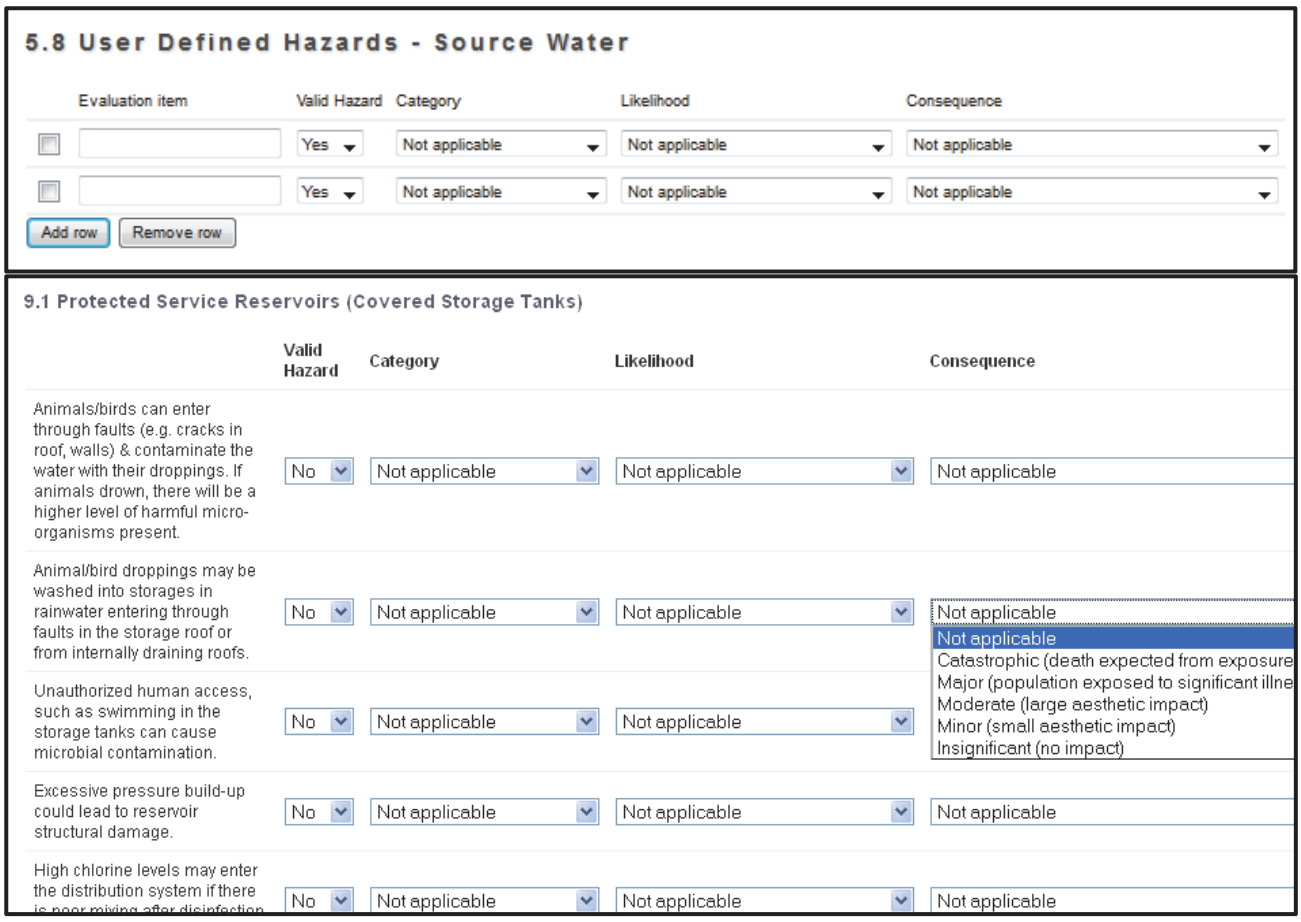


Figure 36: *Determining consequence of a valid hazards: web*

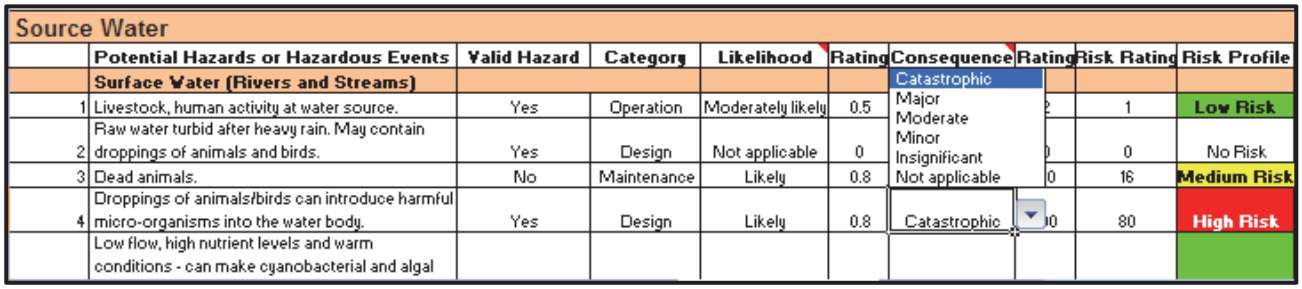


Figure 37: *Determining consequence of valid hazards: Excel*

Note

Using the tool, four columns to be filled in are:

1. Identify if the hazard is valid or not on the “valid hazard” column
2. Determine likelihood of the hazard on the “Likelihood” column
3. Determine the consequence of the hazard on the “consequence” column
4. The category column can be filled in to identify if the hazard is design, operational or maintenance related. This should assist in correctly assigning corrective measures to the responsible person or

- Using the web based tool, click “view summary report” at the end of the questionnaire to view the intensity of the risk (Figure 38).
- This can be viewed on the “Risk Profile” column on the excel format with colour code as seen in Figure 39.

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile
9.5 Distribution System	Pipe bursts/leaks can interrupt supply. Contamination can occur where pipes are below/close to stormwater/sewage pipes or septic tanks. Entry of soil may increase turbidity.	Yes	Operation	56.00	Medium Risk
9.3 Pump Stations	Pump failure (e.g. pump malfunction, power failure, incorrect settings) may result in low flow/no water supply.	Yes	Operation	56.00	Medium Risk
9.1 Protected Service Reservoirs (Covered Storage Tanks)	Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring).	Yes	Operation	56.00	Medium Risk
7.1 General	Power supply can result in interrupted treatment/loss of process control.	Yes	Operation	56.00	Medium Risk
7.1 General	Non optimised treatment processes can result in poor water quality.	Yes	Operation	56.00	Medium Risk

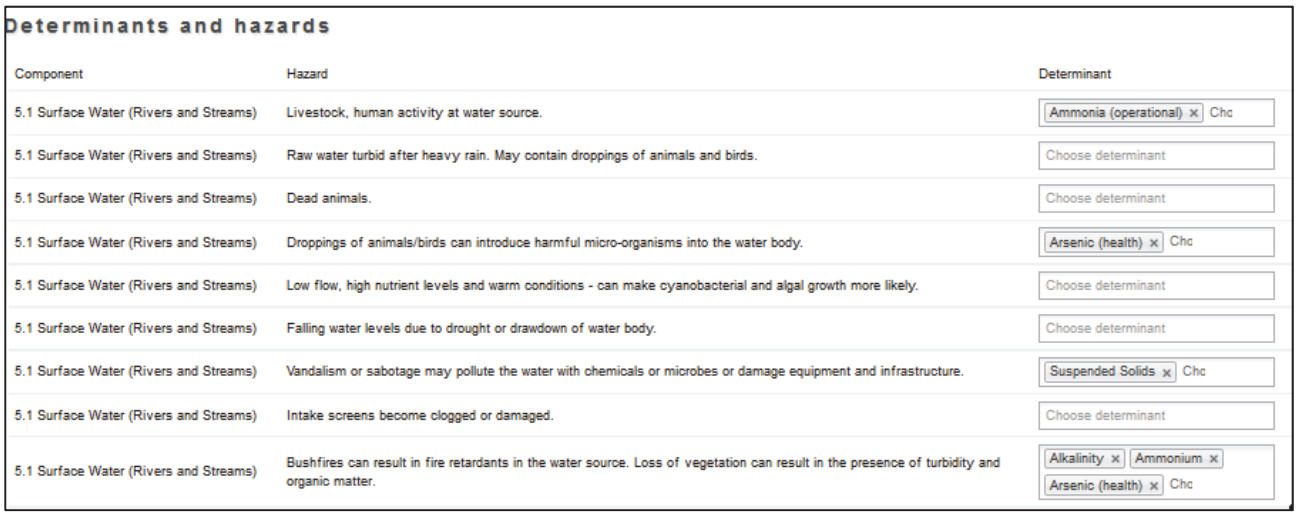
Figure 38: *Risk summarisation representation: web*

Water Safety Plan Tool
Step 11 of 11
Summary
NOTE: The results presented below are automatically populated from previous inputs - DO NOT MODIFY HERE
To prioritise residual risks (considering control measures), users need to click on the arrow on "Risk Rating" (column F), then select "Sort Largest to Sr
Summary Status and Ranking

Component	Hazard	Valid Hazard / Hazardous Event	Hazard Category	Hazard Name (Water Quality Determinand)	Risk Rating	Risk Profile	Control Measure in Place (if any)	Correctiv
Source		Yes	Operation	0	1	Low Risk	0	New fenc
Source		Yes	Design	0	10	Low Risk	Effective monitoring & treatment	Not requir
Source	Dead animals.	No	Maintenance	0	16	Medium Risk	0	0
Source	Droppings of animals/birds can introduce harmful micro-organisms into the water body.	Yes	Design	0	0	No Risk	0	0
Source	Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal growth more likely.	Yes	Operation	0	2	Low Risk	0	0
Source	Falling water levels due to drought or drawdown of water body.	No	Maintenance	0	0	No Risk	0	0
Source	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.	Yes	Design	0	16	Medium Risk	0	0

Figure 39: *Risk summary representation: Excel*

After completing section 9 of 9, click “next” you will get a screen with your list of identified valid hazards with an option to select the determinands that could be a threat due to the identified hazardous event. Multiple determinands can be selected for one hazardous event. This will assist in developing a risk based monitoring programme.



Determinants and hazards

Component	Hazard	Determinant
5.1 Surface Water (Rivers and Streams)	Livestock, human activity at water source.	Ammonia (operational) × Chc
5.1 Surface Water (Rivers and Streams)	Raw water turbid after heavy rain. May contain droppings of animals and birds.	Choose determinant
5.1 Surface Water (Rivers and Streams)	Dead animals.	Choose determinant
5.1 Surface Water (Rivers and Streams)	Droppings of animals/birds can introduce harmful micro-organisms into the water body.	Arsenic (health) × Chc
5.1 Surface Water (Rivers and Streams)	Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal growth more likely.	Choose determinant
5.1 Surface Water (Rivers and Streams)	Falling water levels due to drought or drawdown of water body.	Choose determinant
5.1 Surface Water (Rivers and Streams)	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.	Suspended Solids × Chc
5.1 Surface Water (Rivers and Streams)	Intake screens become clogged or damaged.	Choose determinant
5.1 Surface Water (Rivers and Streams)	Bushfires can result in fire retardants in the water source. Loss of vegetation can result in the presence of turbidity and organic matter.	Alkalinity × Ammonium × Arsenic (health) × Chc

Figure 40: *Aligning hazardous events with hazards (SANS 241): web*

HAZARD RISK ASSESSMENT						
Component	**Hazard/Hazard Event**		**Valid Hazard**	**Risk Rating**	**Risk Profile**	**SANS 241 List**
Source						
Source (Cubhu)	Problematic high colour content in raw water	Natural occurring	Yes	70	High Risk	Colour
Source (Cubhu)	Occasionally high turbidity	Low lake levels	Yes	56	Medium Risk	Turbidity
Source (Cubhu)	High Turbidity	Falling water levels due to drought or drawdown of water body increases turbidity at intake water	Yes	35	Medium Risk	Turbidity
Treatment						
DW Treatment	High colour content in final water	Due to insufficient treatment process for colour removal	Yes	70	High Risk	Colour
DW Treatment	High turbidity	Due to flocculent dosing malfunction through equipment failure or power failure	Yes	20	Medium Risk	Turbidity

Figure 41: *Aligning hazardous events with hazards (SANS 241): Excel*

- Click next after identifying determinands and you will get a message “thank you for completing the questionnaire”.
- A “return to questionnaire link will be indicated together with a summary report link. Click the summary report link to view your report where you may indicate the suggested control measures.
- You can also click “return to questionnaire link” where you can select the system you want to view the report for. Click “view report” where you have to identify suggested control measures as indicated below.

Step 8: Identify control measures

Identify existing control/intervention measures, determine effectiveness thereof (e.g. redundancy, alternatives, back-ups, etc.) and identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. There is limited space on the web to see full sentences.

- Fill in control measures directly onto the web
- When done, click ‘submit corrective actions’ at the end of the page.

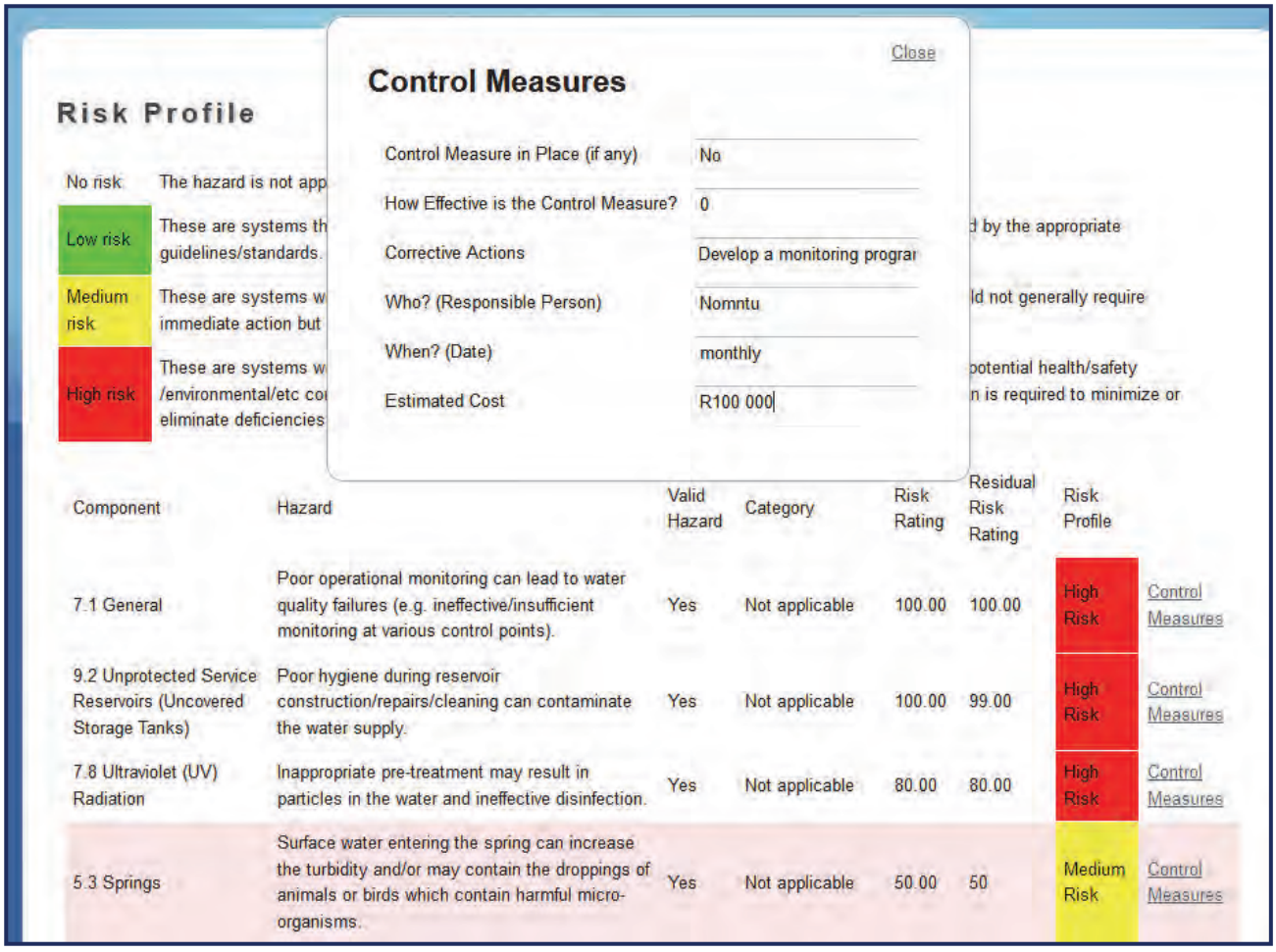
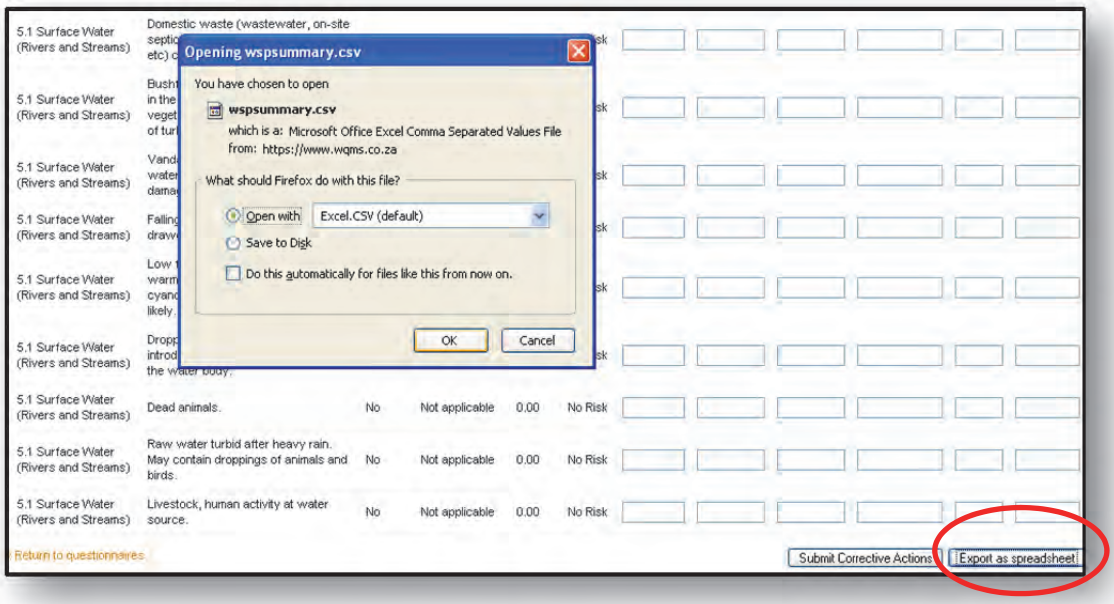


Figure 42: *Capturing and evaluating effectiveness of control measures using the web format*

Alternatively export the report to excel.

- Click export as spreadsheet at the end of the page
- A message box will ask if you want the spreadsheet file to be opened or saved



- Open the spreadsheet and fill in the control measures, estimated costs and estimated time for the control measure to be implemented

Hazard	Valid Hazard	Category	Risk Profile	Control Measure	Is the Control Measure Effective?	Corrective Actions	Who? (Responsible Person)	When? (Date)	Estimated Cost
Bird/animal droppings contaminate water.	Yes	Managem	Medium Risk	No	No	Hold awarenss campaigns educating the public about the importance of protrected(covered) rain water harvesting tankers aor collectors	Councillor Shushu	Immedia tely	To be determined
supply can result in interrupted	Yes	Operation	Medium Risk	No	No	No backup generator at the plant, need to put plans in place to invest in a back up generator.	Mr Phetheni	Jun-12	R100 000
Poor hygiene during reservoir	Yes	Maintena	Medium Risk	No	No	More precaustion should be taken when reservoir cleaning occurs.			

Figure 43: *Developing control measures on exported summary report*

Outputs from the completed web based and/or Microsoft Excel spreadsheet can be copied and pasted into a document to compile a Water Safety Plan Report.

After implementation of control measures and reviewing the effectiveness of existing control measures, the initial risk profile together with the residual risk profile will be indicated (Figures 44 and 45).

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile	Residual Risk Rating	Residual Risk Profile	
5.1 Surface Water (Rivers and Streams)	Livestock, human activity at water source.	Yes	Planning/Design	70	High Risk	70	High Risk	Control Measures
5.1 Surface Water (Rivers and Streams)	Raw water turbid after heavy rain. May contain droppings of animals and birds.	Yes	Operation	70	High Risk	70	High Risk	Control Measures
5.1 Surface Water (Rivers and Streams)	Dead animals.	Yes	Operation	70	High Risk	70	High Risk	Control Measures
5.1 Surface Water (Rivers and Streams)	Droppings of animals/birds can introduce harmful micro-organisms into the water body.	Yes	Operation	70	High Risk	70	High Risk	Control Measures

Figure 44: *Residual Risk Profiling: web*

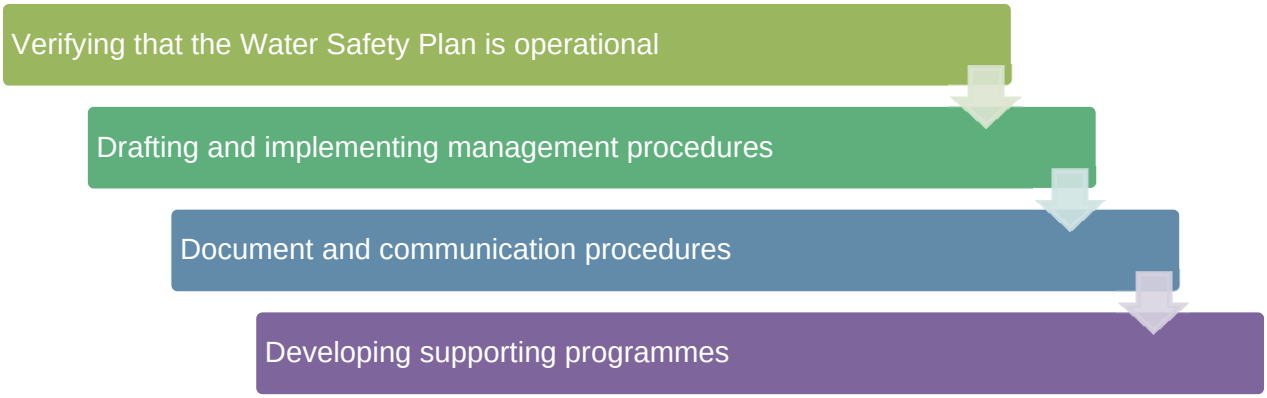
opulated from previous inputs - DO NOT MODIFY HERE
), users need to click on "Residual Risk Rating" (column I), then select "Data", "Sort by", "Residual Risk Rating", "Descending" from the top men

Valid Hazard / Hazardous Event	Hazard Category	Hazard Name (Water Quality Determinand)	Risk Rating	Risk Profile	Control Measure in Place (if any)	Control Measure Effectiveness (%)?	Residual Risk Rating	Residual Risk Profile	Corrective Actions
Yes	Design	Giardia species	80	High Risk	0	30%	56	Medium Risk	0
Yes	Operation	0	2	Low Risk	0	0%	2	Low Risk	0
No	Maintenance	0	0	No Risk	0	0%	0	No Risk	0
Yes	Design	0	16	Medium Risk	0	80%	3.2	Low Risk	0
Yes	Operation	Cryptosporidium species	70	High Risk	0	80%	14	Medium Risk	0
Yes	Maintenance	0	4	Low Risk	0	80%	0.8	Low Risk	0

Figure 45: *Residual Risk Profiling: Excel*

Considering the summarised findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be addressed by ranking the risks.

As indicated earlier that the tool assists in developing Water Safety Planning, management of identified risks depends on the actions taken thereafter. The tool therefore provides suggested corrective actions, therefore implementation of corrective actions, communication procedures, management procedures development and implementation depends on the Water Services Institution (WSI). The next steps of the Water Safety Planning are not included in the tool, however should be considered as discussed earlier. The steps include:



5.3. Water Safety Plan status Checklist

The Water Safety Plan should be reviewed annually. A Water Safety Plan status checklist is also available on eWQMS.

This tool allows one to rapidly assess progress in the Water Safety Planning process (i.e. “where we are and what do we still need to do”). It considers typical steps of the Water Safety Planning process and asks 5 key questions per step. A colour-coded “spider-diagram” output is provided of the status. The tool assists in reviewing the Water Safety Plan.

Step 1: Login to eWQMS

- Go to www.wqms.co.za
- Complete your username and password.
- Click “Login” (Figure 46)
- Once logged in, the Dashboard will open (Figure 47).

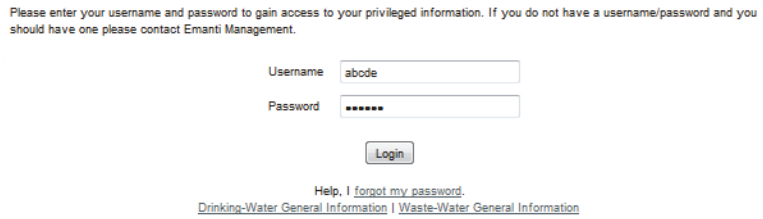


Figure 46: *eWQMS login page*

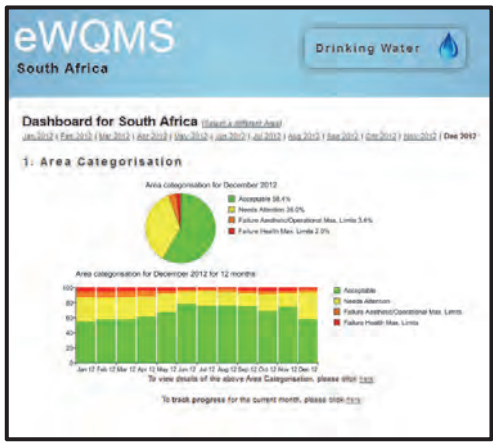


Figure 47: *eWQMS Dashboard page*

Step 2: Go to “Risk Toolbox” and Access Water Safety Plan Status Checklist Tool

- Using the tabs, go to “Risk Toolbox”
- Select the option: Water Safety Plan Status Checklist Tool (web)
- A screen will open asking you to complete the assessment

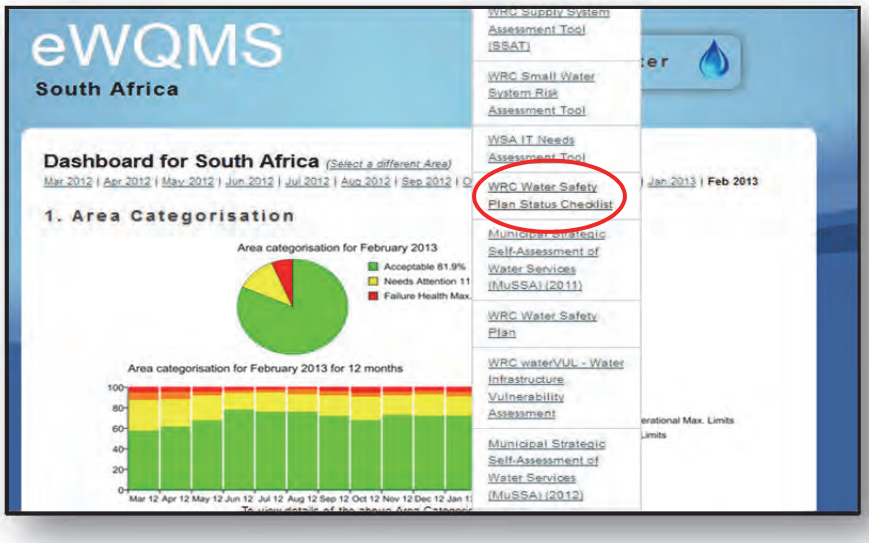


Figure 48: *Selecting the Water Safety Plan Status Checklist Tool*

Step 3: Complete the Water Safety Plan Status Checklist Tool

- Answer all questions presented in the checklist by clicking on the appropriate answer
- Remember to click on “Save” or the information will be lost
- Once you have fully completed all questions, click on “Complete”
- A report with an associated Spider Diagram will be generated once the checklist has been completed (similar to Figure 50).

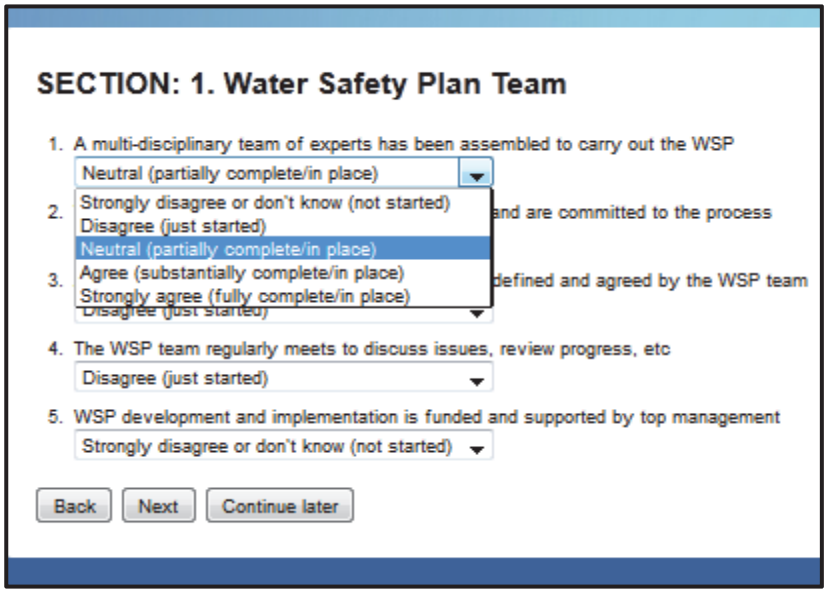


Figure 49: *Completing the Water Safety Plan Status Checklist Tool*

At the end, click ‘view spider chart’.

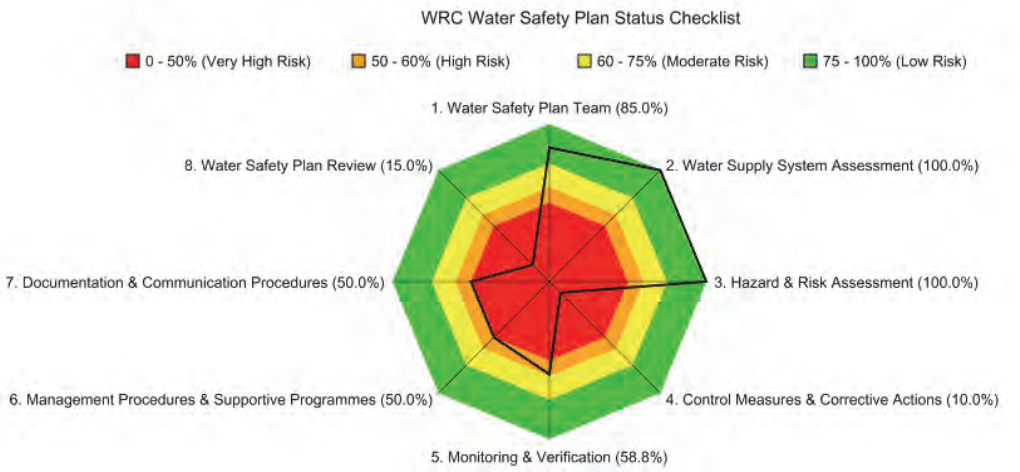


Figure 50: *Water Safety Plan Status Report*

The tools are available on eWQMS. As indicated earlier, the tools are continuously reviewed and enhanced therefore any feedback is acceptable. Please provide feedback to the task team on info@emanti.co.za

A report template and other resources are available under additional resources at the bottom of the Water Safety Plan Tool page (see screenshot below).

Additional Resources

- WRC_Water_Safety_Plan_Tool_eWQMS_Version_Nov_2010.xlsx
- WRC_WSP_ Possible_Corrective_Actions.doc
- WRC_Development_of_a_ Generic_Water_Safety_Plan_Guide.pdf
- WHO_IWA_Water_Safety_Plan_Manual.pdf
- Water_Safety_Plan_Report_Template.doc
- WSP_Flow_Diagram_Template.doc

6 AFRIKAANS TRANSLATED WATER SAFETY PLAN TOOL

6.1. Introduction

The English updated excel spreadsheet and web enabled tool was translated to Afrikaans. It should be noted that the tool is translated to reach wider range of users and strengthen and improve the development and understanding of Water Safety Plans. The output is presented in English as it is then useful for assessment and auditing purposes (e.g. if a DWA Blue Drop inspector assesses the supply system, he would be able to understand the Water Safety Plan outputs).

Considering the above, the same detailed steps followed in the English Water Safety Plan tool are followed in the translated tools. The current steps below form part of the WRC Afrikaans translated Water Safety Planning tool on the electronic Water Quality Management System (eWQMS):

6.2. Accessing and Using the Afrikaans Water Safety Plan Tool

Users who do not have eWQMS login details can access the tool via Emanti website: www.emanti.co.za. Users will be provided with a unique username and password to be able to access the web tool.

The steps presented below do not necessarily follow the traditional steps of developing and implementing Water Safety Plans. However, these are the steps followed when using the Excel and web Water Safety Plan tools developed through this study.

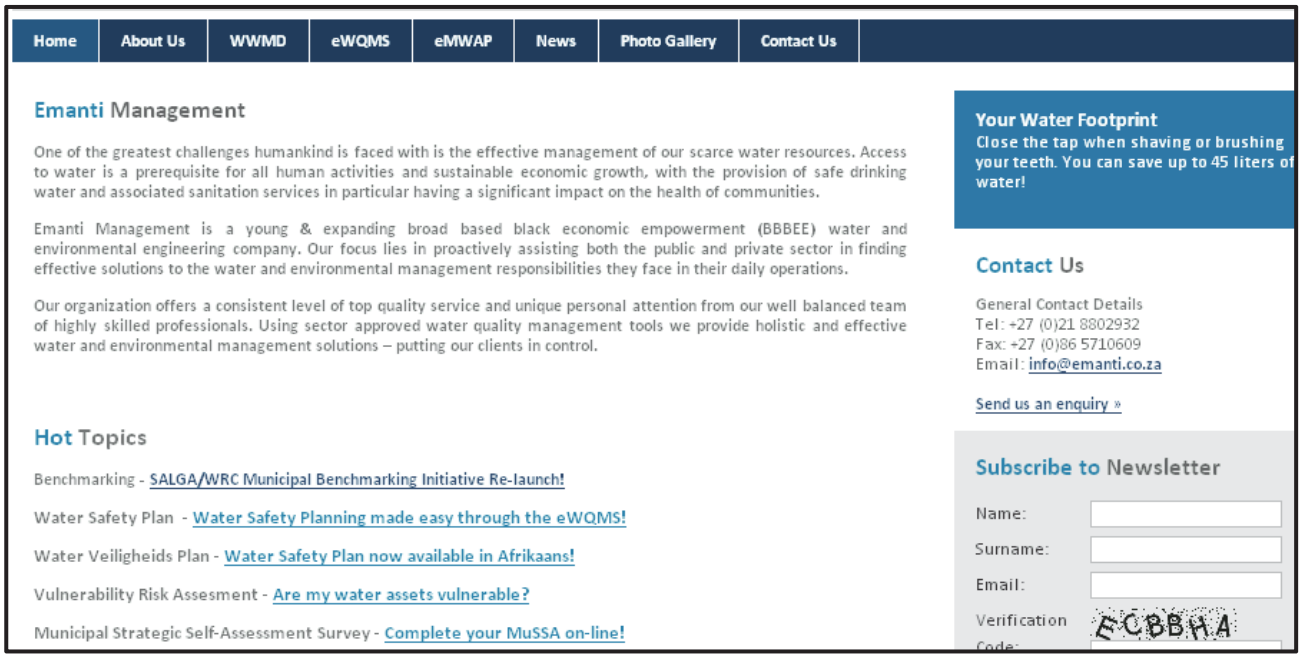


Figure 51: *Emanti home page*

Users who have eWQMS login details can access and use the tool through the steps explained below.

Step 1: Login to eWQMS

- Go to www.wqms.co.za
- Complete your username and password.
- Click “Login”

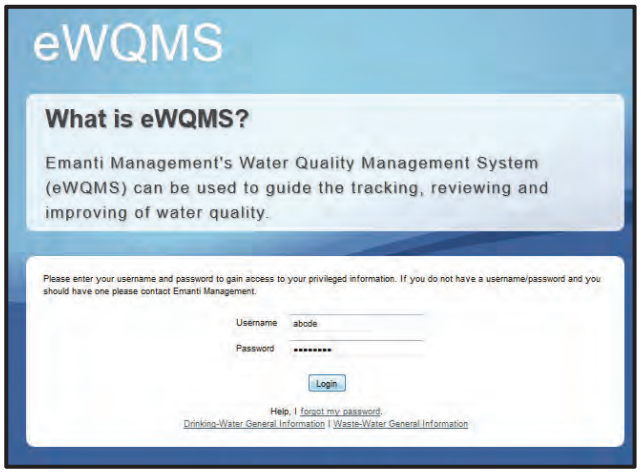


Figure 52: *eWQMS login page*

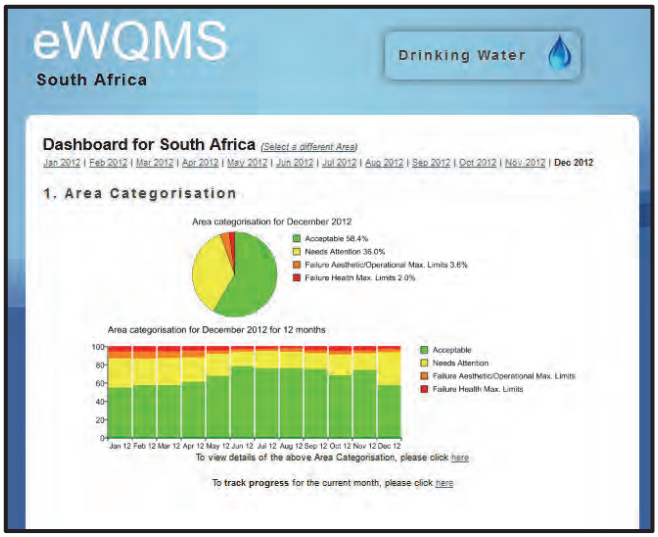


Figure 53: *eWQMS Dashboard page*

Go to Risk Toolbox and access the Afrikaans Water Safety Plan tool (Waterveiligheidsplan)

- Using the tabs, go to “Risk Toolbox”
- Select WRC Waterveiligheidsplan

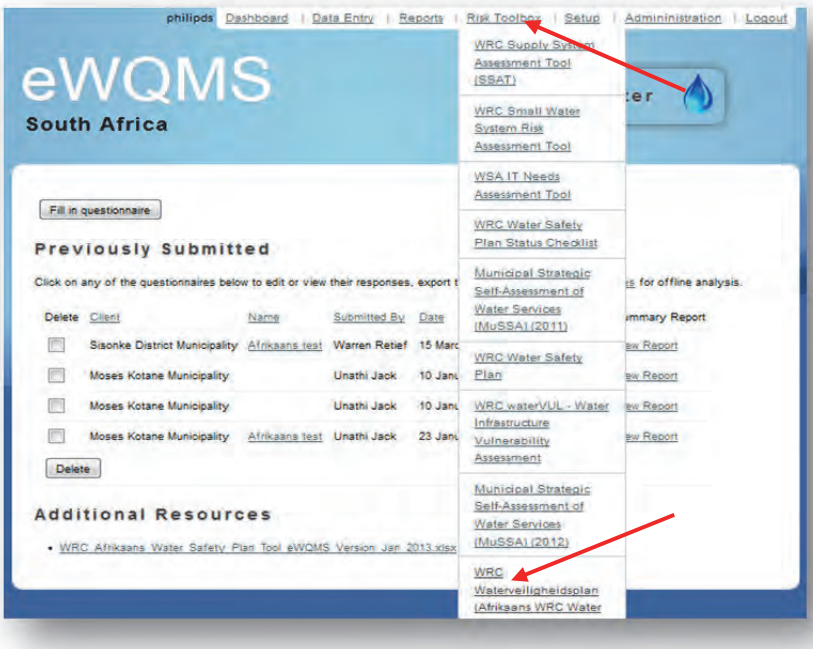


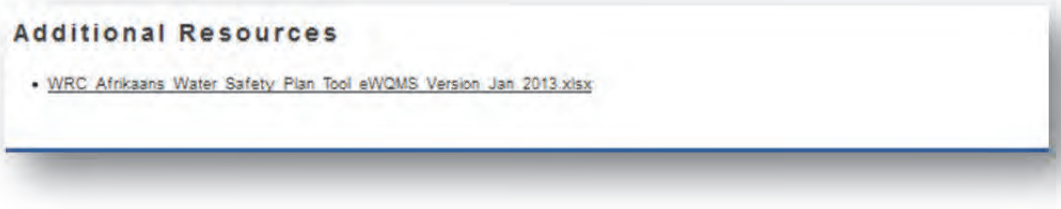
Figure 54: *eWQMS Risk Toolbox options*

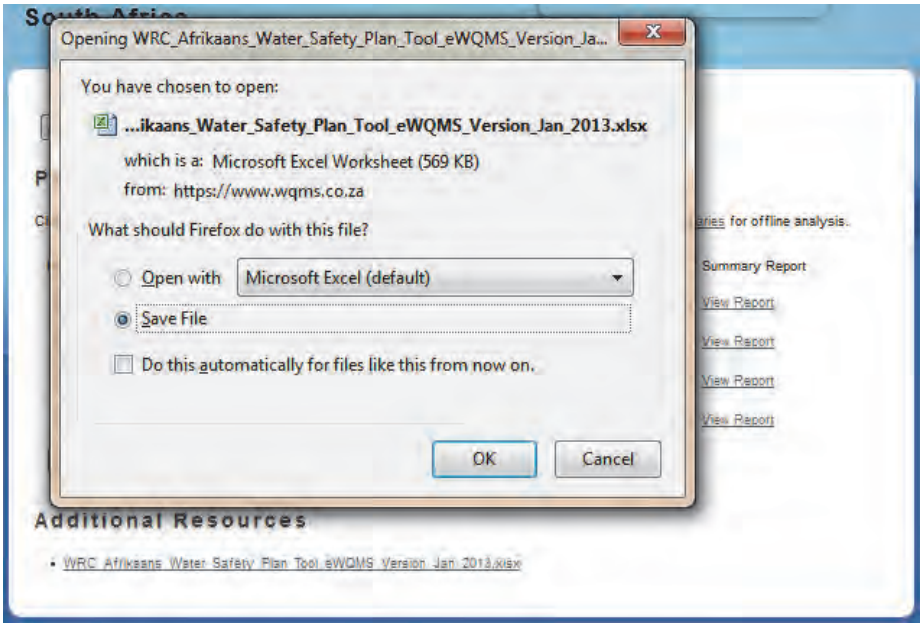
Fill in the Afrikaans Water Safety Plan questionnaire

- Click “fill in questionnaire”
- All present systems within the area of jurisdiction of the user should be registered separately (i.e. as individual water supply systems).

To download the Afrikaans Excel tool via eWQMS, after selecting “Risk Toolbox”:

- On the bottom left corner click on “additional resources”
- A message box will ask if you want the spreadsheet file to be saved.
- The spreadsheet can be saved to a suitable location and opened from there, as shown below.





- A box of downloads will appear where the spreadsheet can be opened and saved at the selected location as shown below.

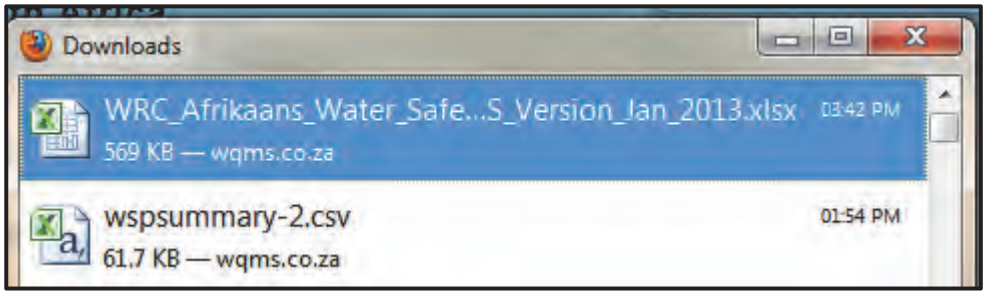


Figure 55: *eWQMS selecting and saving the tool*

Whether the Water Safety Plan is filled in through the spreadsheet or directly on to the web, eWQMS, the same steps to develop a Water Safety Planning are followed and are indicated in this section with screen extracts from the tool as indicated below.

Step 2: Capture the name of the system

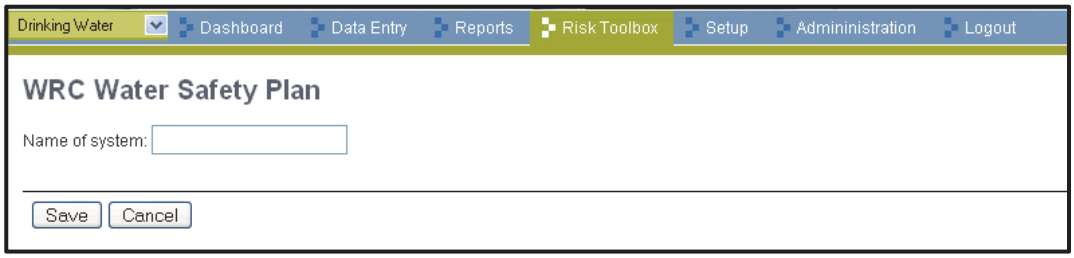


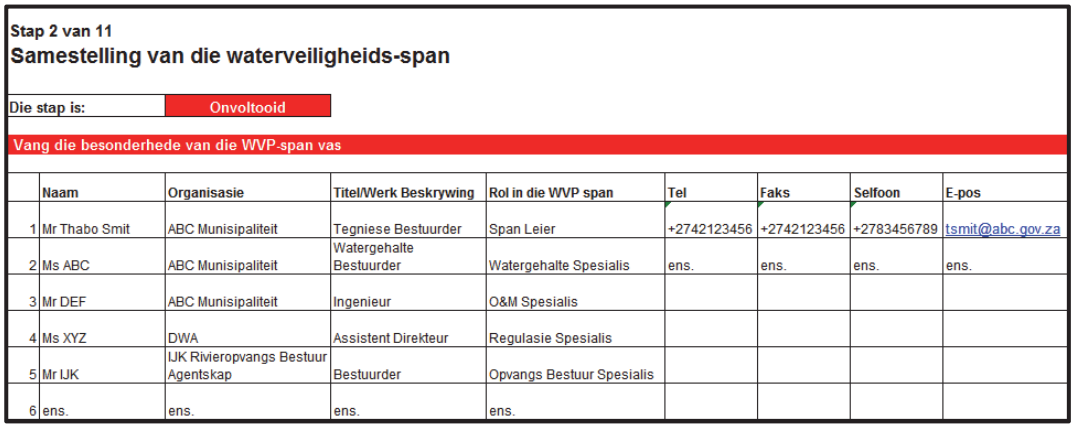
Figure 56: *eWQMS capturing the name of the system*

Step 3: Capture Project Team and Key Stakeholders

Using the Water Safety Planning tool, capture the details of the individuals making up the Water Safety Planning team, including appropriate roles and responsibilities, and associated contact details as shown in the figures below.

- Click 'add row' to create as many rows as the number of the people making up the Water Safety Planning Team. More rows can be added or removed when there are changes to be made.
- Capture details of the team as according to the fields required.

Figure 57: *Capturing Water Safety Planning Team: web (Afrikaans)*



	Naam	Organisasie	Titel/Werk Beskrywing	Rol in die WVP span	Tel	Faks	Selfoon	E-pos
1	Mr Thabo Smit	ABC Munisipaliteit	Tegniese Bestuurder	Span Leier	+2742123456	+2742123456	+2783456789	tsmit@abc.gov.za
2	Ms ABC	ABC Munisipaliteit	Watergehalte Bestuurder	Watergehalte Spesialis	ens.	ens.	ens.	ens.
3	Mr DEF	ABC Munisipaliteit	Ingenieur	O&M Spesialis				
4	Ms XYZ	DWA	Assistent Direkteur	Regulasie Spesialis				
5	Mr IJK	IJK Rivieropvangs Bestuur Agentskap	Bestuurder	Opvangs Bestuur Spesialis				
6	ens.	ens.	ens.	ens.				

Figure 58: *Capturing Water Safety Planning Team: Excel (Afrikaans)*

Step 4: Capture the details of the individual responsible for providing information of the Water Safety Planning

It is important to fill in a record of completion indicating who filled in the tool and the period. This would assist the WSI in determining the need to revise the tool and check if there are any updates required to be made. It is recommended that the information is completed by the individual responsible for conducting the assessment or the Water Safety Planning team leader. An example of record of completion is provided below.

Figure 59: *Capturing details of person responsible for providing information of the Water Safety Plan: web (Afrikaans)*

Stap 1 van 11

Register/Rekord van Voltooiing

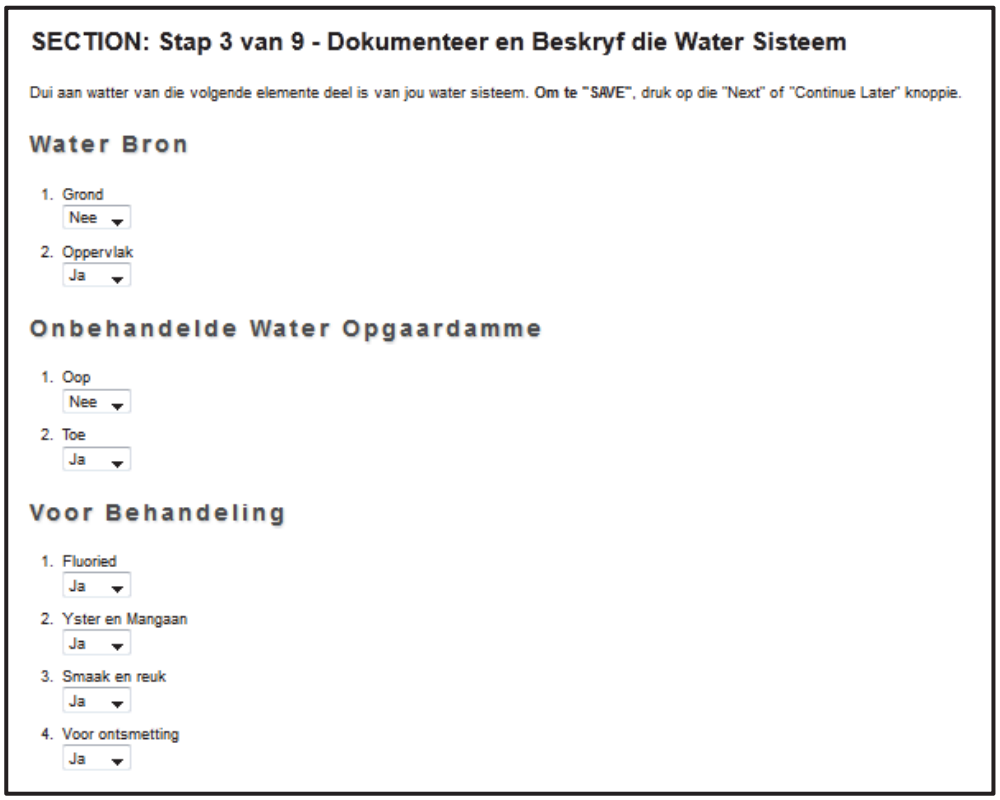
Die stap is:	Onvoltooid
Die volgende inligting moet voltooi word deur die individu wat verantwoordelik is vir die uitvoer van die opname en/of enige addisionele hersiennings	
Naam	Jaco Botha
Titel	Tegniese Bestuurder
Waterdienste Owerheid	ABC Munisipaliteit
Waterstelsel Naam	Stad D
Adres	32 Kerkstraat
Provinsie	Oos Kaap
Poskode	7500
Telefoon	+2742123456
Faks	+2742123456
Selfoon	+2783456789

Figure 60: *Capturing details of person responsible for providing information of the Water Safety Plan: Excel (Afrikaans)*

Step 5: Document and Describe the present Drinking Water Supply System

First identify which components of the water supply system are applicable to the particular system by using examples below.

- Using the down arrow keys, choose yes or no indicating which components are available or not for that particular water supply system.



SECTION: Stap 3 van 9 - Dokumenteer en Beskryf die Water Sisteem

Dui aan watter van die volgende elemente deel is van jou water sisteem. **Om te "SAVE"**, druk op die "Next" of "Continue Later" knoppie.

Water Bron

1. Grond — Nee
2. Oppervlak — Ja

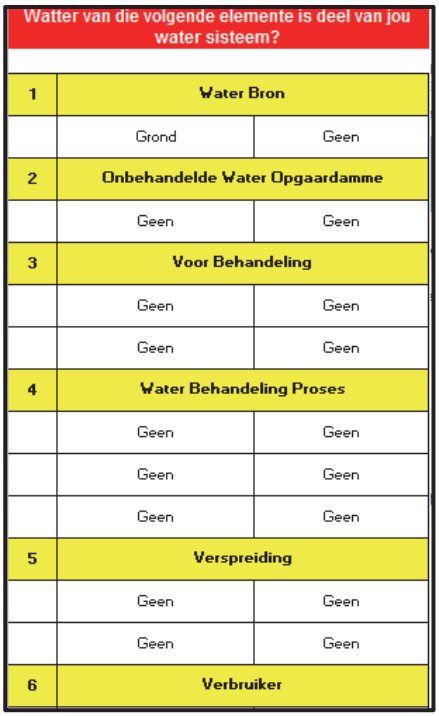
Onbehandelde Water Opgaardamme

1. Oop — Nee
2. Toe — Ja

Voor Behandeling

1. Fluoried — Ja
2. Yster en Mangaan — Ja
3. Smaak en reuk — Ja
4. Voor ontsmetting — Ja

Figure 61: *Documentation and description of water supply system: web (Afrikaans)*



Watter van die volgende elemente is deel van jou water sisteem?		
1	**Water Bron**	
	Grond	Geen
2	**Onbehandelde Water Opgaardamme**	
	Geen	Geen
3	**Voor Behandeling**	
	Geen	Geen
	Geen	Geen
4	**Water Behandeling Proses**	
	Geen	Geen
	Geen	Geen
	Geen	Geen
5	**Verspreiding**	
	Geen	Geen
	Geen	Geen
6	**Verbruiker**	

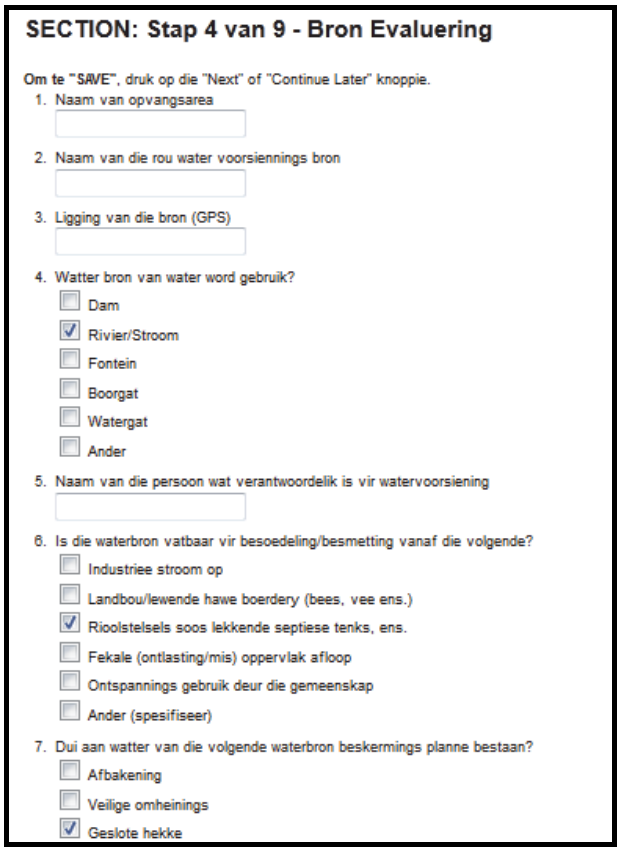
Figure 62: *Documentation and description of water supply system: Excel*

Step 6: Assess the Water Supply System (from source to consumer)

Using the tool, assess each component of the water supply system to obtain an idea of the typical hazards/risks faced.

On the tool, start with source assessment. If bulk water is received, this sectioned can be skipped.

- To fill in the information on source assessment, click add section
- Fill in the information according to the required fields
- If source assessment is not applicable for the system, click 'next' without clicking 'add section'


SECTION: Stap 4 van 9 - Bron Evaluering

Om te "SAVE", druk op die "Next" of "Continue Later" knoppie.

1. Naam van opvangsarea
2. Naam van die rou water voorsiennings bron
3. Ligging van die bron (GPS)
4. Watter bron van water word gebruik?
   - [ ] Dam
   - [x] Rivier/Stroom
   - [ ] Fontein
   - [ ] Boorgat
   - [ ] Watergat
   - [ ] Ander
5. Naam van die persoon wat verantwoordelik is vir watervoorsiening
6. Is die waterbron vatbaar vir besoedeling/besmetting vanaf die volgende?
   - [ ] Industriee stroom op
   - [ ] Landbou/lewende hawe boerdery (bees, vee ens.)
   - [x] Rioolstelsels soos lekkende septiese tenks, ens.
   - [ ] Fekale (ontlasting/mis) oppervlak afloop
   - [ ] Ontspannings gebruik deur die gemeenskap
   - [ ] Ander (spesifiseer)
7. Dui aan watter van die volgende waterbron beskermings planne bestaan?
   - [ ] Afbakening
   - [ ] Veilige omheinings
   - [x] Geslote hekke

Figure 63: *Assessing source water: web (Afrikaans)*

Possible source related hazards (which are also included in the tool are listed in Appendix A.

Drinking Water Treatment Assessment

This section should be filled in by users who have a water treatment system, whether it is a system that use conventional treatment methods or a simple small treatment system. Using the tool, assess each unit of the drinking water treatment system to obtain an idea of the typical hazards/risks faced. If there is no water treatment system, this section can be skipped.

- To fill in the information on water treatment system, click add section (Figure 64):

- Fill in the information according to the required fields (Figure 65)

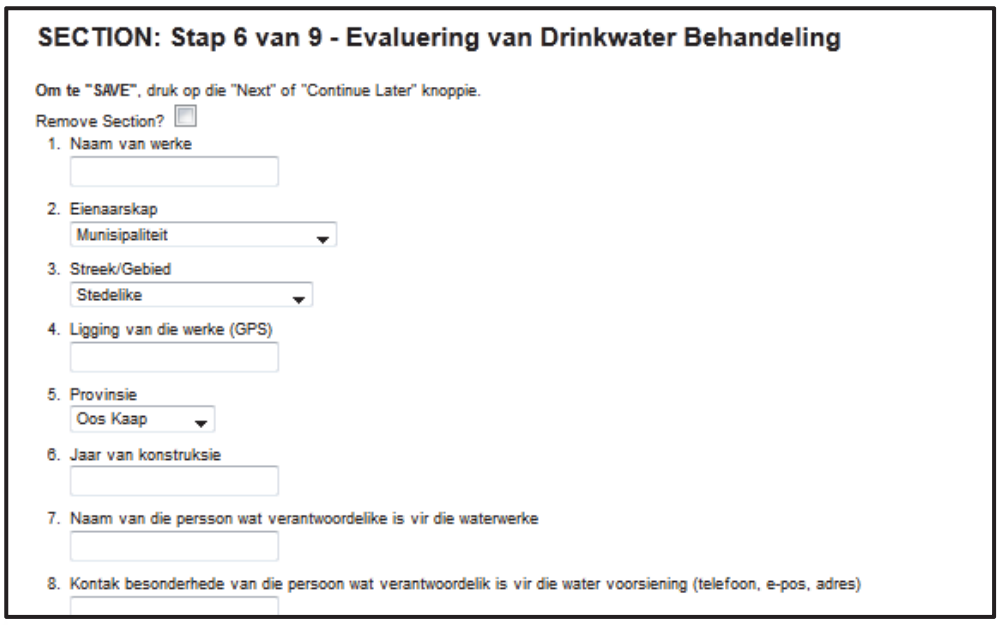


Figure 64: *Assessing Drinking Water Treatment system: web (Afrikaans)*

- If water treatment assessment is not applicable for the system, click 'next' without clicking 'add section'

Stap 6 van 13

Evaluering van Drinkwater Behandeling

Die stap is:	Onvoltooi

Evaluering van Drinkwater Waterwerke Behandeling, Ontwerp en Operasies				
	Aspek	1	Kommentaar	2
	Datum van Opname			
1	Naam van werke			
2	Eienaarskap	Privaat		DWA
3	Streek/Gebied	Buitestedelike/voorstedelike		Peri-urban
4	Ligging van die werke (GPS)			
5	Provinsie	Mpumalanga		Vrystaat
6	Jaar van konstruksie			
7	Naam van die persson wat verantwoordelike is vir die waterwerke			
8	Kontak besonderhede van die persoon wat verantwoordelik is vir die water voorsiening (telefoon, e-pos, adres)			
9	Klassifikasie van die werke	C		B
	- Verlangde klas wat vereis word van prosesbeheerders/operateurs (per skof)	Klas III		Klas IV
	- Verlangde klas wat vereis word van die toesighouer (moet beskikbaar wees ter alle tye)	Klas V (beskikbaar)		Klas V (op die perseel)
10	Aantal prosesbeheerders/operateurs wat benodig word.			

Figure 65: *Assessing Drinking Water Treatment system: Excel (Afrikaans)*

Possible drinking water treatment related hazards (which are also included in the tool) are provided in Appendix A.

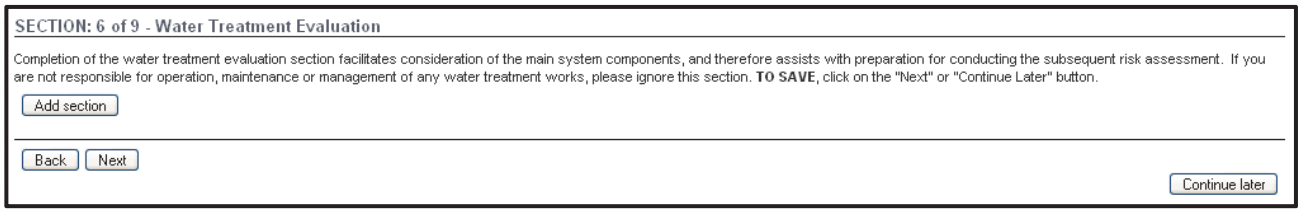
Drinking Water Network Assessment

Network includes bulk mains, network distribution pipes, on site and off site reservoirs, booster stations, valves, standpipes and house connections. Assess the drinking water network to obtain an idea of the typical challenges/risks faced.

Using the tool, assess each unit of the drinking water network to obtain an idea of the typical hazards/risks faced.

Possible drinking water network hazards (which are also included in the tool) are listed in Appendix A.

- To fill in the information on drinking water network system, click add section:



- Fill in the information according to the required fields

Using the tool, drinking water network information should be documented and hazards applicable for that drinking water network should be identified by selecting the appropriate answer. Examples of treatment evaluation are shown in the figures below.

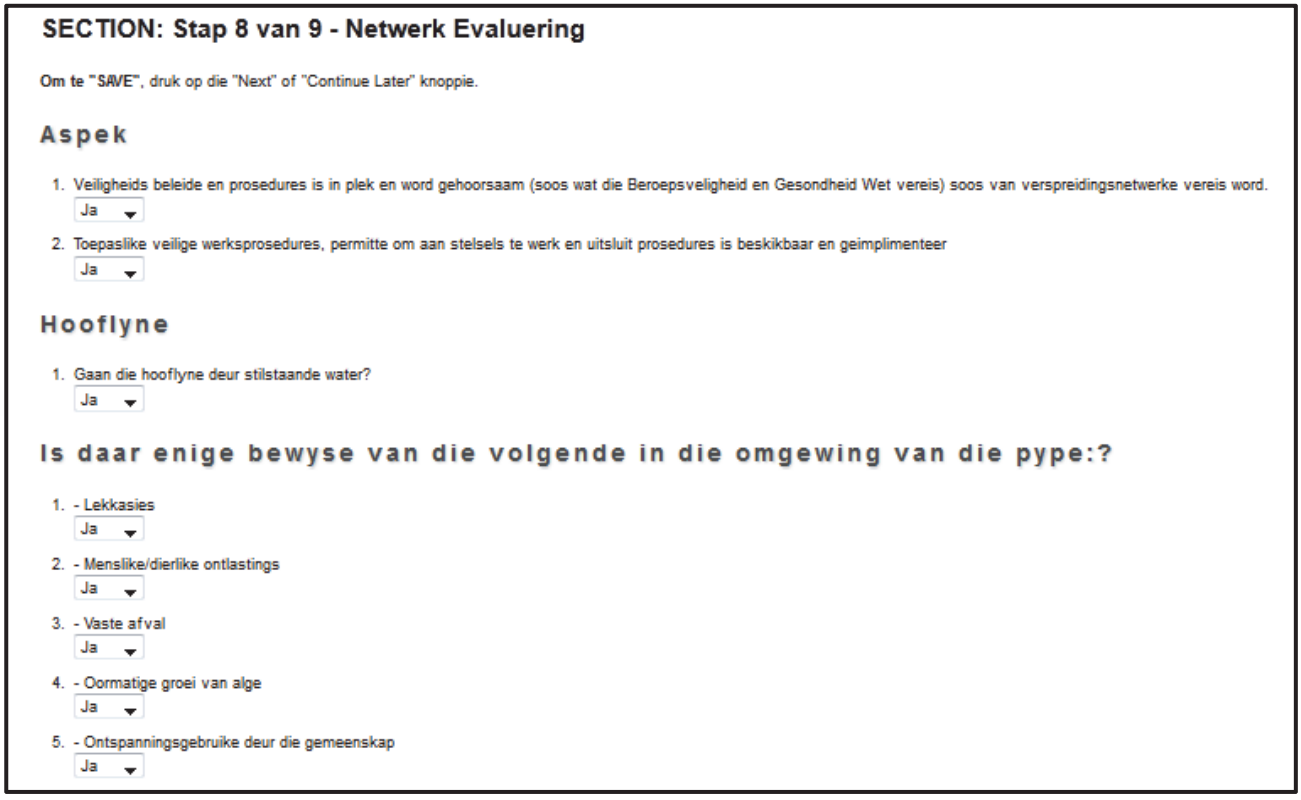


Figure 66: *Assessing Drinking Water Network: web (Afrikaans)*

Stap 8 van 13

Netwerk Evaluering

Die stap is:	Onvoltooid

Evaluering van die verspreidingsnetwerk						
	Aspek	1	Kommentaar	2	Kommentaar	3
1	Veiligheids beleide en prosedures is in plek en word gehoorsaam (soos wat die Beroepsveligheid en Gesondheid Wet vereis) soos van verspreidingsnetwerke vereis word.	Nee				
2	Toepaslike veilige werksprosedures, permitte om aan stelsels te werk en uitsluit prosedures is beskikbaar en geïmplimenteer	Ja				
	Hooflyne					
1	Is daar enige bewyse van die volgende in die omgewing van die pype:?					
	- Lekkasies	Ja				
	- Menslike/dierlike ontlastings					
	- Vaste afval					
	- Oormatige groei van alge	Nee				
	- Ontspanningsgebruike deur die gemeenskap					
	- ander (spesifiseer)	Ja				
2	Gaan die hooflyne deur stilstaande water?					

Figure 67: *Assessing Drinking Water Network: Excel (Afrikaans)*

Step 7: Undertake a Risk assessment

From the hazards identified for each water supply system component, determine the risk associated with them. On the tool it would be already indicating by a yes or no if the hazard is valid or not (if the assessment page has already been filled in). Focus should be given on those hazards already indicated as valid.

- Select the option under likelihood indicating the likelihood of that hazard to happen as shown in the figures below.

Pompstasie

	Geldige gevaar	Kategorie	Waarskynlikheid
Pompe wat faal (bv. pompwanfunksionering, inkorrekte verstellings) mag lei tot lae vloei/geen watertoevoer.	Ja	Operasioneel	Waarskynlik
Natuurlike rampe (bv. storms, aardbewings, vloede) mag die pompstasie beskadig of vernietig wat kan lei in besmette water/of geen water toevoer.	Nee	Nie van toepassing nie	Nie van toepassing nie
Mensgemaakte insidente (bv. swaar voertuig ongeluk) mag die reservoir beskadig of verwoes wat kan lei tot besmette of geen watertoevoer.	Ja	Finansies	
Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.	Ja	Institusionele kennis	
Swak higiëne tydens pomp installasie, instandhouding of herstel kan die watervoorraad besoedel.	Ja	Beplanning / Ontwerp	
Swak monitering kan lei tot besmette of geen watertoevoer (bv. telemetrie kan faal, geen water monitering om die gehalte te bepaal).	Nee	Nie van toepassing nie	Nie van toepassing nie

Nie van toepassing nie
Byna seker
Waarskynlik
Geringe kans
Nie waarskynlik nie
Raar

Figure 68: *Determining Likelihood of a valid hazards: web (Afrikaans)*

Risiko Profiel	
Geen Risiko	Die gevaar is nie van toepassing nie in die geval.
Lae Risiko	Hierdie is stelsels wat funksioneer met geringe defekte/probleme. Die stelsels voldoen gewoonlik aan die water gehalte parameters wat gespesifiseer word deur toepaslike riglyne (
Medium Risiko	Hierdie is stelsels met defekte wat aleenlik of gesaamtelik 'n hoë risko kan inhou tot die gehalte van die water en menslike gesondheid. Hierdie stelsels sal nie noodwendig dadelike toekomstigde probleme vermy word.
Hoë Risiko	Hierdie is stelsels met enorme defekte wat alleenlik of gesaamtelik 'n hoë risko kan inhou tot die gehalte van die water en mag lei tot potensiële gesondheid en veiligheid of omgewi kategorie geklassifiseer, word benodig dit onmiddellike korrektiewe aksie om defekte te verminder of verwyder.

Verspreidingsnetwork

	Potensiële Gevare of Gevaarlike Gebeurtenisse	Geldige Gevaar	Kategorie	Waarskynlikheid	Waarde bepaling	Impak/Gevolg e	Wa
	Beskermde Diensreservoir (Bedekte Opgaartenk)						
1	Diere/voëls kan deurdring deur foute (bv. krake in die dak, mure of vloer) en kan die water besmet met hulle mis. Indien 'n dier verdrink, sal daar 'n hoë vlak van skadelike mikro-organismes teenwoordig wees.	Ja	Beplanning/Ontwerp	Nie waarskynlik nie	0.2	Enorme	
2	Diere-/voël mis wat meng met die reënwater en kan in die stoortenke beland deur foute in die dak van die stoortenke of van interne dreineeringsdakke.			Geringe kans	0.5		
3	Ongemagtigde toegang, bv. mense wat swem in die opgaartenke, kan lei tot mikrobiese besmetting.		Operasioneel		0		
4	Oormatige druk wat opbou kan lei tot strukturele skade aan die reservoir.				0		
5	Hoë chloorvlakke mag die verspreidings netwerk binnegaan, indien daar swak vermengings is na die ontsmetting van stoortenke/reservoirs.	Nee			0		

Katastrofies
Enorme
Gematigde
Geringe
Onbeduidend
Nie van toepassing r

Figure 69: *Determining Likelihood of valid hazards: Excel (Afrikaans)*

- Once the likelihood has been determined, determine the consequence should that hazard happen.
- Select the option under consequence indicating the impact the hazard would have as shown in the figure below.

If the valid hazard is not on the available list, the user can add the hazard/s by going down the page of risk assessment and click “add row” under “User defined hazards” category. Fill in the valid hazard in the evaluation item block and indicate likelihood and consequence. The user identified hazards will be included in the summary report.

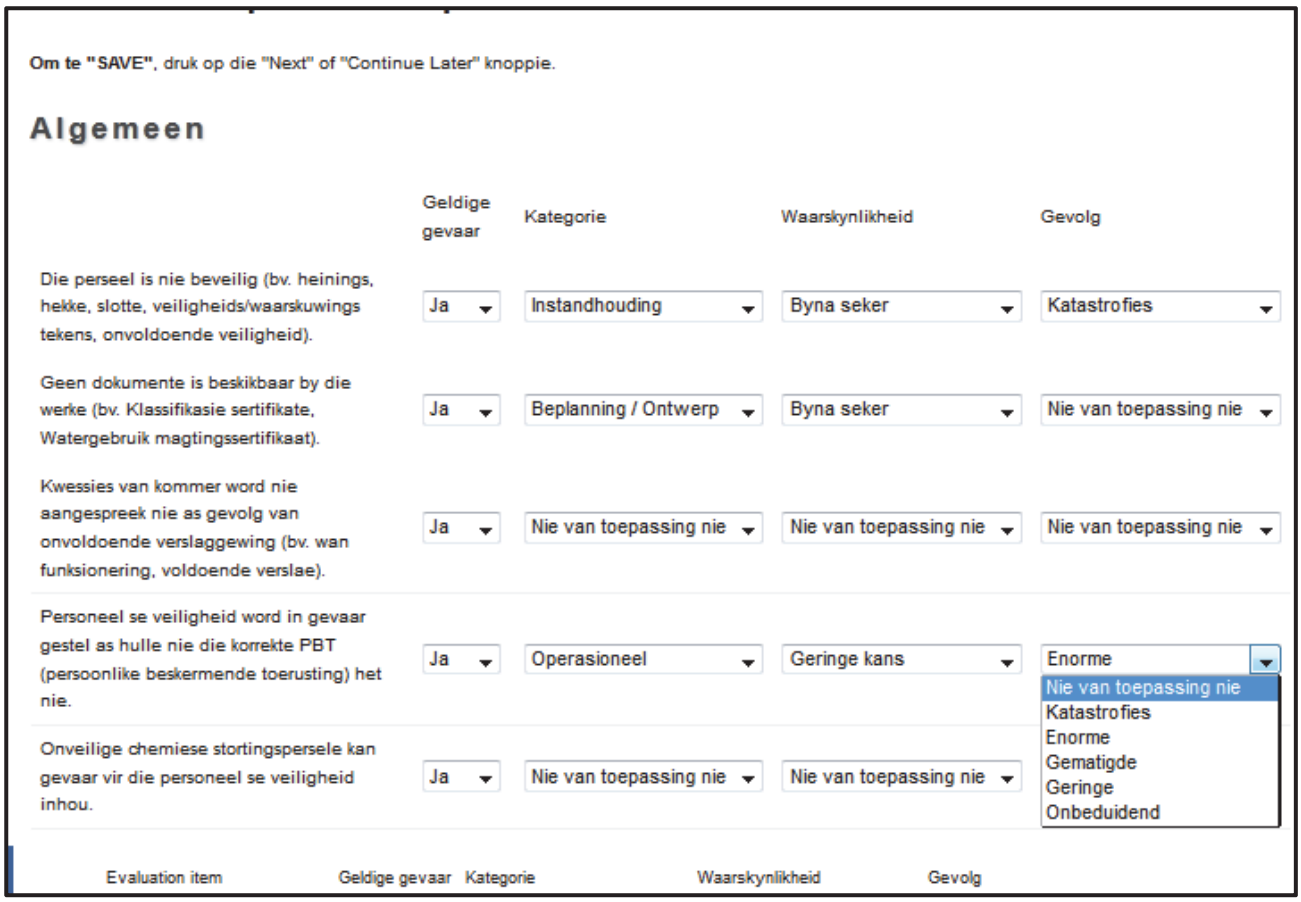


Figure 70: *Determining consequence of a valid hazards: web (Afrikaans)*

Oppervlak waters (riviere en strome)			
Lewende hawe/landbou, menslike aktiwiteite by die waterbron.	Ja	Instandhouding	Nie waarskynlik nie
Onbehandelde water is troebel na swaar reën. Dit mag mis bevat van diere en voëls.	Nee	Beplanning/Ontwerp	
Dooie diere	Nee	Operasioneel	
Mis van diere/voëls kan lei tot die groei van gevaarlike mikro-organismes in die waterliggaam.	Nee	Instandhouding	Geringe kans
Lae vloei, hoë voedingstof vlakke en warm kondisies, kan lei tot die waarkynlike groei van siano bakteriëe en alge.	Ja	Operasioneel	Waarskynlik
Dalende water vlakke as gevolg van droogte of water wat onttrek word van die waterliggaam.	Nee	Operasioneel	Nie van toepassing nie
Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organimes of skade rig aan toerusting en infrastruktuur.	Ja	Operasioneel	Raar
Inneem skerms word geblok of beskadig.	Nee	Instandhouding	Nie waarskynlik nie

Byna seker
Waarskynlik
Geringe kans
Nie waarskynlik nie
Raar
Nie van toepassing nie

Figure 71: *Determining consequence of valid hazards: Excel (Afrikaans)*

Note

Using the tool, four columns to be filled in are:

1. Identify if the hazard is valid or not on the “valid hazard” column
2. Determine likelihood of the hazard on the “Likelihood” column
3. Determine the consequence of the hazard on the “consequence” column
4. The category column can be filled in to identify if the hazard is design, operational or maintenance related. This should assist in correctly assigning corrective measures to the responsible person or team.

- Using the web based tool, click “view summary report” at the end of the questionnaire to view the intensity of the risk.
- This can be viewed on the “Risk Profile” column on the excel format with colour code as seen in Figure 74.

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile
Oppervlak Waters (Riviere en Strome)	Lewende hawe/landbou, menslike aktiwiteite by die waterbron.	Ja	Beplanning/Ontwerp	100	High Risk
Oppervlak Waters (Riviere en Strome)	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organimes of skade rig aan toerusting en infrastruktuur.	Ja	Finansies	80	High Risk
Boorgate	Oppervlak water kan die boorgat deurdring en kan die troebelheid verhoog en/of kan mis van diere/voëls (wat skadelike mikro-organismes dra) bevat.	Ja	Nie van toepassing nie	70	High Risk

Figure 72: *Risk summarisation representation: web (Afrikaans)*

Opsomming status en rangorde					
Komponent	**Gevaar**	**Geldige geva**	**Kategorie**	**Risiko telling**	**Risiko profiel**
Bron	Fonteine moet ontwerp word sodat dit beskerm is teen lewende hawe, menslike aktiwiteit by die waterbron. Vlak boorgate in hoogs deurlaatbare grond of gebreekte rotswaterdraers, is meer vatbaar vir besmetting.	Ja	Instandhouding	80	Hoë Risiko
DW Behandeling	Die perseel is nie beveilig (bv. heinings, hekke, slotte, veiligheids/waarskuwings tekens, onvoldoende veiligheid).	Ja	Operasioneel	80	Hoë Risiko
Netwerk	Ongemagtigde toegang, bv. mense wat swem in die opgaartenke, kan lei tot mikrobiese besmetting.	Ja	Operasioneel	70	Hoë Risiko
Netwerk	Mensgemaakte insidente (bv. trok ongeluk) mag die reservoir beskadig of verwoes wat kan lei tot besmette/of geen watertoevoer.	Ja	Beplanning/Ontwerp	70	Hoë Risiko
Netwerk	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.	Nee	Beplanning/Ontwerp	70	Hoë Risiko
Bron	Lae vloei, hoë voedingstof vlakke en warm kondisies, kan lei tot die waarkynlike groei van siano bakteriëe en alge.	Ja	In werking	16	Medium Risiko
Bron	Huishoudelike vullis (afval /rioolwater, septiese tenks naby stroom, rommel, munisipale vullistortings, ens.) kan die water besoedel.	Nee	Operasioneel	16	Medium Risiko

Figure 73: *Risk summary representation: Excel (Afrikaans)*

After completing section 9 of 9, click “next” you will get a screen with your list of identified valid hazards with an option to select the determinands that could be a threat due to the identified hazardous event. Multiple determinands can be selected for one hazardous event. This will assist in developing a risk based monitoring programme.

Determinants and hazards

Component	Hazard	Determinant
Oppervlak Waters (Riviere en Strome)	Lewende hawe/landbou, menslike aktiwiteite by die waterbron.	Nitrate (health) ×
Oppervlak Waters (Riviere en Strome)	Dooie diere	E.coli (health) × Bacteriological Indicator × Turbidity (Operational) ×
Oppervlak Waters (Riviere en Strome)	Mis van diere/voëls kan lei tot die groei van gevaarlike mikro-organismes in die waterliggaam.	Choose determinant
Oppervlak Waters (Riviere en Strome)	Lae vloei, hoë voedingstof vlakke en warm kondisies, kan lei tot die waarkynlike groei van siano bakteriële en alge.	Ammonium ×
Oppervlak Waters (Riviere en Strome)	Dalende water vlakke as gevolg van droogte of water wat onttrek word van die waterliggaam.	Choose determinant
Oppervlak Waters (Riviere en Strome)	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organimes of skade rig aan toerusting en infrastruktuur.	Choose determinant
Oppervlak Waters (Riviere en Strome)	Inneem skerms word geblok of beskadig.	Fluoride (health) ×

Figure 74: *Aligning hazardous events with hazards (SANS 241): web (Afrikaans)*

Potensiële gevare of gevaarlike gebeurtenisse	Geldige gevaar	Kategorie	SANS 241	Gevaar Naam (Water kwaliteit
Algemeen				
Die perseel is nie beveilig (bv. heinings, hekke, slotte, veiligheids/waarskuwings tekens, onvoldoende veiligheid).	Ja	Operasioneel	Total Coliforms	Cytopathgenic viruses, Total Coliforms, Monochloramine
Geen dokumente is beskikbaar by die werke (bv. Klassifikasie sertifikate, Watergebruik magtingssertifikaat).	Ja		N/A	Colour
Kwessies van kommer word nie aangespreek nie as gevolg van onvoldoende verslaggewing (bv. wan funksionering, voldoende verslae).	Ja		N/A	N/A
Personeel se veiligheid word in gevaar gestel as hulle nie die korrekte PBT (persoonlike beskermende toerusting) het nie.	Ja		pH at 25◦C	E.coli
Onveilige chemiese stortingspersele kan gevaar vir die personeel se veiligheid inhou.	Ja		N/A	
Indien die behandelingsproses nie optimaal/ten volle funksioneer nie, kan dit lei tot swak watergehalte.	Ja		Monochloramine	

Figure 75: *Aligning hazardous events with hazards (SANS 241): Excel* **(***Afrikaans)*

- Click next after identifying determinands and you will get a message “thank you for completing the questionnaire”.
- A “return to questionnaire link will be indicated together with a summary report link. Click the summary report link to view your report where you may indicate the suggested control measures.
- You can also click “return to questionnaire link” where you can select the system you want to view the report for. Click “view report” where you have to identify suggested control measures as indicated below.

Step 8: Identify control measures

Identify existing control/intervention measures, determine effectiveness thereof (e.g. redundancy, alternatives, back-ups, etc.) and identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. There is limited space on the web to see full sentences.

- Fill in control measures directly onto the web
- When done, click 'submit corrective actions' at the end of the page.

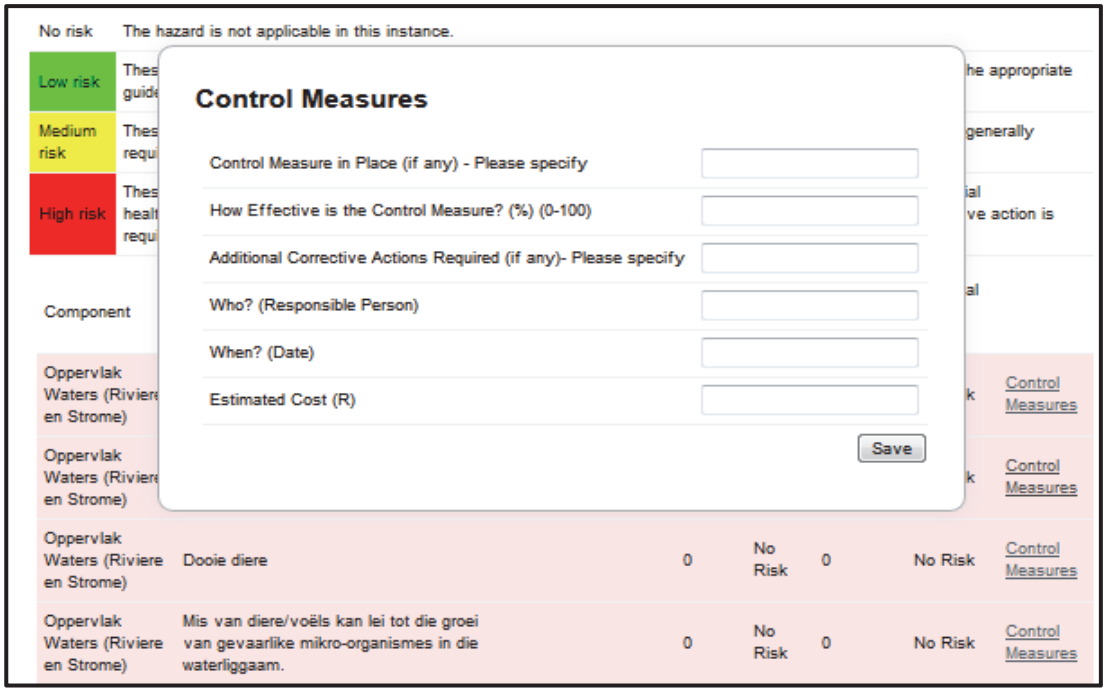
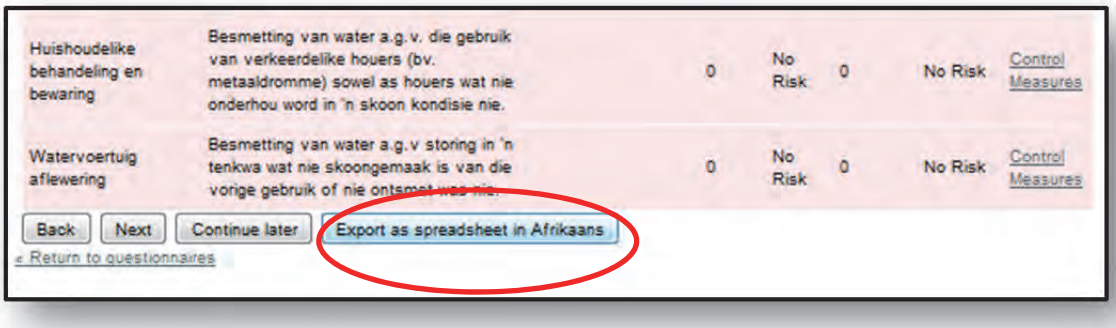


Figure 76: *Capturing and evaluating effectiveness of control measures: web (Afrikaans)*

Alternatively export the report to excel.

- Click export as spreadsheet at the end of the page
- A message box will ask if you want the spreadsheet file to be opened or saved
- Open the spreadsheet and fill in the control measures, estimated costs and estimated time for the control measure to be implemented



Hazard	Valid Hazard	Category	Risk Profile	Control Measure	Is the Control Measure Effective?	Corrective Actions	Who? (Responsible Person)	When? (Date)	Estimated Cost
Bird/animal droppings contaminate water.	Yes	Managem	Medium Risk	No	No	Hold awarenss campaigns educating the public about the importance of protrected(covered) rain water harvesting tankers aor collectors	Councillor Shushu	Immedia tely	To be determined
supply can result in interrupted	Yes	Operation	Medium Risk	No	No	No backup generator at the plant, need to put plans in place to invest in a back up generator.	Mr Phetheni	Jun-12	R100 000
Poor hygiene during reservoir	Yes	Maintena	Medium Risk	No	No	More precaustion should be taken when reservoir cleaning occurs.			

Figure 77: *Developing control measures on exported summary report (Afrikaans)*

Outputs from the completed web based and/or Microsoft Excel spreadsheet can be copied and pasted on a document to compile a Water Safety Plan Report.

After implementation of control measures and reviewing the effectiveness of existing control measures, the initial risk profile together with the residual risk profile will be indicated.

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile	Residual Risk Rating	Residual Risk Profile	
Oppervlak Waters (Riviere en Strome)	Onbehandelde water is troebel na swaar reën. Dit mag mis bevat van diere en voëls.	Ja	Operasioneel	100	High Risk	100	High Risk	Control Measures
Algemeen	Die perseel is nie beveilig (bv. heinings, hekke, slotte, veiligheids/waarskuwings tekens, onvoldoende veiligheid).	Ja	Instandhouding	100	High Risk	100	High Risk	Control Measures
Algemeen	Kwessies van kommer word nie aangespreek nie as gevolg van onvoldoende verslaggewing (bv. wan funksionering, voldoende verslae).	Ja	Operasioneel	100	High Risk	100	High Risk	Control Measures
Algemeen	Onvoldoende vloei kan 'n negatiewe uitwerking het op die behandelingsproses.	Ja	Wetenskaplike Dienste	80	High Risk	80	High Risk	Control Measures
Oppervlak Waters (Riviere en Strome)	Lewende hawe/landbou, menslike aktiwiteite by die waterbron.	Ja	Operasioneel	70	High Risk	70	High Risk	Control Measures

opulated from previous inputs - DO NOT MODIFY HERE
), users need to click on "Residual Risk Rating" (column I), then select "Data", "Sort by", "Residual Risk Rating", "Descending" from the top men

Valid Hazard / Hazardous Event	Hazard Category	Hazard Name (Water Quality Determinand)	Risk Rating	Risk Profile	Control Measure in Place (if any)	Control Measure Effectiveness (%)?	Residual Risk Rating	Residual Risk Profile	Corrective Actions
Yes	Design	Giardia species	80	High Risk	0	30%	56	Medium Risk	0
Yes	Operation	0	2	Low Risk	0	0%	2	Low Risk	0
No	Maintenance	0	0	No Risk	0	0%	0	No Risk	0
Yes	Design	0	16	Medium Risk	0	80%	3.2	Low Risk	0
Yes	Operation	Cryptosporidium species	70	High Risk	0	80%	14	Medium Risk	0
Yes	Maintenance	0	4	Low Risk	0	80%	0.8	Low Risk	0

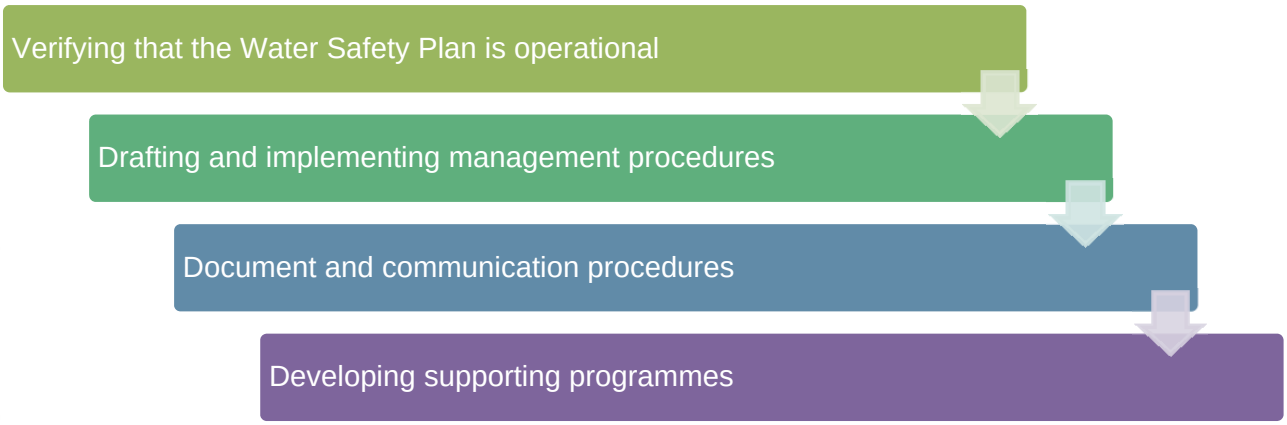
Figure 78: *Residual Risk Profiling: web (Afrikaans)*

Kategorie	Risiko telling	Risiko profiel	Is beheermaatreëls in plek (indien enige)?	Is die beheermaatreël effektief?	Residuele Risiko telling	Residuele Risiko profiel
Instandhouding	80	Hoë Risiko	0	80	64	Lae Risiko
Operasioneel	80	Hoë Risiko	0	40	32	Medium Risiko
Operasioneel	70	Hoë Risiko	0	10	7	Hoë Risiko
Beplanning/Ontwerp	70	Hoë Risiko	0	0	0	Hoë Risiko
Beplanning/Ontwerp	70	Hoë Risiko	0	0	0	Hoë Risiko

Figure 79: *Residual Risk Profiling: Excel (Afrikaans)*

Considering the summarised findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be addressed by ranking the risks.

As indicated earlier that the tool assists in developing Water Safety Planning, management of identified risks depends on the actions taken thereafter. The tool therefore provides suggested corrective actions, therefore implementation of corrective actions, communication procedures, management procedures development and implementation depends on the Water Services Institution (WSI). The next steps of the Water Safety Planning are not included in the tool, however should be considered as discussed earlier. The steps include:



7 ZULU TRANSLATED WATER SAFETY PLAN TOOL

7.1. Introduction

The English updated excel spreadsheet and web enabled tool was translated to isiZulu. It should be noted that the tool is translated to reach wider range of users and strengthen and improve the development and understanding of Water Safety Plans. The output is presented in English as it is then useful for assessment and auditing purposes (e.g. if a DWA Blue Drop inspector assesses the supply system, he would be able to understand the Water Safety Plan outputs).

Considering the above, the same detailed steps followed in the English Water Safety Plan tool are followed in the translated tools. The current steps below form part of the WRC Afrikaans translated Water Safety Planning tool on the electronic Water Quality Management System (eWQMS):

7.2. Accessing and Using the Zulu Water Safety Plan Tool

Users who do not have eWQMS login details can access the tool via Emanti website: www.emanti.co.za. Users will be provided with a unique username and password to be able to access the web tool.

The steps presented below do not necessarily follow the traditional steps of developing and implementing Water Safety Plans. However, these are the steps followed when using the Excel and web Water Safety Plan tools developed through this study.

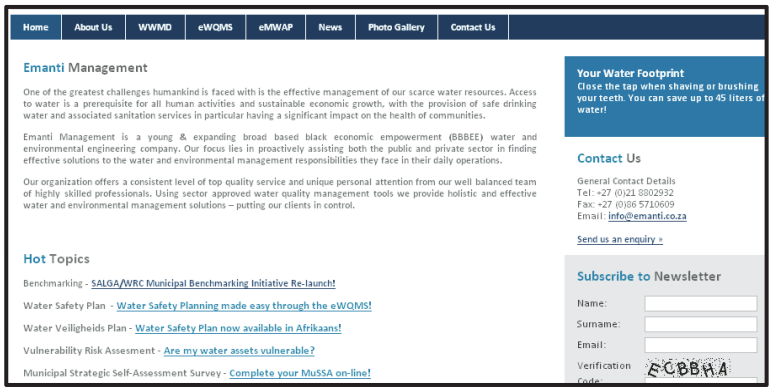


Figure 80: *Emanti home page*

Users who have eWQMS login details can access and use the tool through the steps explained below.

Step 1: Login to eWQMS

- Go to www.wqms.co.za (Figure 82)
- Complete your username and password.
- Click “Login”

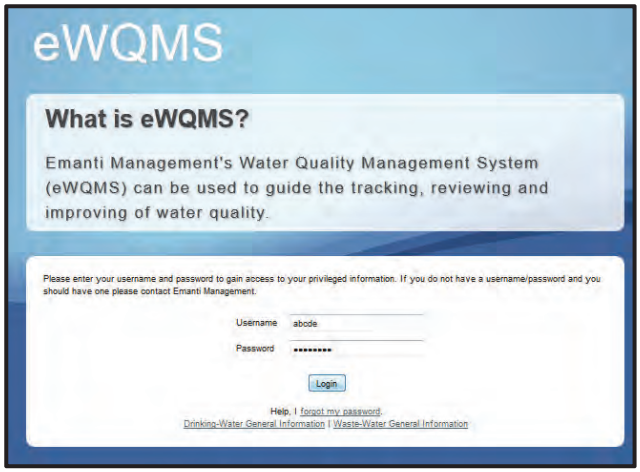


Figure 81: *eWQMS login page*

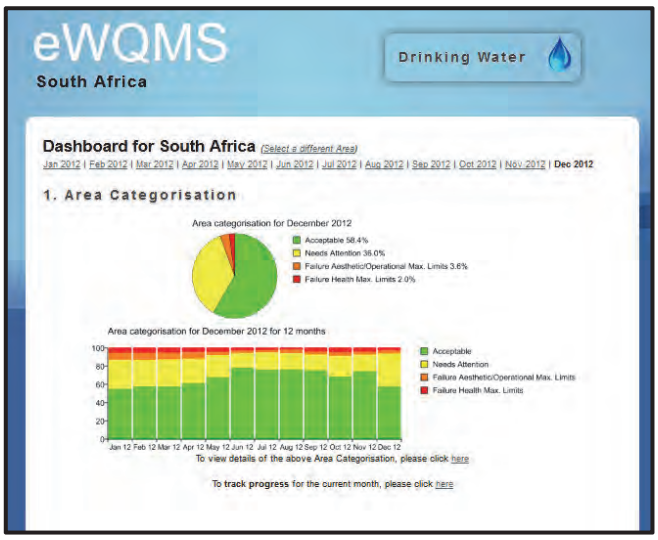


Figure 82: *eWQMS Dashboard page*

Go to Risk Toolbox and access the Afrikaans Water Safety Plan tool (Waterveiligheidsplan)

- Using the tabs, go to “Risk Toolbox”
- Select Zulu WRC Water Safety Plan

Figure 83: *eWQMS Risk Toolbox options*

Fill in the Zulu Water Safety Plan questionnaire

- Click “fill in questionnaire”
- All present systems within the area of jurisdiction of the user should be registered separately (i.e. as individual water supply systems).

To download the Zulu Excel tool via eWQMS, after selecting “Risk Toolbox”:

- On the bottom left corner click on “additional resources”
- A message box will ask if you want the spreadsheet file to be saved.
- The spreadsheet can be saved to a suitable location and opened from there, as shown below.

- A box of downloads will appear where the spreadsheet can be opened and saved at the selected location as shown below.

Figure 84: *eWQMS selecting and saving the tool*

Whether the Water Safety Plan is filled in through the spreadsheet or directly on to the web, eWQMS, the same steps to develop a Water Safety Planning are followed and are indicated in this section with screen extracts from the tool as indicated below.

Step 2: Capture the name of the system

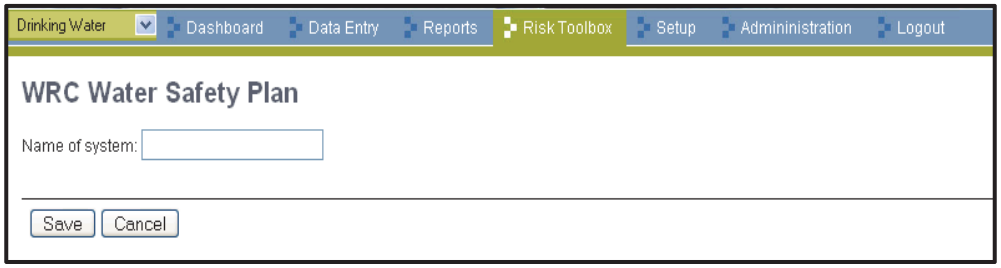


Figure 85: *eWQMS capturing the name of the system*

Step 3: Capture Project Team and Key Stakeholders

Using the Water Safety Planning tool, capture the details of the individuals making up the Water Safety Planning team, including appropriate roles and responsibilities, and associated contact details as shown in the figures below.

- Click 'add row' to create as many rows as the number of the people making up the Water Safety Planning Team. More rows can be added or removed when there are changes to be made.
- Capture details of the team as according to the fields required.

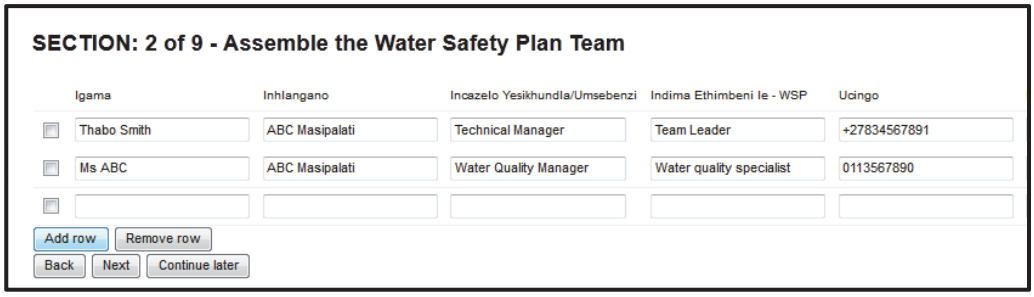


Figure 86: *Capturing Water Safety Planning Team: web (Zulu)*

zokunakekelwa kwamanzi (uma kusebenza), (3) abaphathi/ongoti bekhwalithi yamanzi, (4) abaphathi bamadamu/izindawo ezigcina amanzi, (5) Abahlinzeki Bokuphakelwa Kwamanzi, (6) abagogodile kwezemvelo, ezokunakekelwa kwempilo noma ezenhlanzeko kanye (7) nabameleli

	Igama	Inhlangano	Incazelo Yesikhundla/Um	Indima Ethimbeni le-WSP	Ucingo	Isikhahlamezi	Umakhalekhul	I-email
1	Mr Thabo Smit	ABC Municipality	Technical Manager	Team Leader	+2742123456	+2742123456	+2783456789	tsmit@abc.gov.za
2	Ms ABC	ABC Municipality	Water Quality Manager	Water quality specialist	etc	etc	etc	etc
3	Mr DEF	ABC Municipality	Engineer	O&M specialist				
4	Ms XYZ	DWA	Assistant Director	Regulation specialist				
5	Mr IJK	IJK River Catchment Management Agency	Manager	Catchment Management specialist				

Figure 87: *Capturing Water Safety Planning Team: Excel (Zulu)*

Step 4: Capture the details of the individual responsible for providing information of the Water Safety Planning

It is important to fill in a record of completion indicating who filled in the tool and the period. This would assist the WSI in determining the need to revise the tool and check if there are any updates required to be made. It is recommended that the information is completed by the individual responsible for conducting the assessment or the Water Safety Planning team leader. An example of record of completion is provided below.

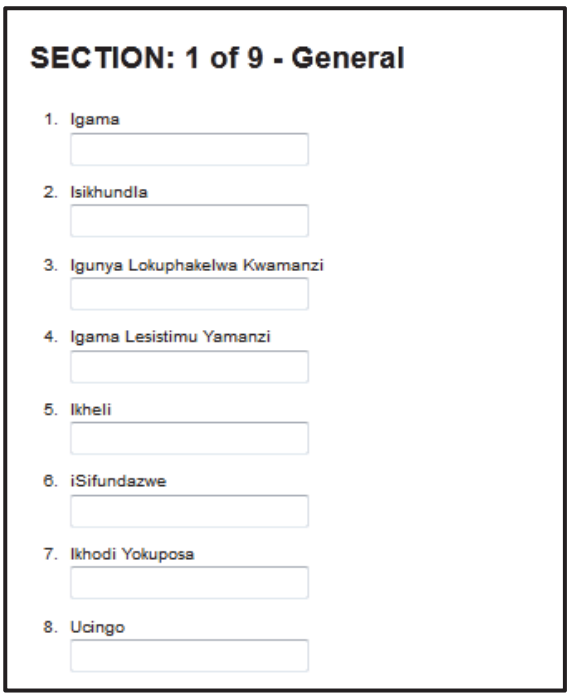


Figure 88: *Capturing details of person responsible for providing information of the Water Safety Plan: web (Zulu)*

zokunakekelwa kwamanzi (uma kusebenza), (3) abaphathi/ongoti bekhwalithi yamanzi, (4) abaphathi bama
Abahlinzeki Bokuphakelwa Kwamanzi, (6) abagogodile kwezemvelo, ezokunakekelwa kwempilo noma eze

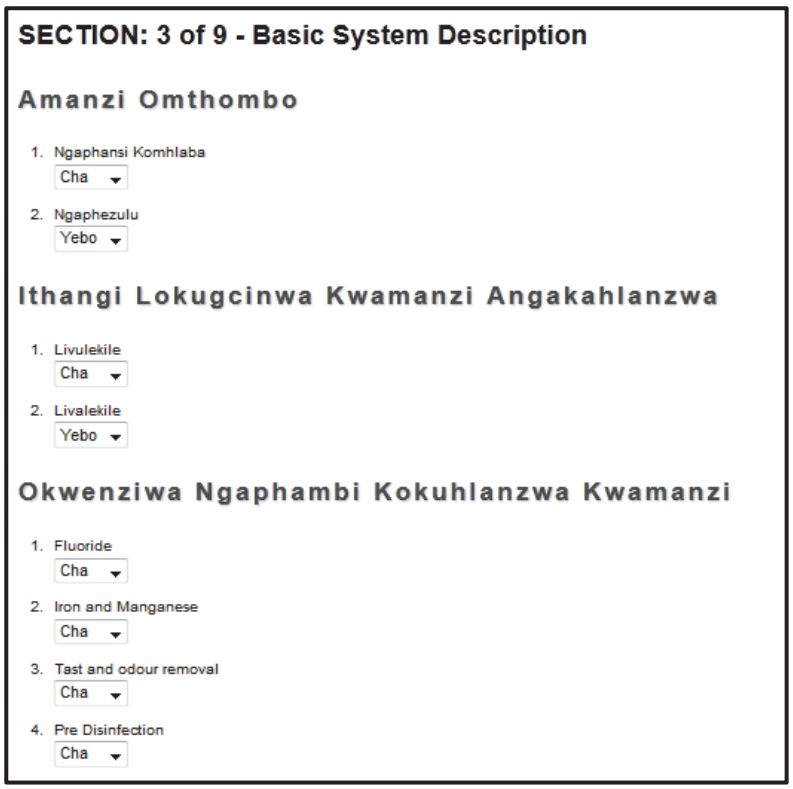
	Igama	Inhlangano	Incazelo Yesikhundla/Un	Indima Ethimbeni le-WSP	Ucingo
1	Mr Thabo Smit	ABC Municipality	Technical Manager	Team Leader	+2742123456
2	Ms ABC	ABC Municipality	Water Quality Manager	Water quality specialist	etc
3	Mr DEF	ABC Municipality	Engineer	O&M specialist	
4	Ms XYZ	DWA	Assistant Director	Regulation specialist	
5	Mr IJK	IJK River Catchment Management Agency	Manager	Catchment Management specialist	

Figure 89: *Capturing details of person responsible for providing information of the Water Safety Plan: Excel (Zulu)*

Step 5: Document and Describe the present Drinking Water Supply System

First identify which components of the water supply system are applicable to the particular system by using examples below.

- Using the down arrow keys, choose yes or no indicating which components are available or not for that particular water supply system.



SECTION: 3 of 9 - Basic System Description

Amanzi Omthombo

1. Ngaphansi Komhlaba
   Cha
2. Ngaphezulu
   Yebo

Ithangi Lokugcinwa Kwamanzi Angakahlanzwa

1. Livulekile
   Cha
2. Livalekile
   Yebo

Okwenziwa Ngaphambi Kokuhlanzwa Kwamanzi

1. Fluoride
   Cha
2. Iron and Manganese
   Cha
3. Tast and odour removal
   Cha
4. Pre Disinfection
   Cha

Figure 90: *Documentation and description of water supply system: web (Zulu)*

This step is:	Ayikaphothulwa	
Yiziphi kulezi zinto ezilandelayo ezakha isistimu yamanzi (water system)?		
1	Amanzi Omthombo	
	Ngaphansi Komhlaba	Ngaphezulu
2	Ithangi Lokugcinwa Kwamanzi Angakahlanzwa	
	Livulekile	Livalekile
3	Okwenziwa Ngaphambi Kokuhlanzwa Kwamanzi	
	Fluoride	Iron_and_Manganese
	Tast_and_odour_removal	Pre_Disinfection
4	Izinqubo Zokuhlanzwa Kwamanzi	
	Coagulation	Flocculation
	Sedimentation	Filtration
	pH_adjustment	Disinfection

Figure 91: *Documentation and description of water supply system: Excel (Zulu)*

Step 6: Assess the Water Supply System (from source to consumer)

Using the tool, assess each component of the water supply system to obtain an idea of the typical hazards/risks faced.

On the tool, start with source assessment. If bulk water is received, this sectioned can be skipped.

- To fill in the information on source assessment, click add section
- Fill in the information according to the required fields
- If source assessment is not applicable for the system, click 'next' without clicking 'add section'

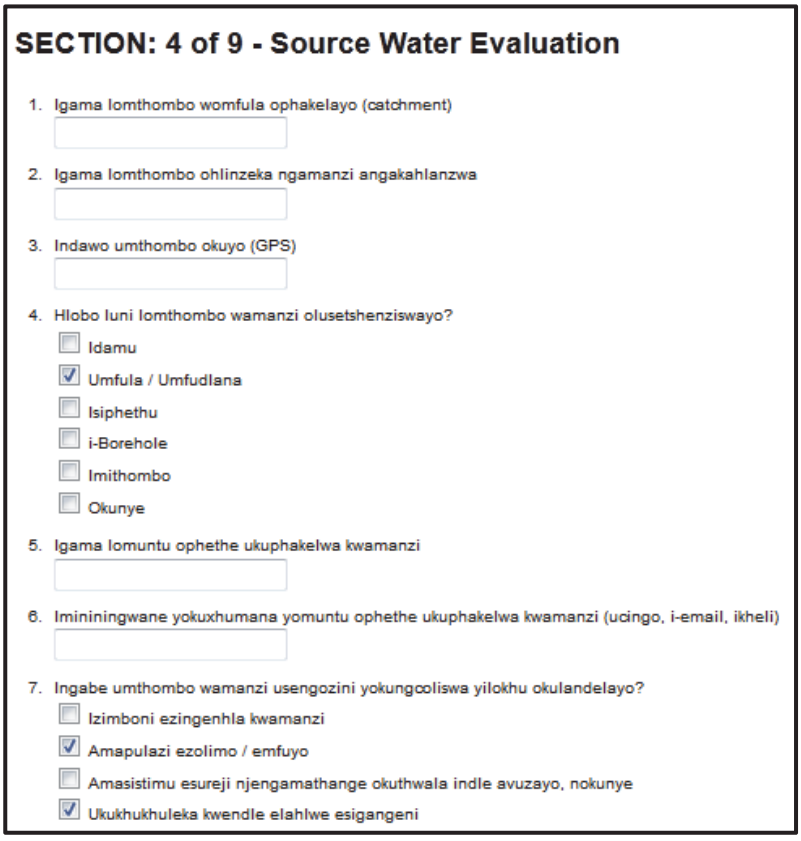


Figure 92: *Assessing source water: web (Zulu)*

Possible source related hazards (which are also included in the tool are listed in Appendix A.

Drinking Water Treatment Assessment

This section should be filled in by users who have a water treatment system, whether it is a system that use conventional treatment methods or a simple small treatment system. Using the tool, assess each unit of the drinking water treatment system to obtain an idea of the typical hazards/risks faced. If there is no water treatment system, this section can be skipped.

- To fill in the information on water treatment system, click add section:

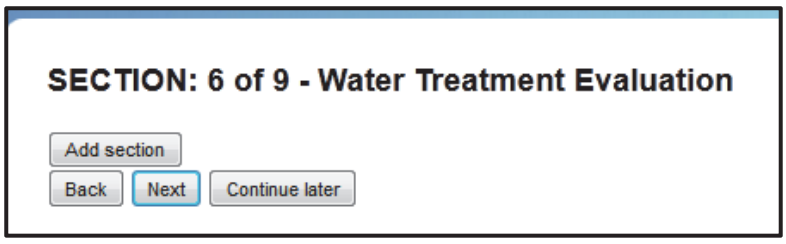


Figure 93: *Assessing Source Water: Excel (Zulu)*

- Fill in the information according to the required fields:

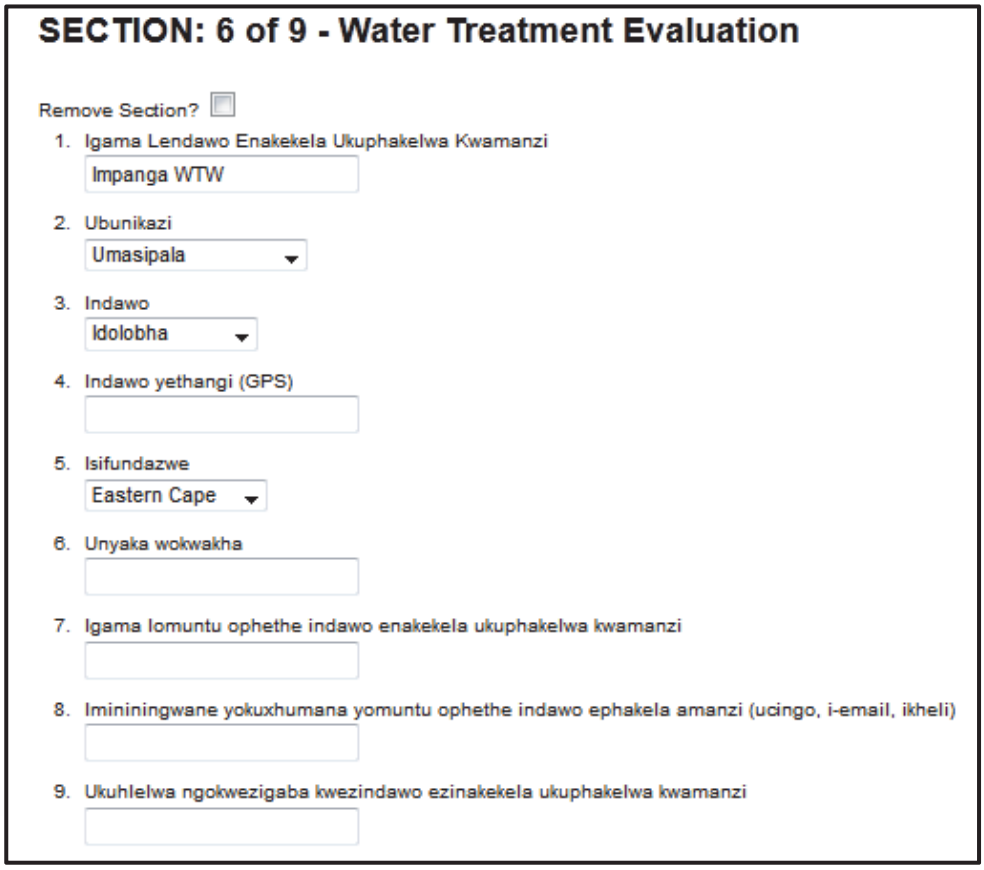


Figure 94: *Assessing Drinking Water Treatment system: web (Zulu)*

- If water treatment assessment is not applicable for the system, click ‘next’ without clicking ‘add section’

Possible drinking water treatment related hazards (which are also included in the tool) are provided in Appendix A.

Ithuluzi Lohlelo Lokuphepha Kwamanzi
Isinyathelo 6 sezingu-11

Ukuhlolwa Kokuhlanzwa Kwamanzi Aphuzwayo

Lesi sinyathelo: Siphothuliwe

Ukuphothulwa kwengxenye yokuhlolwa kokuhlanzwa kwamanzi kwenza kube lula ukucatshangelwa kwezakhi zesistimu eyinhloko, fut ekulungiselelweni kokuqhutshwa kokuhlolwa kwamathuba okungcoliseka kwamanzi okulandelayo.

Ukuhlolwa Komklamo Nokusebenza Kwezindawo Zokunakekelwa kwamanzi

	Ingxenye Edingidwayo	1	Ukuphawula	2
	Usuku Lokuhlola			
	- Okunye (cacisa)	Yebo		Yebo
36	Ingabe indawo yokunakekelwa kwamanzi isebenza ngokuvumelana nezimfuneko zomthetho wokuphepha kwasemsebenzini, ezempilo nezemvelo (OSH Act, 1993)?	Yebo		Yebo
37	Ingabe amanzi ahlanziwe ayahlangabezana nezindinganiso zamanje (SANS 241) zekhwalithi yamanzi aphuzwayo?	Yebo		Yebo
38	Ingabe kunezimbobo ezivuzayo emathangeni okuxuba amakhemikhali?	Yebo		Yebo
39	Ingabe ithange lokuxuba amakhemikhali ligcinwa lisesimweni esihlanzekile? (i.e. Lingenazo izinto ezichithekele kulo/ukuphuphuma/ungqimba lokungcola)	Yebo		Yebo
40	Ingabe amanzi athutheleka ngamandla amakhulu lapho engena endaweni yokunakekelwa kwamanzi?	Cha		Cha

Figure 95: *Assessing Drinking Water Treatment system: Excel (Zulu)*

Drinking Water Network Assessment

Network includes bulk mains, network distribution pipes, on site and off site reservoirs, booster stations, valves, standpipes and house connections. Assess the drinking water network to obtain an idea of the typical challenges/risks faced.

Using the tool, assess each unit of the drinking water network to obtain an idea of the typical hazards/risks faced.

Possible drinking water network hazards (which are also included in the tool) are listed in appendix A.

- To fill in the information on drinking water network system, click add section
- Fill in the information according to the required fields

Using the tool, drinking water network information should be documented and hazards applicable for that drinking water network should be identified by selecting the appropriate answer. Examples of treatment evaluation are shown in the figures below.

8.7 Amapayipi Angasemigwaqweni, Ama-drain Nama-ditch

1. Ingabe kukhona ama-standpipe axhunywe kuma-valve?
   Yebo
2. Ingabe kukhona ibhokisi levalvu ebudeni obungangemitha eliyi-1 lomgwaqo onqamulayo?
   Yebo
3. Ingabe ipayipi elithutha amanzi liseduze nomgwaqo onqamulayo?
   Yebo
4. Ingabe kukhona ubufakazi bendle endaweni ezungeze ipayipi?
   Yebo
5. Ingabe bukhona ubufakazi bokuvuza kwamanzi endaweni ezungeze ipayipi?
   Yebo
6. Ingabe ipayipi linqamula emseleni/i-ditch evulekile?
   Yebo

Figure 96: *Assessing Drinking Water Network: web (Zulu)*

Ithuluzi Lohlelo Lokuphepha Kwamanzi
Isinyathelo 8 sezingu-11
Ukuhlolwa Kwenethiwekhi

Lesi sinyathelo:	**Asiphothuliwe**
Ukuphothulwa kokuhlolwa kwengxenye yenethiwekhi ngokulungiselelwa kokuqhutshwa kokuhlolwa kwamat	kwenza kube lula ukucatshangelwa kwezakhi eziyinhloko zenethiwekhi, huba ezingozi zokukhinyabezeka kohlelo lokuhlanzwa kwamanzi okulandela

Ukuhlolwa Kwenethiwekhi Yokwabiwa Kwamanzi

	Ingxenye Edingidwayo	1	Ukuphawula	2
10	Ingabe unalo uhlelo lokubuyisela amavalvu amoshakele?	Yebo		Yebo
	Amapayipi Asesizeni/Axhunywe Endlini			
1	Ingabe akhona amapayipi asesizeni avuzayo?	Yebo		Yebo
2	Ingabe amanzi angaphezu komhlaba ayabuthana ame eduze kwamapayipi asesizeni?	Yebo		Yebo
3	Ingabe amapayipi aphakela amanzi endaweni yamapayipi asesizeni avele ngaphandle?	Yebo		Yebo
4	Ingabe ikhona indle phansi endaweni engaba ngamamitha angu-10 kunoma yiliphi ipayipi elisesizeni?	Yebo		Yebo
5	Ingabe ipayipi eliyinhloko eliphakela amanzi lingene lashona emanzini amile?	Yebo		Yebo
6	Ingabe ikhona imfucumfucu kadoti endaweni ngamamitha angu-10 ukusuka amapayipini asesizeni?	Cha		Cha

Figure 97: *Assessing Drinking Water Network: Excel (Zulu)*

Step 7: Undertake a Risk assessment

From the hazards identified for each water supply system component, determine the risk associated with them. On the tool it would be already indicating by a yes or no if the hazard is valid or not (if the assessment page has already been filled in). Focus should be given on those hazards already indicated as valid.

Select the option under likelihood indicating the likelihood of that hazard to happen as shown in the figures below.

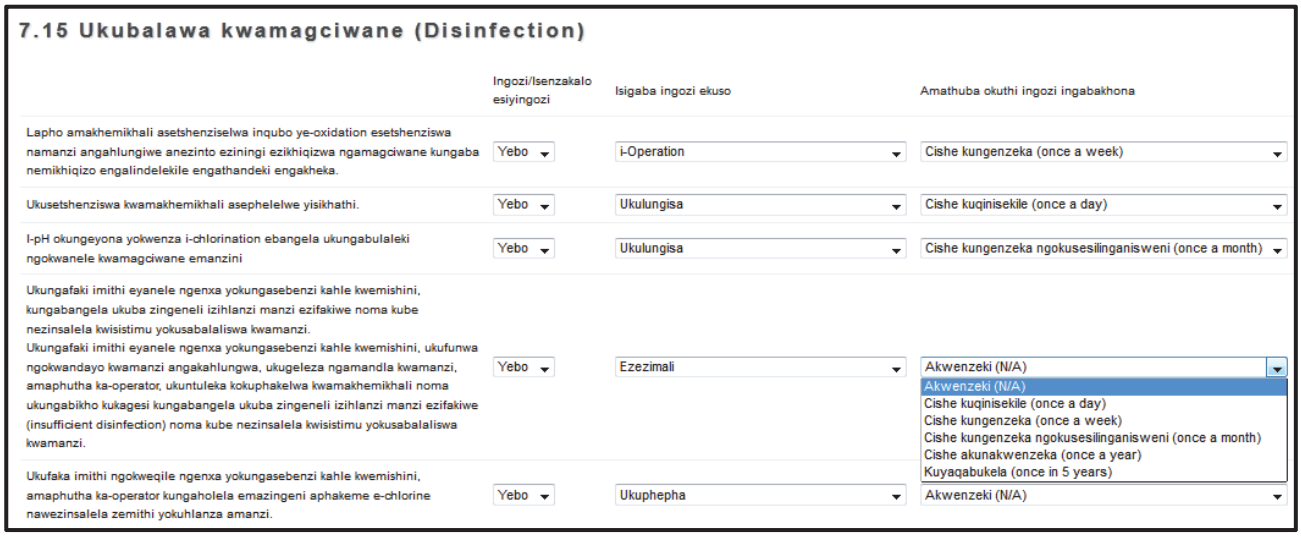


Figure 98: *Determining Likelihood of a valid hazards: web (Zulu)*

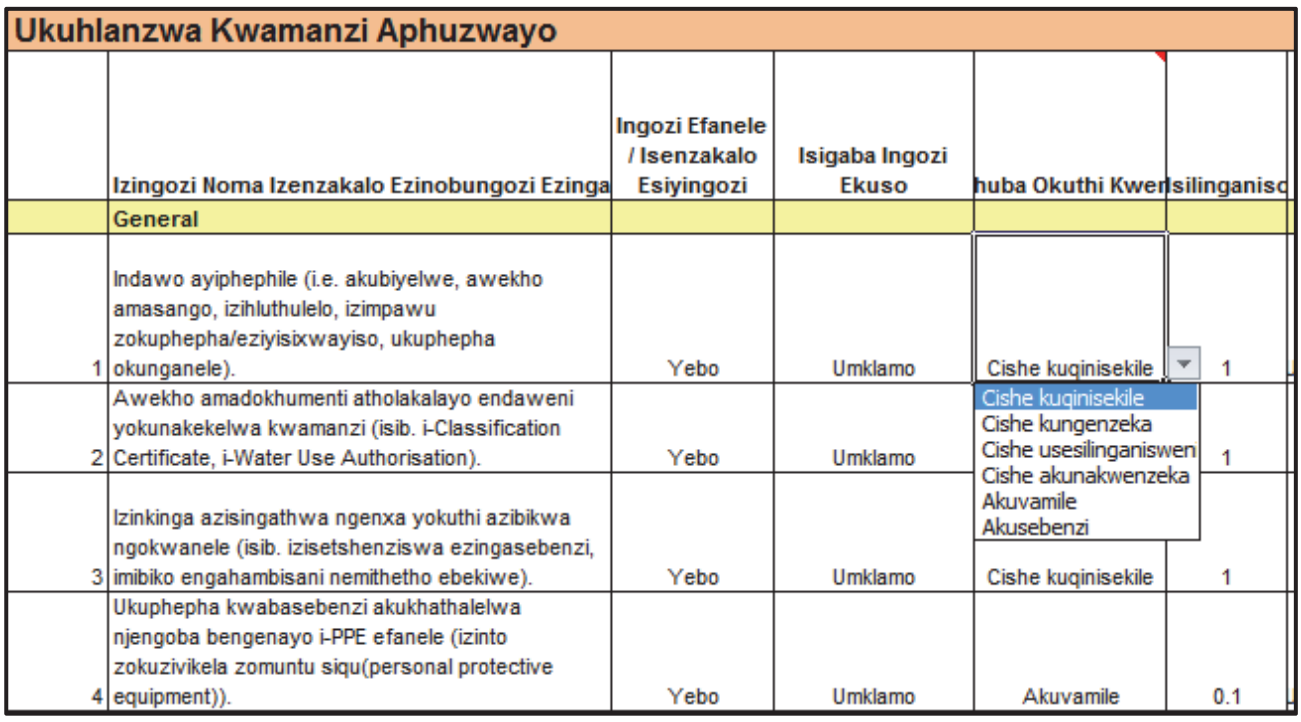


Figure 99: *Determining Likelihood of valid hazards: Excel (Zulu)*

- Once the likelihood has been determined, determine the consequence should that hazard happen.
- Select the option under consequence indicating the impact the hazard would have as shown in the figure below.

If the valid hazard is not on the available list, the user can add the hazard/s by going down the page of risk assessment and click “add row” under “User defined hazards” category. Fill in the valid hazard in the evaluation item block and indicate likelihood and consequence. The user identified hazards will be included in the summary report.

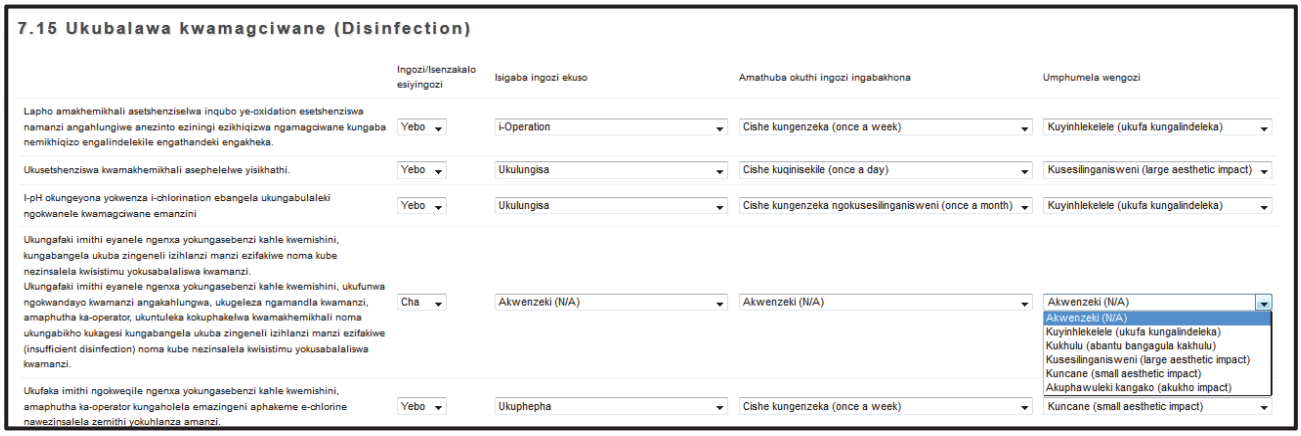
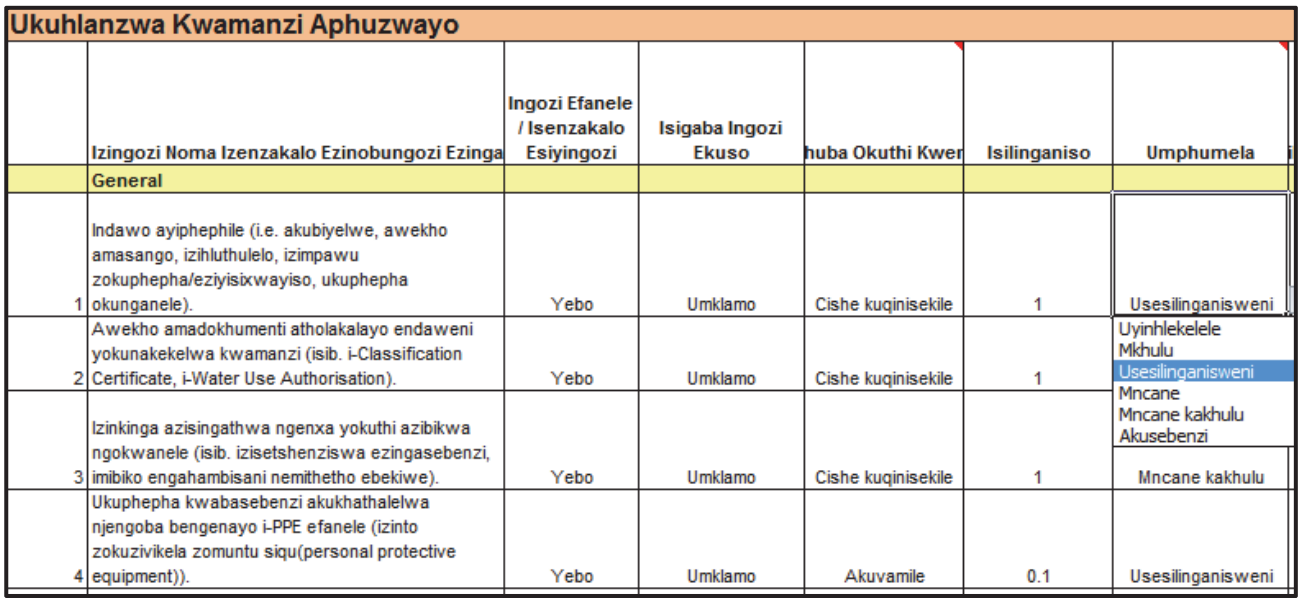


Figure 100: *Determining consequence of a valid hazards: web (Zulu)*



Ukuhlanzwa Kwamanzi Aphuzwayo

	Izingozi Noma Izenzakalo Ezinobungozi Ezinga	Ingozi Efanele / Isenzakalo Esiyingozi	Isigaba Ingozi Ekuso	huba Okuthi Kwer	Isilinganiso	Umphumela
	General					
1	Indawo ayiphephile (i.e. akubiyelwe, awekho amasango, izihluthulelo, izimpawu zokuphepha/eziyisixwayiso, ukuphepha okunganele).	Yebo	Umklamo	Cishe kuqinisekile	1	Usesilinganisweni
2	Awekho amadokhumenti atholakalayo endaweni yokunakekelwa kwamanzi (isib. i-Classification Certificate, i-Water Use Authorisation).	Yebo	Umklamo	Cishe kuqinisekile	1	
3	Izinkinga azisingathwa ngenxa yokuthi azibikwa ngokwanele (isib. izisetshenziswa ezingasebenzi, imibiko engahambisani nemithetho ebekiwe).	Yebo	Umklamo	Cishe kuqinisekile	1	Mncane kakhulu
4	Ukuphepha kwabasebenzi akukhathalelwa njengoba bengenayo i-PPE efanele (izinto zokuzivikela zomuntu siqu(personal protective equipment)).	Yebo	Umklamo	Akuvamile	0.1	Usesilinganisweni

Uyinhlekelele
Mkhulu
Usesilinganisweni
Mncane
Mncane kakhulu
Akusebenzi

Figure 101: *Determining consequence of valid hazards: Excel (Zulu)*

Using the tool, four columns to be filled in are:

1. Identify if the hazard is valid or not on the “valid hazard” column
2. Determine likelihood of the hazard on the “Likelihood” column
3. Determine the consequence of the hazard on the “consequence” column
4. The category column can be filled in to identify if the hazard is design, operational or maintenance related. This should assist in correctly assigning corrective measures to the responsible person or team.

- Using the web based tool, click “view summary report” at the end of the questionnaire to view the intensity of the risk.
- This can be viewed on the “Risk Profile” column on the excel format with colour code as seen in Figure 104.

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile
7.15 Ukubalawa kwamagciwane (Disinfection)	Lapho amakhemikhali asetshenziselwa inqubo ye-oxidation esetshenziswa namanzi angahlungiwe anezinto eziningi ezikhiqizwa ngamagciwane kungaba nemikhiqizo engalindelekile engathandeki engakheka.	Yebo	i-Operation	80	High Risk
7.15 Ukubalawa kwamagciwane (Disinfection)	I-pH okungeyona yokwenza i-chlorination ebangela ukungabulaleki ngokwanele kwamagciwane emanzini	Yebo	Ukulungisa	50	Medium Risk
7.15 Ukubalawa kwamagciwane (Disinfection)	Ukusetshenziswa kwamakhemikhali asephelelwe yisikhathi.	Yebo	Ukulungisa	20	Medium Risk
7.15 Ukubalawa kwamagciwane (Disinfection)	Ukufaka imithi ngokweqile ngenxa yokungasebenzi kahle kwemishini, amaphutha ka-operator kungaholela emazingeni aphakeme e-chlorine nawezinsalela zemithi yokuhlanza amanzi.	Yebo	Ukuphepha	2	Low Risk

Figure 102: *Risk summarisation representation: web (Zulu)*

Ithuluzi Lohlelo Lokuphepha Kwamanzi
Isinyathelo 10 sezingu-11
Izinyathelo Zokulawula Nokulungisa
Lesi sinyathelo: Asiphothuliwe
Evaluation of Existing Control Measures and Corrective Actions

Component	Ingozi	Ingozi Efanele / Isenzakalo Esiyingozi	Isigaba Sengozi	Igama Lengozi (Okunquma Izinga Lekhwalithi Yamanzi)	Ukulinganisa	Iphrofayili Yobungakana ni bengozi
Umthombo	Imfuyo, imisebenzi eyenziwa ngabantu emthonjeni wamanzi.	Yebo	Ukuhlukahluka Kwezinga Lamanzi	i-E.coli noma ama-Faecal coliforms	0.2	Incane Ingozi
Umthombo	Amanzi adungekile ngemva kwezimvula ezinamandla. Angase abe nobulongwe bezilwane nemisimba yezinyoni.	Yebo	Umklamo	Cytopathgenic viruses	0	Ayikho Ingozi
Umthombo	Izilwane ezifele emanzini zingase ziwangcolise noma zingafaka amagciwane emanzini.	Cha	Ukulungisa	0	16	Isesilinganiswe ni Ingozi
Umthombo	Indle yezilwane/izinyoni ingafaka emanzini amagciwane angabonakali ayingozi.	Yebo	Umklamo	Izinhlobo ze-Giarida	80	Inkulu Ingozi
Umthombo	Ukugeleza kancane, amazinga aphakeme ama-nutrient nezimo ezifudumele - kungenza ukuthi kucishe kuvame impela ukukhula kwama-cynobacteria nama-alga.	Yebo	i-Operation	0	2	Incane Ingozi

Figure 103: *Risk summary representation: Excel (Zulu)*

After completing section 9 of 9, click “next” you will get a screen with your list of identified valid hazards with an option to select the determinands that could be a threat due to the identified hazardous event. Multiple determinands can be selected for one hazardous event. This will assist in developing a risk based monitoring programme.

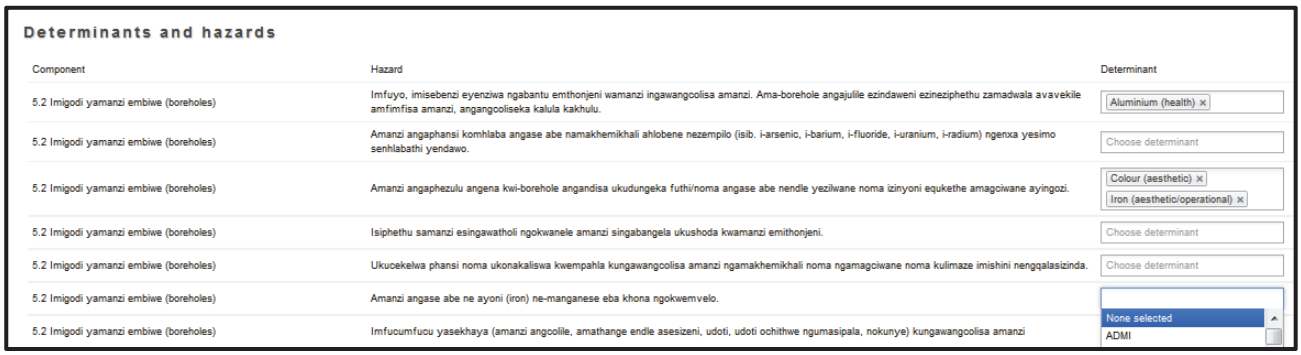


Figure 104: *Aligning hazardous events with hazards (SANS 241): web (Zulu)*

Inethiwekhi Yokusabalaliswa Kwamanzi

	Izingozi Noma Izenzakalo Eziyingozi Ezingaba Khona	Ingozi Efanele / Isenzakalo Esiyingozi	Isigaba Ingozi Ekuso	SANS 241	Igama Lengozi (Okunquma Izinga Lekhwalithi Yamanzi)
	Ithangi Lokuphakela Amanzi Elivikelwe (Ithangi Elivalwe Phezulu)				
1	Izilwane/izinyoni zingangena ngamaphutha (isib. ngemifantu esophahleni, ngezindonga noma phansi) bese zingcolisa amanzi ngemingqatha yazo. Uma izilwane zicwila emanzini, lizonyuka izinga lamagciwane akhona.	Yebo	Umklamo	Izinhlobo ze-Giardia	Amagciwane a-Cytopathgenic, i-Total Coliforms, i-Monochloramine
2	Imingqatha yezilwane/izinyoni ingase ikhukhulekele emathangini amanzi lapho kuna izimvula ezingena ngezimfa phezulu emathangini noma ukusuka ophahleni olugeleza amanzi.	Yebo	Ukuhlela/Umklamo	Umbala	umbala
3	Ukungena kwabantu abangagunyaziwe, njengalapho bebhukuda emathangini okugcina amanzi kungabangela ukungcolisa kwamagciwane.	Yebo	Ukulungisa	Ukudungeka	Turbidity
4	Ukwakheka ngokweqile komfutho ngaphakathi ethangini kungaholela ekulimaleni kwesakhiwo sethangi.	Yebo	Ukulungisa	i-E.coli noma ama-Faecal coliforms	E.coli
5	Amazinga aphakeme e-chlorine angase angene kwisistimu yokusabalalisa amanzi uma kuba khona ukungaxubani kahle kwemithi ngemva kokufakwa kwezibulala magciwane emathangini okugcina amanzi.	Yebo	Umklamo	i-Chloride njenge-Cl^-	

Figure 105: *Aligning hazardous events with hazards (SANS 241): Excel (Zulu)*

- Click next after identifying determinands and you will get a message “thank you for completing the questionnaire”.
- A “return to questionnaire link will be indicated together with a summary report link. Click the summary report link to view your report where you may indicate the suggested control measures.
- You can also click “return to questionnaire link” where you can select the system you want to view the report for. Click “view report” where you have to identify suggested control measures as indicated below.

Step 8: Identify control measures

Identify existing control/intervention measures, determine effectiveness thereof (e.g. redundancy, alternatives, back-ups, etc.) and identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc. for proposed improvements. There is limited space on the web to see full sentences.

- Fill in control measures directly onto the web
- When done, click 'submit corrective actions' at the end of the page.

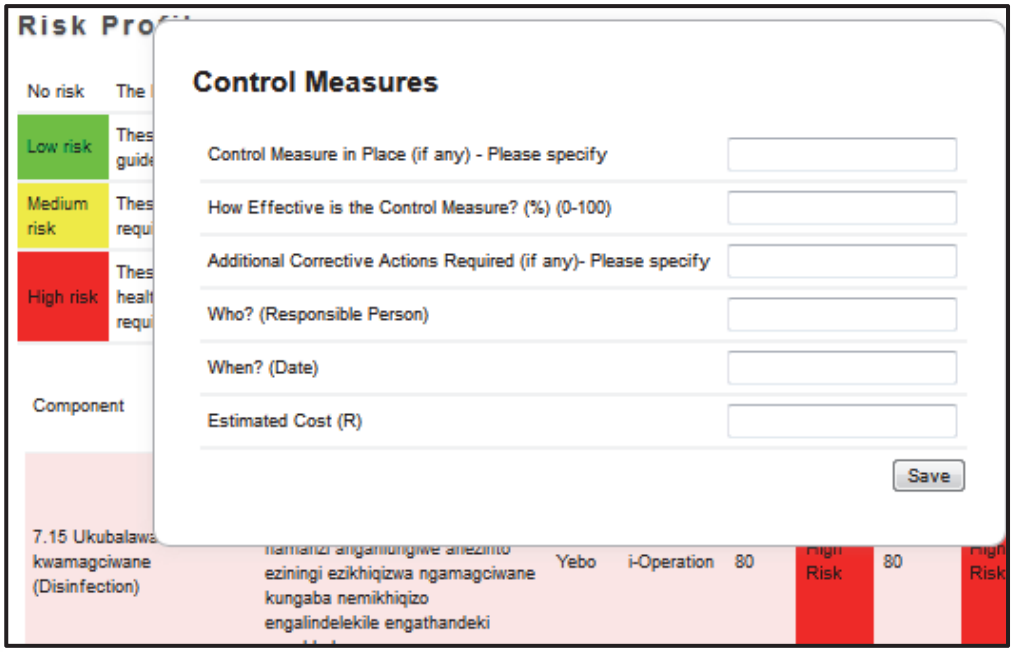


Figure 106: *Capturing and evaluating effectiveness of control measures: web (Zulu)*

Alternatively export the report to Excel (Figure 108):

- Click export as spreadsheet at the end of the page
- A message box will ask if you want the spreadsheet file to be opened or saved
- Open the spreadsheet and fill in the control measures, estimated costs and estimated time for the control measure to be implemented

Outputs from the completed web based and/or Microsoft Excel spreadsheet can be copied and pasted on a document to compile a Water Safety Plan Report.

After implementation of control measures and reviewing the effectiveness of existing control measures, the initial risk profile together with the residual risk profile will be indicated (Figure 109).

Hazard	Valid Hazard	Category	Risk Profile	Control Measure	Is the Control Measure Effective?	Corrective Actions	Who? (Responsible Person)	When? (Date)	Estimated Cost
Bird/animal droppings contaminate water.	Yes	Managem	Medium Risk	No	No	Hold awarenss campaigns educating the public about the importance of protrected(covered) rain water harvesting tankers aor collectors	Councillor Shushu	Immedia tely	To be determined
supply can result in interrupted	Yes	Operation	Medium Risk	No	No	No backup generator at the plant, need to put plans in place to invest in a back up generator.	Mr Phetheni	Jun-12	R100 000
Poor hygiene during reservoir	Yes	Maintena	Medium Risk	No	No	More precaustion should be taken when reservoir cleaning occurs.			

9.12 Consumer	yokusetshenziselwa izinjongo ezihlukahlukene (izimboni, ukuphuza, ezolimo) kungaholela ekudonsweni ngokwedlulele noma ekupheleni kwamanzi.	Yebo	Akwenzeki (N/A)	0	No Risk	0	No Risk	Control Measures
9.12 Consumer	Ukungatholakali ngokwanele noma ukungabi khona kwamanzi asezingeni elifanele nolwazi olungenele / noma ukutholakala kokuhlanzwa kwamanzi asendlini.	Yebo	Akwenzeki (N/A)	0	No Risk	0	No Risk	Control Measures

Back | Next | Continue later | Export as spreadsheet in Zulu

Figure 107: *Developing control measures on exported summary report*

Component	Hazard	Valid Hazard	Category	Risk Rating	Risk Profile	Residual Risk Rating	Residual Risk Profile	
7.15 Ukubalawa kwamagciwane (Disinfection)	Lapho amakhemikhali asetshenziselwa inqubo ye-oxidation esetshenziswa namanzi angahlungiwe anezinto eziningi ezikhiqizwa ngamagciwane kungaba nemikhiqizo engalindelekile engathandeki engakheka.	Yebo	i-Operation	80	High Risk	80	High Risk	Control Measures
7.15 Ukubalawa kwamagciwane (Disinfection)	I-pH okungeyona yokwenza i-chlorination ebangela ukungabulaleki ngokwanele kwamagciwane emanzini	Yebo	Ukulungisa	50	Medium Risk	50	Medium Risk	Control Measures
7.15 Ukubalawa kwamagciwane (Disinfection)	Ukusetshenziswa kwamakhemikhali asephelelwe yisikhathi.	Yebo	Ukulungisa	20	Medium Risk	20	Medium Risk	Control Measures
7.15 Ukubalawa kwamagciwane (Disinfection)	Ukufaka imithi ngokweqile ngenxa yokungasebenzi kahle kwemishini, amaphutha ka-operator kungaholela emazingeni aphakeme e-chlorine nawezinsalela zemithi yokuhlanza amanzi.	Yebo	Ukuphepha	2	Low Risk	2	Low Risk	Control Measures

Figure 108: *Residual Risk Profiling: web (Zulu)*

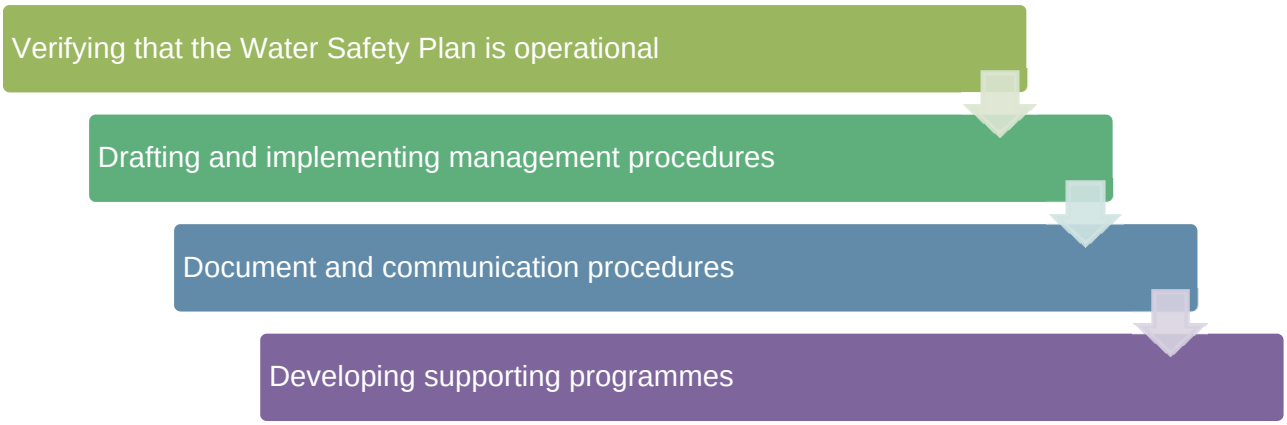
Ithuluzi Lohlelo Lokuphepha Kwamanzi
Isinyathelo 10 sezingu-11
Izinyathelo Zokulawula Nokulungisa
Lesi sinyathelo: Asiphothuliwe
Evaluation of Existing Control Measures and Corrective Actions

Component	Ingozi	Ingozi Efanele / Isenzakalo Esiyingozi	Isigaba Sengozi	Igama Lengozi (Okunquma Izinga Lekhwalithi Yamanzi)	Ukulinganisa	Iphrofayili Yobungakana ni bengozi	Isinyathelo Sokulungisa Sithathiwe (uma sikhona)?	Ukuphumelela Kwesinyathelo Sokulungisa (%)?	Ukulinganiswa Kwengozi Yezinsalela	Iphrofayili Yezingozi Zezinsalela	Izinyathelo Zokulungi	Ngubani? (Umuntu Ophathiswe Umthwalo)	Nini?
Umthombo	Imfuyo, imisebenzi eyenziwa ngabantu emthonjeni wamanzi.	Yebo	Ukuhlukahluka Kwezinga Lamanzi	i-E.coli noma ama-Faecal coliforms	0.2	Incane Ingozi		80%	0.0	Incane Ingozi	Uthango olusha	P Smit	2010/
Umthombo	Amanzi adungekile ngemva kwezimvula ezinamandla. Angase abe nobulongwe bezilwane nemisimba yezinyoni.	Yebo	Umklamo	Cytopathgenic viruses	0	Ayikho Ingozi	Ukubeka iso okuphumelelayo nokuhlanzwa kwamanzi		0.0	Ayikho Ingozi	Azidingeki	-	-
Umthombo	Izilwane ezifele emanzini zingase ziwangcolise noma zingafaka amagciwane emanzini.	Cha	Ukulungisa	0	16	Isesilinganiswe ni Ingozi		50%	8.0	Incane Ingozi			
Umthombo	Indle yezilwane/izinyoni ingafaka emanzini amagciwane angabonakali ayingozi.	Yebo	Umklamo	Izinhlobo ze-Giarida	80	Inkulu Ingozi		30%	56.0	Isesilinganisweni Ingozi			
Umthombo	Ukugeleza kancane, amazinga aphakeme ama-nutrient nezimo ezifudumele - kungenza ukuthi kucishe kuvame impela ukukhula kwama-cynobacteria nama-alga.	Yebo	i-Operation	0	2	Incane Ingozi			2.0	Incane Ingozi			

Figure 109: *Residual Risk Profiling: Excel (Zulu)*

Considering the summarised findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be addressed by ranking the risks.

As indicated earlier that the tool assists in developing Water Safety Planning, management of identified risks depends on the actions taken thereafter. The tool therefore provides suggested corrective actions, therefore implementation of corrective actions, communication procedures, management procedures development and implementation depends on the Water Services Institution (WSI). The next steps of the Water Safety Planning are not included in the tool, however should be considered as discussed earlier. The steps include:



8 CONCLUSIONS

It is recommended that the tool is continuously reviewed and updated according to the sector needs and innovations. A committee may be established which could include WRC, DWA, SANS representative, other sector partners, etc.

A need to profile and train the users on the use of the tools and development and implementation of Water Safety Planning has been identified. This may be done by conducting workshops and/or one on one training sessions depending on the nature of the area (e.g. areas with formal supply systems will have different challenges to rural areas.) Therefore the training programme should take into consideration the type of supply system managed by the targeted audience.

Linking the outputs of this project with the new WRC Emergency Response Plans project (conducted by the same team) that will start in April 2013 should be considered.

Although the risk/hazard database of the current WRC Water Safety Planning Tool is rapidly growing (based on user feedback/requests for amendments/additions), it is not exhaustive and opportunity therefore exists for the sector to continue to contribute site specific risks/hazards to the database (i.e. the list of hazards/risks will never be finalised). In particular, the ability for users to define their own hazardous events is required.

9 REFERENCES

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APPENDIX A

While some hazards are generic, implying that they may apply to every physical component of water services infrastructure (e.g. destruction of property, explosive devices), some threats are only specific to a specific component. The following tables provide examples of the water supply system possible hazards.

Table A1: Source water possible hazards in English

Source Water	
	Potential Hazards or Hazardous Events
	Surface Water (Rivers and Streams)
1	Livestock, human activity at water source.
2	Raw water turbid after heavy rain. May contain droppings of animals and birds.
3	Dead animals.
4	Droppings of animals/birds can introduce harmful micro-organisms into the water body.
5	Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal growth more likely.
6	Falling water levels due to drought or drawdown of water body.
7	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
8	Intake screens become clogged or damaged.
9	Bushfires can result in fire retardants in the water source. Loss of vegetation can result in the presence of turbidity and organic matter.
10	Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the water.
11	Industrial and agricultural activity can pollute the water (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, land spreading of manure, feedlot runoff, etc.).
12	Gaseous emissions from industrial accidents or forest fires can pollute the water (e.g. explosions, fires, etc.).
13	Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc.
14	Leaking pipelines can pollute the water body with harmful organisms or chemicals.
15	Earthquake, landslides can pollute the source.
16	Salt water intrusion (e.g. from sea) can contaminate fresh water sources.
17	Contaminated stormwater can pollute the source.
18	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.
19	Water stratification caused by temperature changes, low flows and other seasonal changes can lead to low oxygen concentrations in lower levels. For surface water bodies, this would only be relevant for larger lakes.
20	Source water quality is of challenging quality (e.g. low pH, elevated organics, high turbidity, fluctuating temperature) and/or varies seasonally.
21	Free-living microorganisms can end up in the water supply.
22	Natural geologic conditions can lead to the presence of chemicals that cause operational or aesthetic concerns in groundwater supplies.
	Boreholes
1	Livestock, human activity at water source. Shallow boreholes in highly permeable solids or fractured rock aquifers, are more vulnerable to contamination.
2	Groundwater may contain health related chemicals (e.g. arsenic, barium, fluoride, uranium, radium) as a result of local geology.
3	Surface water entering a borehole can increase the turbidity and/or may contain the droppings of animals or birds which contain harmful micro-organisms.
4	Aquifer not sufficiently fed with water can lead to a shortage of resources.
5	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.

6	Water may contain naturally occurring iron and manganese.
7	Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the borehole.
8	Industrial and agricultural activity can pollute the borehole (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, fuel stations - hydrocarbon contamination, land spreading of manure, feedlot runoff, etc.).
9	Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the borehole.
10	Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc.
11	Graveyards can pollute the borehole.
12	Salt water intrusion (e.g. from sea) can contaminate fresh water sources.
13	Contaminated stormwater can pollute the source.
14	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.
15	Hydrogen sulphide from geothermal sources or anaerobic metabolism may produce undesirable water quality.
16	Groundwater aquifers that have been previously polluted are more likely to retain pollution than surface waters. Ground water generally flows slowly and there is little mixing.
17	Infrastructure (e.g. dam, borehole pump) is old and more prone to breakdown or need repair.
18	Access to borehole, water intake or other infrastructure is restricted due to poor roads, poor access.
19	Inappropriate or inadequate source water monitoring data due to failure of equipment or lack of knowledge or training of operator.
20	When unused wells are not closed properly (abandoned well) there is an increased risk that surface water can enter the well and contaminate the aquifer leading to contamination of other wells that have been drilled into the same aquifer.
	Springs
1	Spring must be designed to protect spring from livestock, human activity at water source. Shallow boreholes in highly permeable soils or fractured rock aquifers, are more vulnerable to contamination.
2	Groundwater/spring water may contain health related chemicals (e.g. arsenic, barium, fluoride, uranium, radium) as a result of local geology.
3	Surface water entering the spring can increase the turbidity and/or may contain the droppings of animals or birds which contain harmful micro-organisms.
4	Aquifer not sufficiently fed with water can lead to a shortage of resources.
5	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
6	Water may contain naturally occurring iron and manganese.
7	Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the spring.
8	Industrial and agricultural activity can pollute the spring (e.g. harmful organisms, toxic chemicals, air deposits, air pollution, fuel stations - hydrocarbon contamination, land spreading of manure, feedlot runoff, etc.).
9	Domestic waste (wastewater, on-site septic tanks, litter, municipal landfills, etc.) can pollute the spring.
10	Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc.
11	Salt water intrusion (e.g. from sea) can contaminate fresh water sources.
12	Contaminated stormwater can pollute the source.
13	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.

	Impoundments (Dams)
1	Urban areas and wastewater discharge (permitted or unauthorised) can lead to pollution of water with harmful organisms. Extent of pollution will be dependent on level of treatment and management of sewage collection system and extent of dilution in the catchment storage (e.g. on-site septic tank systems).
2	Urban areas can pollute water via unauthorised discharge of chemicals or spills from stored chemicals.
3	Recreational activities can cause: microbial (faecal waste) and chemical (boating) contamination and soil erosion (off road vehicles).
4	Waste water discharge can lead to an increase in nutrient levels in catchments and reservoirs.
5	Urban areas can be a source for turbidity, litter and plant debris in the water body (e.g. domestic waste dumping, municipal landfills).
6	Access to reservoirs can lead to accidental damage to infrastructure and increased contamination from spills.
7	Agricultural activities involving livestock can pollute the water with harmful organisms (e.g. land spreading of manure or fertilizer). The concentration of pollutant is dependent of intensity of activity and level of access to storage area.
8	Industrial or agricultural practices may lead to contamination by toxic chemicals including herbicides, pesticides, heavy metals, pharmaceutical residuals, spillage of diesel and petroleum products.
9	Gaseous emissions from industrial accidents or forest fires can pollute the water (e.g. explosions, fires, etc.).
10	Agricultural practices may increase nutrient levels in water due to entry of fertilizers or nitrogenous compounds associated with livestock (e.g. feedlot runoff).
11	Forestry involving the development of timber plantations can lead to the discharge of pesticides and herbicides.
12	Agricultural practices and livestock can cause erosion on the water body and lead to an increase in turbidity.
13	Forestry can cause erosion on the water body and lead to an increase in turbidity.
14	After heavy rain, water entering impoundment may be turbid (soil, sand) and contain droppings of animals/birds, contaminants and contain high levels of organic matter.
15	Dead animals.
16	Low flow, high nutrient levels and warm conditions - can make cyanobacterial and algal blooms/growth more likely.
17	Water stratification can lead to low oxygen concentrations at lower levels. Promotes algal growth and releases iron and manganese from sediments.
18	Falling water levels due to drought or drawdown of water body.
19	Bushfires can result in fire retardants in the water source. Loss of vegetation can result in the presence of turbidity and organic matter.
20	Traffic accidents can lead to spillage of toxic or other chemicals, harmful substances, etc.
21	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
22	Intake screens become clogged or damaged.
23	Earthquake, landslides can pollute the source.
24	Leaking pipelines can pollute the water body with harmful organisms or chemicals.
25	Salt water intrusion (e.g. from sea) can contaminate fresh water sources.
26	Contaminated stormwater can pollute the source.
27	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.
	Surface Water Intake and Transport
1	Physical obstacles at the intake can lead to a shortage/unavailability of water.
2	Failure of the intake can lead to a shortage/unavailability of water.
3	Failure of the pumping system (e.g. power failure) can lead to a shortage/unavailability of water.

4	Pipe burst (mains, transport tunnels) can result from aging infrastructure/poor conditions/external factors leading to a shortage/unavailability of water.
5	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.
	Groundwater Abstraction and Transport
1	Physical obstacles (trees, roots, cracks) can damage the abstraction facility and lead to a shortage/unavailability of water.
2	Failure of the abstraction facility can lead to a shortage/unavailability of water.
3	Failure of the pumping system (e.g. power failure) can lead to a shortage/unavailability of water.
4	Pipe burst (mains, transport tunnels) can result from aging infrastructure/poor conditions/external factors leading to a shortage/unavailability of water.
5	An accident, equipment defect, power failure, sabotage, vandalism, etc. can lead to failure of the source monitoring system.
	Catchment
1	Manure storage or disposal and land application of manure can lead to water contamination.
2	Direct livestock access to source water.
3	Land application of sewage or sewage sludge can lead to water contamination
4	Source water quality is of challenging quality (e.g. low pH, elevated organics, high turbidity, low temperature) and/or varies seasonally.
5	Flooding can lead to increased surface flow and run-off.
6	Flooding of reservoirs can lead to leaching of heavy metals.
7	Free-living microorganisms can end up in the water supply.
8	Excavation/disturbance of acid sulphate soils can lead to the formation of sulphuric acid that can result in the release of iron, aluminium and other heavy metals that can then migrate to downstream water bodies
9	Snow melt and spring runoff can lead to the introduction of contaminants into the water source.
10	Airports, including those that have been abandoned, can be a source of contamination to water bodies. In particular, de-icing chemicals, fuels, firefighting chemical and foams and historic contamination can be issues.
11	Commercial activities such as gas service stations, auto repair facilities, car washes, dry cleaners can discharge effluent that has contaminants in it.
12	The use of heating oil or fuels by households can result in leaks to water sources, particularly from underground storage tanks.
13	Military activities such as the use of ammunition, fuel use and storage and weapon and equipment maintenance can result in contaminated discharges to drinking water sources.
14	Illegal dumping, litter and other debris can lead to solid waste directly entering source water.
15	Abattoirs can release effluent that is high in organic material.
16	Aquaculture practices, particularly waste effluent and feed/nutrient application, can lead to release of contaminants in water sources. Massive fish-die-offs can also lead to surface water contamination.
17	Industrial activities that involve land clearing, excavation or road development can lead to erosion, increased run-off for surface water and loss of in-situ filtration capability.
18	Industrial effluents or sludge disposal can lead to contamination of source waters.
19	Shipping industry maintenance such as descaling and antifoaming can lead to direct contamination of water sources.
20	Dredging of water bodies can disturb sediment including contaminated areas.
21	Illegal logging can lead to increased levels of erosion in the catchment area.
22	Illegal settlements or industries often lack wastewater treatment.
23	Roads and other paved surfaces can increase surface run-off.
	End

Table A2: Drinking water treatment system possible hazards in English

Drinking Water Treatment	
	General
1	The site is not secure (i.e. no fencing, gates, locks, safety/warning signs, inadequate security).
2	No documentation available at the works (e.g. Classification Certificate, Water Use Authorisation).
3	Issues of concern are not addressed due to inadequate reporting (e.g. malfunctions, compliance reports).
4	Staff safety is compromised as they do not have proper PPE (personal protective equipment).
5	Inadequate storage of chemicals can compromise staff safety.
6	Non optimised treatment processes can result in poor water quality.
7	Poor quality raw water can impact treatment process.
8	Insufficient flow can have a negative impact on treatment process.
9	Capacity of the works is not sufficient for needs.
10	Poor or inappropriate materials of construction can lead to treatment failure.
11	Instrumentation failure (e.g. telemetry, SCADA) can lead to loss of process control.
12	Poor operational monitoring can lead to water quality failures (e.g. ineffective/insufficient monitoring at various control points).
13	Power supply can result in interrupted treatment/loss of process control.
14	By-pass facility for untreated water due to inadequate treatment/treatment failure.
15	On-site reservoirs can be compromised/contaminated.
16	Inappropriate maintenance can lead to treatment failure.
17	Natural disasters (e.g. storms, earthquake) can damage treatment unit operations.
18	Access to laboratory facilities within an appropriate time period for sample analysis is restricted due to remote location of community.
19	Infrastructure (e.g. treatment plant) is old and more prone to breakdown or need repair.
20	Access to treatment system or other infrastructure is restricted due to poor roads, poor access.
21	Inappropriate or inadequate treated water monitoring data due to failure of equipment or lack of knowledge or training of operator.
22	Blockages in screen due to incorrect size or inadequate cleaning.
23	High winds and cold weather can contribute to malfunctioning of the sludge collector. Excessive build-up of sludge/solids can affect the functioning of the clarifier, resulting in re-suspension of flocs.
	Pre-oxidation
1	Under dosing of oxidant due to dosing malfunction, power failure, oxidant supply runs out or increased demand on raw water.
2	Overdosing of oxidant due to dosing system malfunction or decreased demand of water.
3	Pre-oxidation cause cyanobacteria to burst and release toxins.
4	Treatment chemicals of poor quality/unapproved treatment chemicals.
	Coagulation, Flocculation and Sedimentation
1	Dosing malfunction can reduce floc formation and thus the inefficient removal of harmful micro-organisms, organic material, colour and turbidity.
2	Chemical supply runs out so treatment effectively stops.
3	Large changes in flow rate or turning the works on/off can impair coagulation and flocculation.
4	Poor control of pH and alkalinity can reduce coagulation and floc formation.
5	Flocculation and particle removal can be reduced if mixing of chemicals poor (insufficient turbulence). There is not enough contact time for floc formation or floc does not settle properly.
6	Inadequate floc settling can result from wind and/or low temperatures.
7	Coagulation, flocculation and sedimentation can be compromised if biofilm growth is not controlled.
8	Changes in raw water quality can occur either seasonally or following events such as bushfire or floods. If dosing of coagulant and flocculant is not modified in response to water quality changes, treatment will be impaired.
9	Use of wrong chemicals can impair treatment and contaminate product water.

10	Treatment chemicals of poor quality/unapproved treatment chemicals.
11	Excessive mixing would result in inadequate flocculation.
12	pH outside of acceptable range can result in inadequate flocculation. Coagulation/flocculation is generally more effective at lower pH levels.
13	Under dosing (due to increased demand in raw water, process not optimized, high turbidity).
14	Overdosing (due to decreased demand in raw water, lower turbidity, process not optimized).
15	High nitrite/nitrate concentration in source water.
	Coagulation, Flocculation and Sedimentation
16	High concentration of dissolved chemicals (such as arsenic, pesticides, phosphates, other hazardous organic chemicals) will not be removed.
17	Inadequate time period allowed between filter uses (<1 hr or >48 hr)
18	Improper bubble size and rise velocity due to temperature variation can result in poor attachment of flocs with bubbles.
19	Non-evenly distributed bubbles due to clogging of fixed-orifice nozzles can result in poor attachment of flocs with bubbles.
20	If the bubble blanket is too thin, flocs can settle at the outlet end. The most important factor that affects the formation of the bubble blanket is the air loading per unit volume of raw water (air loading rate). Operational conditions such as the recycle flow rate and bubble volume concentration affect the air loading rate.
	Filtration (e.g. Rapid, Slow Sand, Multimedia, MF/UF)
1	Sudden increase in flow rate can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
2	Hydraulic shock due to sudden open and closing of valves can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
3	Incomplete or insufficient backwash (too short, rate to low, air scour inadequate or too short) can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
4	Rapid start up following backwashing can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
5	Failure to reduce flow rates during backwashing can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
6	Media displacement, cracking or loss can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
7	Media blockage including mudballs can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
8	Trapping of air bubbles including air binding can lead to inadequate removal of turbidity (and particles) and harmful micro-organisms.
9	No alternative disinfection treatment applied during filter ripening period (2 weeks - 30 days following building or cleaning the filter).
10	Corrosion of the metal diffuser plate results in large holes in the plate; Malfunctioning diffuser plate causes disturbed/uneven sand below the plate, disturbing the biolayer, and potentially leading to short circuiting of the filter.
11	Sand level is either too high or too low preventing the formation of the biolayer.
12	Filter dries out (completely or the top sand layer). Cracks in the casting of the concrete shell can result in leaks that also cause the filter to dry out and the biolayer to die off.
13	High turbidity in source water (or build-up/fouling over time) can clog the filter, resulting in decreased flow rates through the filter.
14	Filter short circuiting (not enough contact time for treatment/chemical removal).
15	High turbidity in source water (or build-up/fouling over time) can clog the filter, resulting in decreased flow rates through the filter.
16	Holes form in th3 screen resulting in inadequate removal of large particles/debris.
17	Coarse screening is used on its own with no other form of treatment.
18	Pre-chlorination is applied prior to the slow sand filter resulting in inactivation of the biolayer.
19	Inadequate removal of target contaminants.

20	If only one filtration line is in place, then the water supply would be disrupted during maintenance, cleaning or repair.
21	Use of sand of poor quality can reduce filter performance.
22	Negative pressure in outlet pipes can cause external water to flow back in to the filter.
23	Break-through of media due to high head loss or unevenly placed media can reduce filter performance and result in inadequate removal of particles.
24	Inadequate filter maintenance (e.g. sand replacement, cleaning of air release nozzles, lubrication, cleaning of media, pump maintenance).
25	Inadequate filter media depth or type of media is not suitable for the quality of the water being filtered and the flow rate.
	Powdered/Granular Activated Carbon
1	Poor operation leading to inadequate removal of cyanobacterial (blue-green algae) toxins.
2	Poor operation leading to inadequate removal of taste and odour compounds (geosmin and MIB).
3	Poor operation leading to inadequate removal of pesticides and organic compounds.
4	Poor operation leading to inadequate removal of naturally occurring organic matter, increasing turbidity.
5	Inadequate design (e.g. insufficient empty bed contact time) results in insufficient removal of target contaminants.
6	Inadequate maintenance leading to increased head loss and insufficient production capacity.
7	Inadequate backwashing/maintenance leading to increased biological growth in filters and poor water quality.
8	Escape of activated carbon to finished water due to failure or inadequate carbon retaining devices.
9	Insufficient production capacity due to increased head loss.
10	Overdosing of fluoridation chemicals.
11	Incorrect adjustment of pH due to equipment malfunction or failure, operator error or changes in raw water quality.
12	High turbidity in source water (or build-up/fouling over time) can clog the resin or filter, resulting in decreased flow rates. Organic material accumulation in resins can support microbial growth which can decrease treatment effectiveness.
13	Adequate treatment is not in place
	Chlorination (Including Secondary Chlorination)
1	Dosing malfunction due to equipment failure or power failure. Possible interruption to chlorination (chlorine under dosing, chlorine overdosing).
2	Disinfection chemical supply runs out.
3	Chlorine under dosing (inadequate contact time) may occur due to increased chlorine demand in raw water or increased water flows. Changes in water quality could be seasonal or due to events such as heavy rain or bush fires.
4	Chlorine overdosing may occur due to decreased chlorine demand in raw water or decreased water flows.
5	Low free chlorine residual in the distribution system reduces protection against faecal contamination and free living organisms.
6	Treatment chemicals of poor quality/unapproved treatment chemicals.
7	Chlorination facilities not complying to safety regulations can lead to chlorine gas leakages.
	Ozonation
1	Inappropriate pre-treatment may result in particles in the water and ineffective disinfection.
2	Ozonation may be interrupted due to equipment malfunction, exhaustion or power failure (e.g. failing air compressor, failing oxygen supply, failing ozone generator).
3	Failure or incorrect calibration of the gas meter or dissolved ozone meter can lead to the ozone dose being too low.
4	Increased water flows can lead to under dosing (inadequate contact time).
5	High pH (> 8) or high turbidity can result in under dosing.
6	Bromide may be present in raw water.

	Ultraviolet Radiation
1	Inappropriate pre-treatment may result in particles in the water and ineffective disinfection.
2	Incorrect dosing location results in too short reaction time for disinfection.
3	Disinfection may be interrupted by equipment malfunction, aging equipment or power failure.
4	Inadequate irradiation (disinfection) may be due to increased turbidity or colour in raw water or increased flows.
5	Improper maintenance, such as not replacing lamps or not removing sediment from the quartz tube, can lead to reduced lamp performance and less effective treatment. As well, equipment malfunction, incorrect installation of lamps or using lamps with incorrect specifications can lead to inadequate irradiation.
	Softening
1	Softened water can be corrosive and leach chemicals from pipes.
2	Softening of very hard waters using ion exchange can lead to increased concentrations of sodium in the water.
3	Organic material may accumulate in resins (where used) and support microbial growth.
	Softening
4	Where lime softening is used incorrect dosing or poor pH control can reduce the efficiency of the process and may interfere with other treatment processes (e.g. if used in conjunction with coagulation, flocculation and sedimentation).
5	Where lime softening is used, treatment chemicals may be of poor quality.
6	If NF membranes are used and inadequate electricity supply exists, the process cannot operate.
7	If NF membranes are used and inadequate skills exist, system failure may occur.
8	Source water very hard (> 200 mg calcium carbonate).
	Stabilisation
1	Unstabilised water can be corrosive and leach chemicals from pipes.
2	Where lime stabilisation is used incorrect dosing or poor pH control/lack of CO2 can reduce the efficiency of the process.
3	Where lime stabilisation is used, treatment chemicals may be of poor quality.
4	Where limestone stabilisation is used, lack of maintenance (e.g. flushing of bed, irregular topping up of limestone bed) can lead to poor performance.
5	Source water very soft (0 mg calcium carbonate).
	Membrane Filtration
1	If membranes are incorrectly operated and maintained (i.e. erratic hydraulic stress, inadequate pre-treatment, poor cleaning), system failure may occur.
2	If membranes are used and inadequate skills exist, system failure may occur.
3	If membranes are used and inadequate spares/back-up equipment exist, system failure may occur.
4	Membrane cleaning chemicals may be of poor quality or wrong chemicals may be used due to improper storage or handling; mis-labelling; problems during production, transport or delivery; or use of expired chemicals.
5	Inadequate removal of membrane cleaning chemicals after maintenance and prior to return to service.
6	Membrane or resin breakthrough, damage or failure (breaks or leaks) due to manufacturing deficiencies, failure to pretreat water, failure to remove pre-treatment oxidants, lack of maintenance or operational errors (e.g. pressure of backwash is too high).
7	Adverse/excessive biological activity in filter potentially due to: decrease in pH, high water temperature, ineffective backwash protocol, prolonged wet storage of carbon before use, too low velocity or stagnant water, influent water quality, (an)aerobic condition.
	Desalination
1	If RO membranes are used and inadequate electricity supply exists, the process cannot operate.
2	If RO membranes are used and inadequate skills exist, system failure may occur.
3	If RO membranes are used and inadequate spares/back-up equipment exist, system failure may occur.

	Ion Exchange
1	Spent resin is disposed of in an appropriate manner.
2	Insufficient chemical supply (regeneration chemicals) due to factors such as untimely order or delivery, insufficient availability or production, transport or custom delays or cost increases.
3	Filter media can become saturated due to inadequate maintenance/regeneration.
4	pH outside of acceptable range during treatment (pH is too high or low for treatment to be effective - depending on the contaminant being removed)
5	Filter media is diminished with the regeneration process resulting in decreased bed volume and decreased filter run time between regeneration events.
6	Flow rate is inadequate in response to changes in source water quality
7	Insufficient addition of oxygen due to equipment malfunction (e.g. pumps/blowers breakdown) or inadequate stirring/shaking (at the household level) will lead to inadequate aeration.
8	No subsequent sedimentation/filtration stage is provided for aerated water (containing Fe or Mn).
9	No subsequent disinfection treatment is provided for aerated water
10	Ion exchange resin becomes saturated due to inadequate maintenance/regeneration leading to an ineffective treatment process.
	Disinfection
1	When oxidation chemicals are used with a raw water that is high in organic matter (and other disinfection by-product precursors) disinfection by-products can be formed.
2	Use of expired chemicals.
3	Incorrect pH for chlorination resulting in insufficient disinfection.
4	Underdosing due to equipment malfunction, increased demand in the raw water, increased flows, operator error, loss of chemical supply or loss of power can lead to insufficient disinfection or residual in the distribution system.
5	Overdosing due to equipment malfunction, decreased demand in the raw water, decreased flows, operator error or insufficient monitoring can lead to high chlorine and disinfectant residual levels.
6	Inappropriate pre-treatment or failure to remove particles in the raw water can lead to inadequate disinfection.
7	Inadequate or inappropriate design of the treatment system can lead to insufficient contact time for disinfection chemicals resulting in inadequate treatment and high disinfectant levels.
8	Presence of bromide, humic acids or organic matter in the raw water.
	Home Treatment
1	Holes form in the cloth material, the cloth has a large weave or is not folded a sufficient number of times leading to inadequate removal of large particles.
2	Not cleaning or washing the cloth between batches of source water can potentially contaminate subsequent batches.
3	Cloth straining is used on its own with no other form of treatment.
4	Filter becomes clogged due to accumulation of materials in and on surface of the filter element (due to highly turbid water or lack of maintenance) resulting in decreased flow rates. Increased turbidity and natural organic matter can also block sorptive sites (e.g. iron oxyhydroxides) or silver applied to the filter element.
5	Decay or degradation of the ceramic element can result in decreased treatment capacity. Holes or cracks in the ceramic element can result in particles/turbidity passing through the filter.
6	If abrasive materials are used for cleaning the ceramic element, the silver coating could be removed resulting in reduced treatment capability or reduced lifespan of the element and the filter.
	Solar
1	Bottles not exposed to full sunlight for a long enough time period (6 hr) or decreased solar irradiation due to clouds/change in weather results in inadequate disinfection.
2	Plastic/glass bottles or bags are scratched and less transparent or bottles are very dirty.
3	Source water has a high turbidity or colour level.
4	Microbial reactivation and regrowth during storage
	End

Table A3: Drinking Water Network possible hazards in English

Distribution Network	
Protected Service Reservoir (Covered Storage Tank)	
1	Animals/birds can enter through faults (e.g. cracks in roof, walls or floor)and contaminate the water with their droppings. If animals drown, there will be a higher level of harmful micro-organisms present.
2	Animal/bird droppings may be washed into storages in rainwater entering through faults in the storage roof or from internally draining roofs.
3	Unauthorized human access, such as swimming in the storage tanks can cause microbial contamination.
4	Excessive pressure build-up could lead to reservoir structural damage.
5	High chlorine levels may enter the distribution system if there is poor mixing after disinfection of storages.
6	Resuspension of sediments containing slimes and odour producing micro-organisms may occur.
7	Water quality may deteriorate due to aging of water caused by low turnover rates, uneven hydraulic mixing, etc.
8	Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply.
9	Natural disasters (e.g. storm, earthquake, flood) may damage or destroy reservoir resulting in contaminated/no water supply.
10	Manmade incidents (e.g. truck accident) may damage or destroy reservoir resulting in contaminated/no water supply.
Protected Service Reservoir (Covered Storage Tank)	
11	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
12	Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring).
	Unprotected Service Reservoir (Uncovered Storage Tank)
1	Animals/birds can enter through faults and contaminate the water with their droppings. If animals drown, there will be a higher level of harmful micro-organisms present.
2	Animal/bird droppings may be washed into storages in rainwater entering through faults in the storage roof or from internally draining roofs.
3	Growth of cyanobacteria (blue-green algae) and other algae can be a problem where storage tanks are open to sunlight.
4	Spray drifts from nearby farming activities including pesticides and agricultural chemicals can enter storage as well as dirt and other wind borne debris.
5	Bushfires may lead to retardants and large amounts of ash entering storage.
6	Unauthorized human access, such as swimming in the storage tanks can cause microbial contamination.
7	High chlorine levels may enter the distribution system if there is poor mixing after disinfection of storages.
8	Resuspension of sediments containing slimes and odour producing micro-organisms may occur.
9	Water quality may deteriorate due to aging of water caused by low turnover rates, uneven hydraulic mixing, etc.
10	Poor hygiene during reservoir construction/repairs/cleaning can contaminate the water supply.
11	Natural disasters (e.g. storm, earthquake, flood) may damage or destroy reservoir resulting in contaminated/no water supply.
12	Man-made incidents (e.g. truck accident) may damage or destroy reservoir resulting in contaminated/no water supply.
13	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
14	Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring).

15	Uncovered tanks can serve as breeding sites for mosquitoes or other insects.
16	Poor condition of tanks, covers, leaks and cracks can lead to contamination.
17	Storage and distribution systems are not designed for the appropriate water capacity required by the community. Over-design can lead to water aging and loss of residuals. Under-design can lead to an insufficient water supply.
18	Tanks made of steel can corrode introducing rust into the water supply and resulting in cracks/leaks in or damage to the structure.
	Pump Station
1	Pump failure (e.g. pump malfunction, power failure, incorrect settings) may result in low flow/no water supply.
2	Natural disasters (e.g. storm, earthquake, flood) may damage or destroy pump station resulting in contaminated/no water supply.
3	Man-made incidents (e.g. truck accident) may damage or destroy pump station resulting in contaminated/no water supply.
4	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
5	Poor hygiene during pump installation, maintenance or repair can contaminate the water supply.
6	Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring).
7	Accidental sudden pump shutdowns or valve closures can lead to pressure transients or water hammer which can lead to sloughing of biofilms, dislodging of sediment or pipe bursts.
8	Flooding leading to contaminated water entry through above-ground hydrants or air valves.
	Valves and Meters
1	Valve or meter failure (e.g. wear of mechanical parts, power failure, incorrect settings) may result in low flow/no water supply.
2	Poor hygiene during valve/meter installation, maintenance or repair can contaminate the water supply.
3	Poor pressure management (e.g. malfunctioning/failure of pressure reducing valves) can result in excess pressure in the network and result in damaged valves, water wastage, etc.
4	Backflow of non-potable/contaminated water (from illegal connections or household plumbing) can occur due to absent or ineffective check valves or when negative pressure situations occur. Cross-connections between potable and non-potable water systems (e.g. fire sprinkler systems, hot water heating systems, sewage systems) can also result in the contamination of drinking water.
5	Flooding, standing water near taps or unsanitary conditions due to improper construction (no/inadequate apron, gutter/drainage)
6	Storms, natural disasters or accidents leading to damage to equipment or infrastructure.
7	Unsuitable materials and coatings can introduce contaminants and support microbial growth.
8	Low flows/stagnant water or aggressive source water (low pH, high salinity, low alkalinity) can cause leaching from solder, brass fittings, galvanized tanks or pipes, lead service lines and can introduce contaminants.
9	Operational errors (e.g. improper/excessive pressure, lack of maintenance) and external stresses (e.g. freeze/thaw, traffic weight, invasive tree roots) can lead to pipe bursts, breaks or leaks as well as damage to tanks and reservoirs.
10	Lack of maintenance, stagnant water or elevated iron levels can lead to accumulation of silts, sediments, sludge and slimes/biofilms.
11	Valves or fittings that are improperly sealed or leaking can lead to intrusion of pathogens and loss of supply.
	Distribution System
1	Excessive pressure build-up could lead to reservoir structural damage.
2	Pipe burst and leaks can interrupt the water supply. Contamination can occur where water pipes are below or close to stormwater or sewage pipes or in an area with septic tanks leading to microbial and chemical contamination. Entry of soil may increase turbidity.

3	Microbial or chemical contaminants can enter the water supply system through cross-connections, unauthorized connections or backflow (e.g. pressure fluctuations, intermittent supply).
4	Poor hygiene during pipe repairs/cleaning can contaminate the water supply.
5	Entry of soil during repair and maintenance can increase turbidity and contaminate water.
6	Inadequate disinfection or flushing before commissioning of new mains results in chemical and microbial contamination. Presence of soil may increase turbidity.
7	Contaminated water may enter the system during flooding, particularly through above ground hydrants and air valves. Microbial and chemical contamination possible. Presence of soil may increase turbidity.
8	Raised temperatures (e.g. 25 - 30ºC) in long, above ground pipelines can support the growth of some organisms.
9	Leaching from cement pipes, particularly during periods of low flow, can cause a high pH.
10	Changes in flow or increased concentrations of disinfectant can cause sloughing and resuspension of biofilms.
11	Opening/closing valves - reversed or changed flow disturbing deposits, introduction of stale water.
12	Third party access to hydrants - contamination by backflow, increased flow disturbing deposits.
13	Dead-end mains and low water flows can lead to stagnant water and loss of residual chlorine.
14	Unsuitable coatings and materials can leach chemicals or support bacterial growth.
15	Loss of pipe hydraulic capacity (scaling/tubercle formation) can result in reduced/insufficient or no water supply.
16	Chlorine under/over-dosing at Chlorine Booster Stations.
17	Lack of safety precautions at Chlorine Booster Stations can lead to hazardous conditions.
18	Vandalism or sabotage may pollute the water with chemicals or microbes or damage equipment and infrastructure.
19	Poor pressure management (e.g. malfunctioning/failure of pressure reducing valves) can result in excess pressure in the network and result in burst pipes, water wastage, etc.
20	Poor monitoring can lead to contaminated/no water supply (e.g. failure of telemetry, no water quality monitoring).
21	Inadequate disinfection or flushing before commissioning new mains or after repair and maintenance activities. Contamination can occur due to human access and/or unsanitary conditions during repair and maintenance activities.
22	Warm ambient temperatures, heating of pipes and heat transfer from nearby objects/environments can lead to high water temperatures (e.g. 25-30 deg. C+) that promote growth/occurrence of certain microorganisms. As well warm temperatures will result in a quicker dissipation of chlorine residual.
23	Improper installation of pipes, fittings, valves and other components can lead to leaks and intrusion. Illegal connections can also result in leaks and intrusion.
24	Intermittently supplied piped water lead to lack of pressure for long periods of time as well as low pressure due to high demand when water is being supplied resulting in intrusion.
25	Intermittently supplied piped water can result in frequent velocity changes, increasing risks from scouring and sloughing of biofilms and sediments.
26	Where piped water is supplied intermittently, consumers may use pumps to draw water out when the supply is not being provided. This creates negative pressure and leads to intrusion.
27	Where piped water is supplied intermittently, consumers may switch to source of lower quality or may experience unequal provision of supply.
28	Organic pollutants in the soil may leach through the rubber joints of pipes or the pipe wall of polyethylene or PVC pipes.
29	Low flows/stagnant water or aggressive source water (low pH, high salinity, low alkalinity) can cause leaching from plastic/PVC pipes and tanks.
30	Infrastructure (e.g. reservoir, distribution pipes) is old and more prone to breakdown or need repair.
31	Access to reservoirs, pipes or other infrastructure is restricted due to poor roads, poor access.
32	Inappropriate or inadequate network monitoring data due to failure of equipment or lack of knowledge or training of operator.

	Household Connections
1	Household plumbing can (i) leach chemicals that have health impacts or cause tastes and odours, (ii) support microbial growth that can also cause tastes and odours.
2	Household plumbing can become corroded through incorrect installation or from action of water supply on fittings.
3	Backflow from household plumbing devices or water storages (e.g. rainwater tanks, swimming pools, garden ponds) can contaminate drinking water systems.
4	Water is transferred/extracted/dispensed using dirty utensils (e.g. buckets, cups, ladles), unclean spigots or hands.
5	Metal containers used for storage can corrode and leach metals into the water supply.
6	Containers are exposed to unsanitary conditions, e.g. waste/runoff from latrines, access by animals, etc.
	Community Standpipes
1	Poor access to standpipe leads to unavailability of water/interruption in supply.
2	Backflow from tankers connecting to standpipes can lead to microbial and chemical contamination of the water.
3	Water standing at access points can attract birds and animals raising vector and disease concerns.
4	Damage/vandalism to the filling point can interrupt supply and allow entry of contamination.
5	Containers used to collect and transport the water may be contaminated.
6	Spillage of chemicals (e.g. fuel/detergents from leaking containers) in proximity of the standpipe can cause contamination.
	Rain Water Harvesting
1	Roof paint contains chemical contaminants.
2	Foliage collection over/along gutters and rooftops.
3	Bird/animal droppings contaminate water.
4	First flush of water can enter storage tank.
	Household Treatment and Storage
1	Chlorine under dosing.
2	Chlorine overdosing.
3	Re-contamination of water due to incorrect/improper use of tap based filter.
4	Re-contamination of water due to storage in open containers that may be accessible to birds/animals/dust/dirt.
5	Re-contamination due to unhygienic practices when handling/drawing water from the storage container.
6	Re-contamination due to use of improper storage container (e.g. metal drums) and the container not being maintained in a clean condition.
	Tanker Truck Delivery
1	Re-contamination of water due to storage in tanker truck that is not clean from previous use or sterile.
2	Water may be contaminated during transfer to and from the vehicle due to dirty hoses, fittings or filling points. Leaks in pipes, hoses, fittings or tanks related to the trucked supply can also result in contamination.
3	The source of water for the trucked supply may be unsuitable for drinking.
4	The water truck/tanker may be unsuitable for use for potable water, e.g. it is used to transport other liquids containing chemical contaminants or human waste.
	Consumer
1	Insufficient water is supplied for industry which forces them to curtail or stop production.
2	Water demands by industry or agriculture threaten continuity of supply for consumption and hygiene by domestic users.
3	High permanent population can lead to water demand exceeding treatment capacity.
4	Where demand exceeds treatment capacity, water quality may decrease.
5	Not enough water is available to meet increased demand of transient populations.

6	Bottle-fed infants (primarily those under 3 months of age) are susceptible to elevated levels of nitrates.
7	Some people are more likely to get infections if there are problems with the water supply (children < 6 months, old people, hospital patients, people with cancer, chronic illness, organ transplants, AIDS, or other conditions that compromise immunity).
8	Renal dialysis patients are at high risk due to onsite treatment that could be sensitive to water quality changes.
9	Water withdrawals for various uses (industrial, drinking, agriculture) can lead to over extraction and drawdown of water.
10	Limited or no access to good water quality sources and insufficient knowledge of / or access to household treatment.
11	Increased water use and flows may scour pipes and dislodge deposits.
	End

Table A4: Source Water Treatment System possible hazards in Afrikaans

Bronwaters	
	Potensiële gevare of gevaarlike gebeure
	Oppervlak Waters (Riviere en Strome)
1	Lewende hawe/landbou, menslike aktiwiteite by die waterbron.
2	Onbehandelde water is troebel na swaar reën. Dit mag mis bevat van diere en voëls.
3	Dooie diere
4	Mis van diere/voëls kan lei tot die groei van gevaarlike mikro-organismes in die waterliggaam.
5	Lae vloei, hoë voedingstofvlakke en warm toestande kan lei tot die waarskynlike groei van siano bakterieë en alge.
6	Dalende watervlakke as gevolg van droogte of water wat onttrek word van die waterliggaam.
7	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organimes of skade aanrig aan toerusting en infrastruktuur.
8	Inneemskerms word geblok of beskadig.
9	Veldbrande kan lei tot brandblusmiddels wat in die waterbron beland. Verlies aan plantegroei kan aanleiding gee tot troebelheid of ongewenste organiese materie.
10	Huishoudelike vullis (afval /rioolwater, septiese tenks naby stroom, rommel, munisipale vullistortings, ens.) kan die water besoedel.
11	Industriële en landbouaktiwiteite kan die water besoedel (bv. skadelike organismes, chemikaliëe, lugbesoedeling, lugneerslae, landelike verspreiding van mis, voerkraal afloop, ens.).
12	Gas emissies van industriële ongelukke of veldbrande kan die water besoedel (bv. ontploffings, vure, ens.).
13	Verkeersongelukke kan lei tot storting van toksiese of ander chemkaliese, skadelike stowwe.
14	Lekkende pype kan die waterliggaam besoedel met skadelike organismes of chemikaliëe.
15	Aardbewings, grondverskuiwings kan die bron besoedel.
16	Soutwater indringing (bv. van die see) kan vars waterbronne besoedel.
17	Besmette stormwater kan die bron besoedel.
18	'n Ongeluk, toerustingdefek, kragonderbreking, vandalisme, sabotasie, ens. kan veroorsaak dat moniteringstelsel van die bron faal.
19	Waterstratifikasie/laagvorming veroorsaak deur temperatuurveranderinge, lae vloei en seisoene wat verander kan lei tot lae suurstofkonsentrasies in die laer vlakke. Dit sou slegs geld vir water van groot mere of waterliggame met groot oppervlakte.
20	Bronwaterkwaliteit is uitdagend (bv. lae pH, verhoogde organiese materiaal, hoë troebelheid, temperatuurvariasies en/of seisoenwisseling).
21	Vry-lewende mikro-organismes kan in die watervoorraad beland.
22	Natuurlike geologiese toestande kan aanleiding gee dat chemikalieë verandering, bedryfs-of estetiese vrese in grondwater-voorrade laat ontstaan.
	Boorgate
1	Lewende hawe/boerdery, menslike aktiwiteit by die waterbron. Vlak boorgatte in hoogs deurdringbare vastestowwe of verbrokkelende, waterdraende rotse, is meer vatbaar vir besoedeling.
2	Grondwater mag gesondheidsverwante chemikaliëe (bv. arseen, barium, fluoried, uranium, radium) bevat as gevolg van plaaslike geologiese aktiwiteite.
3	Oppervlakwater kan die boorgat deurdring en kan die troebelheid verhoog en/of kan mis van diere/voëls (wat skadelike mikro-organismes dra) bevat.
4	Waterdraer wat nie met voldoende water gevoed word nie, kan lei tot 'n tekort aan hulpbronne.
5	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organimes of skade rig aan toerusting en infrastruktuur.
6	Water mag natuurlike yster en mangaan bevat.
7	Huishoudelike vullis (afval /rioolwater, septiese tenks naby stroom, rommel, munisipale vullistortings, ens.) kan die water besoedel.

8	Industriële en landbouaktiwiteit kan die water besoedel (bv. skadelike organismes, toksiese chemikalië, lugbesoedeling, lug deeltjies/partikels, landelike verspreiding van mis, ens.).
9	Huishoudelike vullis (rioolwater, septiese tenks op die perseel, rommel. Munisipale vullistortings, ens.) kan die boorgat besoedel.
10	Verkeersongelukke kan lei tot storting van toksiese of ander chemkaliese, skadelike stowwe.
11	Begrafplase kan die boorgat besoedel.
12	Soutwater indringing (bv. van die see) kan vars waterbronne besoedel.
13	Besmette stormwater kan die bron besoedel.
14	'n Ongeluk, toerustingdefek, kragonderbreking, vandalisme, sabotasie, ens. kan veroorsaak dat moniteringstelsel van die bron faal.
15	Waterstofsulfaat van geo-termiese bronne of “anaerobic” metabolisme kan ongewenste kwaliteite in die water laat ontstaan.
16	Grondwaterdraers wat voorheen besoedel was, is meer geneig om besoedeling te behou as oppervlakwater. Grondwater vloei oor die algemeen stadig en vermenging vind stadig plaas.
17	Infrastruktuur (bv. dam, boorgatpomp) is oud en is geneig om meer te breek of herstel te word.
18	Toegang tot boorgat, waterinname of ander infrastrukture is beperk, as gevolg van swak paaie en die toeganklikheid daarvan.
19	Onvanpaste of onvoldoende bronwatermoniteringsdata as gevolg van swak toerusting of 'n gebrek aan kennis of opleiding van die operateur of moniteerder.
20	Wanneer ongebruikte putte nie behoorlik toegemaak word nie (putte wat nie meer gebruik word nie) is daar 'n verhoogde risiko dat oppervlakwater die putte kan binnedring en die ondergrondse waterdraer kan besoedel wat kan lei tot besoedeling van ander waterputte wat deur dieselfde ondergrondse waterdraer voorsien word.
	Fontein (Bron)
1	Fonteine moet ontwerp word sodat dit beskerm is teen lewende hawe en menslike aktiwiteite by die waterbron. Vlak boorgate in hoogs deurlaatbare grond is meer vatbaar vir besmetting.
2	Grondwater mag gesondheidsverwante chemikalieë (bv. arseen, barium, fluoried, uranium, radium) bevat as gevolg van plaaslike geologiese aktiwiteite.
3	Oppervlakwater kan die fontein (bron) deurdring en kan die troebelheid verhoog en/of mis van diere/voëls (wat skadelike mikro-organismes dra) bevat.
4	Waterdraer wat nie met voldoende water gevoer word nie, kan lei tot 'n tekort aan hulpbronne.
5	Vandalisme en sabotering kan die water besoedel/besmet met chemikalieë of mikrobes of beskadigde toerusting en infrastruktuur.
6	Water mag natuurlike yster en mangaan bevat.
7	Huishoudelike vullis/afval (rioolwater, op die perseel septiese tenks, rommel, munisipale vullistortings, ens.) kan die fontein (bron) besoedel.
8	Industriële en landbouaktiwiteit kan die water besoedel (bv. skadelike organismes, toksiese chemikalië, lugbesoedeling, lugneerslae, landelike verspreiding van mis, voerkraal afloop, ens.).
9	Huishoudelike afval (rioolwater, perseel septiese tenks, vullis, munisipale stortingsterrein, ens.) kan die fontein besoedel.
10	Verkeersongelukke kan lei tot stortings van toksiese of ander chemikaliese, skadelike stowwe.
11	Soutwater indringing (bv. van die see) kan vars waterbronne besoedel.
12	Besmette stormwater kan die bron besoedel.
13	'n Ongeluk, toerustingdefek, kragonderbreking , vandalisme, sabotering ens. kan veroorsaak dat die bronmoniteringstelsel faal.
	Opgedamde Water (Damme)
1	Stedelike gebiede en rioolwaterstorting kan lei tot waterbesoedeling. Die omvang van die besoedeling sal afhanklik wees van die vlak van behandeling en bestuur van die rioolopvangstelsel.
2	Stedelike gebiede mag water besoedel via ongemagtigde afvoering van chemikalieë of stortings van gestoorde chemikalieë.
3	Ontspanningsaktiwiteite kan die volgende veroorsaak: mikrobiese (fekale afval) en chemiese besmetting en gronderosie (veld voertuie).

4	Rioolwaterafvoer kan lei tot 'n toename in voedingsvlakke in opvangareas en reservoirs.
5	Stedelike gebiede kan 'n oorsaak wees vir troebelheid, vullis en plantafval in die waterliggaam (bv. huishoudelike vullisstorting, munisipale stortingsterrein).
6	Toegang tot reservoirs kan lei tot infrastruktuur skade en toename in besmetting.
7	Landbouaktiwiteite wat lewende hawe behels kan lei tot waterbesoedeling. Die konsentrasie van die besoedelende stof is afhanklik van die intensiteit en toeganglikheid tot die stoorarea.
8	Industriële- en landboupraktyke mag lei tot besmetting a.g.v toksiese chemikalieë wat onkruiddoders, insekdoders, farmaseutiese oorblyfsels, dieselstortings en petroleumprodukte insluit.
9	Uitlaatgasse van industriële ongelukke of veldbrande kan die water besoedel (bv. ontploffings, vure, ens.).
10	Landbouaktiwiteite mag die voedingsvlakke verhoog in water as gevolg van die inname van kunsmis of stikstofbevattende verbindings wat geassosieer word met lewende hawe (bv. voerkraalafloop).
11	Bosbouaktiwiteite wat die ontwikkeling van plantasies behels, kan lei tot die storting van insekdoders en onkruiddoders.
12	Landbouaktiwiteite en lewende hawe kan erosie van die waterliggaam veroorsaak en kan lei tot 'n toename in troebelheid.
13	Bosbou kan erosie van die waterliggaam veroorsaak en kan lei tot 'n toename in troebelheid.
14	Na swaar reën, kan water wat die dam binnegaan troebel wees en kan verder meer diere/voël mis, besoedelende middele en hoë vlakke van organiese materie bevat.
15	Dooie diere.
16	Lae vloei, hoë voedingstofvlakke en warm toestande, kan lei tot die waarkynlike groei van siano bakterie en alge.
17	Waterlaagvorming (of watestratifikasie) kan lei tot lae suurstofkonsentrasie by lae vlakke. Algegroei word bevorder en stel yster en mangaanneerslae vry van sedimentasie.
18	Dalende watervlakke as gevolg van droogte of aftrek uit waterreservoirs.
19	Veldbrande kan lei tot brandblusmiddels wat in die waterbron beland. Verlies aan plantegroei kan aanleiding gee tot troebelheid of ongewenste organiese materie.
20	Verkeersongelukke kan lei tot stortings van toksiese of ander chemkaliese, skadelike stowwe.
21	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of skade aanrig aan toerusting en infrastruktuur.
22	Inneemskerms word geblok of beskadig.
23	Aardbewings, grondverskuiwings kan die bron besoedel.
24	Lekkende pype kan die waterliggaam besoedel met skadelike organismes of chemikalieë.
25	Soutwaterindringing (bv. van die see) kan varswaterbronne besoedel.
26	Besmette stormwater kan die bron besoedel.
27	'n Ongeluk, toerustingdefek, kragonderbreking, vandalisme, sabotering, ens. kan veroorsaak dat die bronmoniteringstelsel faal.
	Oppervlak Waterinname en Vervoer
1	Fisiese hindernisse by die inname kan lei tot 'n tekort/nie beskikbaarheid van water.
2	Indien die inname faal, kan dit lei tot 'n tekort/nie beskikbaarheid van water.
3	Die faal van pompsisteem (bv. kragonderbreking) kan lei tot 'n tekort (nie beskikbaarheid) van water.
4	Pypbreke (hooflyne en watertonnels) as gevolg van verouderde infrastruktuur/swak toestande/eksterne faktore kan lei tot 'n tekort (of nie beskikbaarheid) van water.
5	'n Ongeluk, toerustingdefek, kragonderbreking, vandalisme, sabotasie, ens. kan veroorsaak dat moniteringstelsel van die bron faal.
	Grondwater Ekstraksie en Vervoer
1	Fisiese hindernisse (bome, wortels, krake) kan die onttrekkingsfasiliteit beskadig en kan lei tot 'n tekort (of nie beskibaarheid) aan water.
2	As onttrekkingsfasiliteit faal, kan dit lei tot 'n tekort (of nie beskikbaarheid) van water.

3	Die faal van pompsisteem (bv. kragonderbreking) kan lei tot 'n tekort (nie beskikbaarheid) van water.
4	Pypbreke (hooflyne en watertonnels) as gevolg van verouderde infrastruktuur/swak toestande/eksterne faktore kan lei tot 'n tekort (of nie beskikbaarheid) van water.
5	'n Ongeluk, toerustingdefek, kragonderbreking, vandalisme, sabotasie, ens. kan veroorsaak dat moniteringstelsel van die bron faal.
	Opvangsgebied
1	Misophoping of verwydering en storting van mis kan lei tot waterbesoedeling.
2	Direkte toegang vir vee tot waterbron.
3	Storting van riool of rioolslyk kan lei tot waterbesoedeling.
4	Bronwaterkwaliteit is uitdagend (kan veroorsaak word deur bv. lae pH, verhoogde organiese materiaal, hoë troebelheid, temperatuurvariasies en/of seisoenvariasies).
5	Oorstromings kan lei tot verhoogde oppervlakvloei en afloop.
6	Oorstroming van reservoirs kan lei tot uitloging van swaar metale.
7	Vry-lewende mikro-organismes kan in die watervoorraad beland.
8	Uitgrawing/versteuring van suur sulfaat grond kan lei tot die vorming van swawelsuur wat op sy beurt weer kan lei tot die vrystelling van yster, aluminium en ander swaar metale wat kan migreer na stroomaf-waterliggame.
9	Gesmelte sneeu en fontein-aflope kan lei tot die aanvang van kontaminasie in waterbron.
10	Lughawens, insluitende lughawens wat nie meer gebruik word nie, kan kontaminasie aan watervoorraad/waterliggame veroorsaak. In besonder gesmelte ys wat met chemikalieë besoedel is, brandstof, brandbestrydings-chemikalieë, skuim en historiese besoedelings-insidente moet genotuleer word of in ag geneem word.
11	Kommersiële aktiwiteite soos vulstasie, motor dienstasies, motor wassery en droogskoonmakery se afvalwater kan kontaminante bevat tydens vrystelling.
12	Die gebruik van verwarmingsolie of brandstof vir huishouding, kan die waterbronne bereik deur ‘n lekkasie, veral vanaf ondergrondse opgaartenke.
13	Militêre aktiwiteite, soos die gebruik van ammunisie, brandstofgebruik en storing, instandhouding van wapen en toerusting mag moontlik die gevolg wees tot die besoedeling van drinkwaterbronne.
14	Onwettige storting, rommel en ander puin kan daartoe lei dat vaste afval direk in waterbron beland.
15	Slagpale/abattoirs kan afvalstowwe vrylaat wat hoë organiese materiaal bevat.
16	Akwakultuur-praktyke, veral afvalwater, voerstowwe/voedingstowwe, kan lei tot vrystelling van besoedelde stowwe in die waterbronne. Massiewe visvrektes kan ook lei tot oppervlakwaterbesoedeling.
17	Industriële-aktiwiteite wat die skoonmaak van grond behels, uitgrawing of padonwikkeling, kan lei tot erosie, verhoogde afloop van oppervlakwater en verlies van insitu-filtrasie vermoë.
18	Industriële-afvalwater of slykverwydering kan lei tot die besoedeling van die bronwaters.
19	Instandhoudingsbedryf van skepe soos ontkalking en ontskuimingsproses kan lei tot besoedeling van waterbronne.
20	Verrigting van baggerswerk op waterliggame kan sedimentversteuring teweegbring, asook besmetting van gebiede.
21	Onwettige houtkap kan watervlakke verhoog en erosie laat geskied in opvangsgebied.
22	In onwettige nedersettings of nywerheidsbedrywighede sal daar dikwels nie behandeling van afvalwater wees nie.
23	Paaie en ander geplaveide oppervlaktes kan oppervlakaflope verhoog.

Table A5: Drinking Water Treatment System possible hazards in Afrikaans

Behandelde Drinkwater Risko's	
	Potensiële gevare of gevaarlike gebeure
	Algemeen
1	Die perseel is nie beveilig nie (bv. heinings, hekke, slotte, veiligheids/waarskuwings tekens, onvoldoende veiligheid).
2	Geen dokumente is beskikbaar by die werke (bv. Klassifikasiesertifikate, Watergebruikmagtingssertifikaat).
3	Kwessies van kommer word nie aangespreek nie as gevolg van onvoldoende verslaggewing (bv. wanfunksionering, onvoldoende verslae).
4	Personeel se veiligheid word in gevaar gestel as hulle nie die korrekte PBT (persoonlike beskermende toerusting) het nie.
5	Onveilige chemiese stortingspersele kan gevaar vir die personeel se veiligheid inhou.
6	Indien die behandelingsproses nie optimaal/ten volle funksioneer nie, kan dit lei tot swak watergehalte.
7	Swak gehalte rou/onbehandelde water, kan die behandelingsproses vererger.
8	Onvoldoende vloei kan 'n negatiewe uitwerking hê op die behandelingsproses.
9	Die kapasiteit van die werke voldoen nie aan die waterbehoeftes nie.
10	Swak of onvoldoende boumateriaal vir boukonstruksie kan lei tot mislukte waterbehandeling.
11	Instrumente (bv. telemetrie, SCADA) wat nie in 'n goeie werkende toestand is nie, kan 'n negatiewe effek op die behandelingsproses hê.
12	Ongereelde/oneffektiewe/onvoldoende monitering by moniterings-/kontroleringspunte wat gereeld nagegaan moet word, kan lei tot watergehalte wat nie voldoen aan die standaarde.
13	Kragonderbreking kan lei tot onderbreking van die behandelingseenhede of 'n algehele verlies van die behandelingsproses.
14	Omloop ("by-pass") fasiliteite vir onbehandelde water as gevolg van onvoldoende behandeling/behandeling wat gefaal het.
15	Reservoirs op die perseel kan in gevaar gestel of besmet word.
16	Onvanpaste instandhouding kan lei tot behandeling-mislukking.
17	Natuurlike rampe (bv. storms, aardbewing) kan die behandelingseenheid beskadig.
18	Blokkasies van die skerm as gevolg van verkeerde grootte (skeidingsgrootte) of onvoldoende skoonmaak.
19	Sterk winde en koue weer kan bydra tot die wanfunksionering van die slykversamelaar. Oormatige opbou van slyk/vastestowwe kan ‘n invloed hê op die funksionering van die besinkingstenk/”clarifier” Dit kan lei tot die hersuspensie van die flok.
20	Toegang tot laboratoriumfasiliteite binne 'n geskikte tyd vir die analisering van ‘n monster, is beperk weens die feit dat die gemeenskap afgeleë is.
21	Infrastruktuur (bv. behandelingsaanleg) is oud en meer geneig tot onderbrekings of het herstelwerk nodig.
22	Toegang tot behandelingsisteem of ander infrastrukture is beperk, as gevolg van swak paaie en die swak toeganklikheid daarvan.
23	Onvanpaste of onvoldoende behandelde watermoniteringsdata as gevolg van swak toerusting of 'n gebrek aan kennis of opleiding van die operateur.
	Pre-oksidasie/Voorbelugting
1	Onder/lae dosering van oksidante kan wanfunksionering teweegbring by behandelingswerke soos kragonderbrekings, uitloop van oksidante of verhoogde aanvraag na rou water.
2	Chemikaliese voorraad is op, dus sal effektiewe behandeling ook nie moontlik wees nie.
3	Pre-oksidasie kan veroorsaak dat siano-bakterieë/blou-groen alge (cyanobacteria/blue-green algae) oopbars en gifstowwe vrystel.
4	Behandelingschemikalieë van 'n swak gehalte/nie goedgekeurde behandelingschemikalieë.
	Koagulasie (stolling), flokkulasie en sedimentasie (besinking)

1	Foutiewelike dosering kan lei tot verminderde/verlaagde vlokvorming en dus oneffektiewe verwydering van skadelike mikro-organismes, organiese materiaal, kleur en troebelheid.
2	Onvoldoende voorsiening van die chemikalieë kan die behandeling effektief stop.
3	Drastiese veranderinge in die vloeitempo wat die aansit/afsit van die werke betref, kan koagulasie en flokkulasie benadeel.
	Koagulasie (stolling), flokkulasie en sedimentasie (besinking)
4	Swak kontrole van pH en alkaliniteit kan koagulasie en vlokvorming verlaag.
5	Flokkulasie en partikelverwydering word onvoldoende verwyder indien die chemikalieë nie behoorlik gemeng word nie. Daar is nie genoeg kontaktyd vir vlokvorming nie of onvoldoende stabilisering.
6	Onvoldoende vlokvorming kan toegeskryf word aan wind en/of lae temperature.
7	Koagulasie, flokkulasie en besinking kan benadeel word indien die biofilm-(slymlaag) groei nie beheer word nie.
8	Veranderinge in rou water kwaliteit kan seisoenaal of i.g.v vloede voorkom. As die flokkulasieproses nie aangepas word volgens die rou watergehalte nie, sal dit die waterkwaliteit benadeel.
9	Die gebruik van verkeerde chemikalië kan die proses benadeel en die waterproduk besmet.
10	Chemikaliëe wat gebruik word vir behandelings, is van 'n swak gehalte/nie goedgekeur.
11	Oneweredige verspreiding van borrels as gevolg van klontvorming/"clogging" van die sproeieropeninge kan veroorsaak dat die flok nie goed bind met die borrels nie.
12	As die borrellaag te dun is, kan flokvorming onstaan by die uitlaatpunt. Die belangrikste faktor wat 'n invloed het op die vorming van die borrellaag is lugvorming van die eenheidsvolume van rouwater (lug laai koers). Bedryfstoestande soos die herwinningsvloeitempo en die konsentrasie van die borrelvolume, beïnvloed die luglaaitempo.
13	Oormatige vermenging sou lei tot onvoldoende flokkulasie.
14	pH buite aanvaarbare vlakke kan lei tot onvoldoende flokkulasie. Koagulering/ flokkulasie is oor die algemeen meer doeltreffend by laer pH-vlakke.
15	Onder-dosering (as gevolg van verhoogde aanvraag in rouwater, prosessering is nie optimaal, hoë troebelheid)
16	Oordosering (as gevolg van die afname in die vraag na rouwater, laer troebelheid/"turbidity", die proses is nie geoptimiseer nie)
17	Hoë nitriet/nitraat konsentrasie in die bronwater.
18	Hoë konsentrasie van opgeloste chemikalieë (soos arseen, plaagdoders, fosfate, ander gevaarlike organiese chemikalieë) word nie verwyder nie.
19	Onvoldoende tyd toegelaat tussen filtergebruike (<1 uur of > 48 uur)
	Filtrasie (bv. vinnige, stadige sand, multi-media, MF/UF)
1	Skielike toename in die vloeitempo kan lei tot onvoldoende verwydering van troebelheid (deeltjies) en skadelike mikro-organismes.
2	Hidroliese skok as gevolg van die skielike oop- en toemaak van kleppe kan lei tot onvoldoende verwydering van troebelheid (partikels) en skadelike mikro-organismes.
3	Onvolledige of onvoldoende terugwas (te kort, tempo te laag, lugspoeling onvoldoende of te kort) kan lei tot onvoldoende verwydering van troebelheid (partikels) en skadelike mikro-organismes.
4	Aanskakeling wat te vinnig volg op die terugwas, kan lei tot onvoldoende verwydering van troebelheid (partikels) en skadelike mikro-organismes.
5	Indien die vloeitempo tydens terugwas nie genoegsaam verlaag word, kan dit lei tot onvoldoende verwydering van troebelheid (en partikels) en skadelike mikro-organsimes.
6	Mediaversteuring, kraakvorming of verlies aan filtermedia, kan lei tot onvoldoende verwydering van troebelheid (partikels) en skadelike mikro-organismes.
7	Filtermedia wat verstop is, insluitend modderballe, kan lei tot onvoldoende verwydering van troebelheid (partikels) en ander skadelike mikro-organismes.
8	Vasvang van lugborrels en die vorming van lugbinding kan lei tot onvoldoende verwydering van troebelheid (partikels) en ander skadelike mikro-organismes.

9	Indien slegs een filtrasielyn in plek is, sal dit veroorsaak dat die watertoevoer ontwrig word tydens die onderhoud, skoonmaak of herstel.
10	Gebruik van sand van ‘n swak gehalte kan filtrasieprestasie verlaag.
11	Negatiewe druk in uitlaatpype kan veroorsaak dat eksterne water terug vloei na die filter.
12	Deurbraak van die media as gevolg van hoë verlies of oneweredige mediaplasing, kan ‘n daling in die filter se werksverrigting hê en onvoldoende verwydering van deeltjies veroorsaak.
13	Ongereelde onderhoud van die filter (bv. sandvervanging, die skoonmaak van die spuitpunte wat lug vrylaat, smering, skoonmaak van media, pompinstandhouding)
14	Onvoldoende filtermedia-diepte of tipe van die media is nie geskik vir die gehalte van water wat filtreer word en die lae vloeitempo nie.
15	Geen alternatiewe ontsmettingsbehandeling is toegepas tydens die filter se rypwordingsperiode (2 weke tot 30 dae na die opbouing of die skoonmaak van die filter).
	Filtrasie (bv. vinnige, stadige sand, multi-media, MF/UF)
16	Korrosie van die metaalverspreiderplaat kan lei tot groot gate in die plaat, gebrekkige funksionering van die verspreiderplaat veroorsaak steurnisse of nie-eweredige verspreiding van sand onder die plaat, versteuring van die biolaag; kan lei tot ‘n kortsluiting van die filter.
17	Sandvlak wat te hoog of te laag is, voorkom biolaag vorming.
18	Filter uitdroog (totale filter of die boonste sand laag). Krake in die betonstruktuur waar dit opgevul was, kan lei tot lekkasies wat ook die filter laat uitdroog en die biolaag laat afsterf.
19	Hoë troebelheid van die bronwater (of opbou/aangroei met verloop van tyd) kan die filter verstop, wat lei tot ‘n afname in vloeitempo deur die filter.
20	Filteronderbreking (nie genoeg kontaktyd vir behandeling/verwydering van chemikalieë).
21	Hoë troebelheid van die bronwater (of opbou/aangroei met verloop van tyd) kan die filter verstop, wat lei tot ‘n afname in vloeitempo deur die filter.
22	Opening wat ontstaan in die skerm, veroorsaak onvoldoende verwydering van groot deeltjies/opdrifsels.
23	Growwe skeiding word op sigself gebruik met geen ander vorm van behandeling.
24	Chlorinering wat vooraf plaasvind by stadige sandfilter kan die biolaag vernietig.
25	Onvoldoende verwydering van vooraf bepaalde kontaminante
26	Gebruik van swak gehalte mediafilter kan die filter se werkverrigting verminder.
	Geaktiveerde Koolstof (poeier/granulêr)
1	Swak bedryf kan lei tot onvoldoende verwydering van toksiene/gifstowwe wat veroorsaak word deur sianobakteriële (blou-groen alge).
2	Swak bedryf kan lei tot die onvoldoende verwydering van smaak en kleurverbindings (geosmin en MIB).
3	Swak bedryf kan lei tot onvoldoende verwydering van onkruiddoders en organiese verbindings.
4	Swak bedryf kan lei tot onvoldoende verwydering van natuurlike organiese materie, en toename in troebelheid.
5	Ontwerptekortkominge (bv. onvoldoende kontaktyd) kan lei tot onvoldoende verwydering van kontaminante wat geteiken word.
6	Onvoldoende instandhouding kan lei tot 'n toename in druk verlies en afname in produksie kapasiteit.
7	Onvoldoende terugwas/instandhouding kan lei tot 'n toename in biologiese groei in die filters en swak watergehalte.
8	Ontsnap van geaktiveerde koolstof van water wat behandel was as gevolg van versuiming of onvoldoende koolstofbergingstoestelle.
9	Onvoldoende produksiekapasiteit as gevolg van verhoogte drukverlies.
10	Oordosering van fluoried soute/chemikalieë.
11	Verkeerde aanpassing van pH as gevolg van toerusting wat wanfunksioneer of foutief is, operateursfout of veranderinge in die kwaliteit van die rouwater.

12	Hoë troebelheid van die bronwater (of opbouing/aangroei met verloop van tyd) kan die hars of filter verstop, dit lei tot afname in vloeitempo. Organiese materiaal wat aanpak op die hars kan ondersteunend wees vir die groei van mikro-organismes, wat die doeltreffendheid van die behandeling kan verlaag.
13	Voldoende behandeling is nie in plek.
	Chlorinering (insluitend sekondêre chlorinering)
1	Wanfunksionele dosering as gevolg van toerusting wat faal of 'n kragonderbreking. Moontlike onderbrekings in die chlorinering (onderdosering van chloor of oordosering van chloor).
2	Onvoldoende voorraad in ontsmetting chemikalieë.
3	Onderdosering van chloor mag plaasvind a.g.v toename in die chlooraanvraag van die onbehandelde water of toename in vloeitempo. Veranderings in waterkwaliteit kan seisoenaal voorkom of i.g.v. vloede
4	Oordosering van chloor mag voorkom as gevolg van 'n afname in die chloor aanvraag van die onbehandelde water of afname in watertempos.
5	Lae vrye chloorvlakke in die verspreidingstelsel verminder die beskerming teen fekale besmetting en vry lewende organismes.
6	Chemikalieë wat gebruik word vir behandeling is van swak gehalte/of is nie goedgekeur nie.
7	Chlorineringfasiliteite wat nie voldoen aan die veiligheidsregulasies, kan lei tot chloorgaslekkasie.
	Osonering
1	Onvoldoende voorbehandeling mag lei tot partikels in die water en water wat nie effektief ontsmet is nie.
2	Osonering mag onderbreek word as gevolg toerusting wat wanfunksioneer, uitputting of kragonderbrekings (bv. lugkompressor wat faal, suurstoftoevoer wat faal, osoon kragopwekker wat faal).
3	Gasmeter wat faal of nie korrek gekalibreer is nie, of opgeloste osoon meter, kan lei tot 'n te lae osoon dosering.
4	Toename in die watervloei, kan lei tot onderdosering (onvoldoende kontaktyd).
5	n Hoë pH (>8) of hoë troebelheid kan lei tot onderdosering.
6	Bromied mag dalk in die onbehandelde water teenwoordig wees.
	Ultraviolet Bestraling
1	Onvoldoende voorbehandeling mag lei tot partikels in die water en oneffektiewe ontsmetting.
2	Inkorrekte doseringpunte, kan aanleding gee tot 'n te kort tyd vir disinfektering.
3	Ontsmetting mag onderbreek word deur wanfunksionele toerusting, verouderde toerusting of 'n kragonderbreking.
4	Onvoldoende bestraling (ontsmetting) mag voorkom as gevolg van 'n toename in troebelheid of kleur in die onbehandelde water (of toename in vloeitempo).
5	Onbehoorlike onderhoud, soos om nie lampe te vervang of om nie sediment van die kwartsbuis te verwyder, kan die leeftyd van die lamp verminder en die lamp sal nie ‘n doeltreffende waterbehandel kan verrig. Toerusting wat wanfunksioneer. Installering van verkeerde lampe of die gebruik van lampe met verkeerde spesifikasies kan lei tot onvoldoende bestraling.
	Versagting
1	Water wat sag is kan korrosief wees en kan chemikalieë uit die pype loog.
2	Versagting van baie harde water deur die gebruik van ioonuitruiling, kan lei tot 'n toename in die natrium (Na) konsentrasie in die water.
3	Organiese materiaal mag ophoop in die hars ("resins") en kan mikrobiese groei bevorder.
4	Die verkeerde dosering van kalk vir versagting of swak pH beheer kan die effektiwiteit van die proses, sowel as ander behandelingsprosesse negatief beinvloed.
5	Waar kalk gebruik word vir versagting, kan die chemikalieë vir behandlingsdoeleindes van swak gehalte wees.
6	Indien nano-filtrasie membrane (NF membrane) gebruik word en onvoldoende voorsiening van elektrisiteit bestaan, kan die proses nie funksioneer nie.
7	Indien nano-filtrasie membrane gebruik word en die nodige vaardighede bestaan nie, kan die stelsel faal.

8	Bronwater is baie hard (>200 mg kalsiumkarbonaat).
	Stabilisering
1	Ongestabiliseerde water kan korrosief wees en chemikalieë kan uit die pype loop.
2	Waar kalk gebruik word vir stabilisering maar verkeerdelik gedoseer word of swak pH beheer/gebrek aan CO_2, kan dit die effektiwiteit van die proses verlaag.
3	Waar kalk gebruik word vir stabilisering, kan die behandelingschemikalieë van 'n swak gehalte wees.
4	Waar kalk gebruik word vir stabilisering, maar instandhouding nie voldoende is nie (bv. onreëlmatige aanvulling of spoeling van die kalkbed), kan dit lei tot gebrekkige/onvoldoende behandeling.
5	Bronwater is baie sag (0 mg kalsiumkarbonaat).
	Membraanfiltrasie
1	Indien membrane nie korrek bedryf en onderhou word nie (m.a.w wisselvallige hidroliese stres, onvoldoende voorbehandeling, swak skoonmaak), kan die stelsel faal.
2	Indien daar van membrane gebruik gemaak word, maar die nodige vaardighede bestaan nie, kan die stelsel faal.
3	Indien membrane gebruik word , maar die nodige onderdele/bystandtoerusting bestaan nie, kan die stelsel faal.
4	Chemikalieë wat gebruik word om die membraan skoon te maak, kan van 'n swak gehalte of verkeerd wees, as gevolg van onbehoorlike berging of hantering, mis-etikettering, probleme tydens die produksie, vervoer of aflewering, of gebruik van chemikalieë waarvan die vervaldatum verstryk het.
5	Onvoldoende verwydering van chemikalieë waarmee die membraan skoongemaak word, tydens instandhouding en voor die membraan weer in werking gestel word.
6	Membraan of hars deurbraak, skade of mislukking (breke of lekkasies) as gevolg van vervaardigingstekortkominge, versuim om die water vooraf te behandel, versuim om vooraf oksidante te verwyder, gebrek aan onderhoud of bedryfsfoute (bv. druk van die terugslag is te hoog).
7	Ongunstige/oormatige biologiese aktiwiteit in filter potensieel as gevolg van: afname in pH, hoë watertemperatuur, oneffektiewe terugspoelprotokol, langdurige nat berging van koolstof voor gebruik, te lae snelheid van stagnante water, kwaliteit van die invloeiende water, ('n) aërobiese toestand.
	Ontsouting
1	Indien tru-osmose membrane gebruik word, maar elektrisiteitvoorsiening is nie betroubaar nie, kan die proses faal.
2	Indien tru-osmose membrane gebruik word, maar die nodige vaardighede bestaan nie, kan die stelsel faal.
3	Indien tru-osmose membrane gebruik word, maar die nodige onderdele/bystandstoerusting is nie beskikbaar nie, kan die stelsel faal.
	Ioonuitruiling
1	Gebruikte media/hars word verwyder op 'n gepaste wyse.
2	Ontkiemingschemikalieë kan van 'n swak gehalte wees of verkeerde chemikalieë kan gebruik word as gevolg van onbehoorlike berging of hantering, verkeerde etikettering, probleme tydens produksie, vervoer of aflewering, of gebruik van vervalde/verouderde chemikalieë.
3	Onvoldoende chemiese aanbod (ontkiemingschemikalieë) as gevolg van faktore soos aanvraag/aankope, aflewering is laat, te min van die produk, vervoer of vertragings by verskaffer of kosteverhogings.
4	Versadigde filtermedia as gevolg van onvoldoende onderhoud/hergroeiing.
5	pH buite die aanvaarbare vlakke tydens behandeling (pH te hoog of te laag kan tot gevolg hê dat behandeling nie doeltreffend kan wees nie - kan afhang of die onsuiwerhede verwyder word).
6	Filtermedia is verminder tydens ontkiemingsfase wat lei tot vermindering in bedvolume en ‘n verkorte filterlooptyd gedurende die ontkiemingfase.
7	Vloeitempo is nie reg in reaksie op veranderinge tot die bron se waterkwaliteit nie.

8	Nie genoegsame toevoer van suurstof as gevolg van toerusting wat nie reg funksioneer (bv. pompe-/blasers-onderbrekings) of onvoldoende roer/skud (op huishoudelike vlak/klein skaal) sal lei tot lugtekort.
9	Geen daaropvolgende sedimentasie-/filtrasie-stadium is verskaf vir die belugte water (met yste(Fe) of mangaan (Mn) nie.
10	Geen opvolg ontsmettingsbehandeling word verskaf vir die belugte water nie.
11	Ioonuitruilingshars word versadig weens die gebrek aan onderhoud/herontkieming ‘n oneffektiewe behandelingsproses tot gevolg.
	Ontsmetting
1	Wanneer geoksideerde chemikalieë gebruik word met rouwater van‘n hoë konsentrasie organiese materiaal (en ander ontsmettingsbyprodukvoorgangers), kan ontsmettingsbyprodukte gevorm word.
2	Gebruik van chemikalieë waarvan die vervaldatum verstrek het.
3	Verkeerde pH vir chlorinering kan lei tot onvoldoende ontsmetting.
4	Te lae dosering as gevolg van toerusting wat wanfunksioneer, verhoogde aanvraag na rouwater, verhoogde vloei, operateursfout, verlies van chemikalieë-toedienning of verlies van krag kan lei tot onvoldoende ontsmetting. Van die residue beland in die verspreidingsnetwerk.
	Huishoudelike Behandeling
1	Gate vorm in die materiaal as die materiaal groot weefsels het of nie voldoende gevou is, wat mag lei tot onvoldoende verwydering van groot deeltjies.
2	Vuil of nie was van die materiaal tussen bedryfsperiodes van die bronwater, kan potensiële besmetting teweegbring met die volgende bedryfsperiodes.
3	Doeksifting word gebruik met geen ander vorm van behandeling.
4	Filter raak verstop as gevolg van aanpaksels van materiaal in en op die oppervlak van die filterelement (as gevolg van hoë troebel water of 'n gebrek aan onderhoud) wat kan veroorsaak dat die vloeitempo afneem. Verhoogde troebelheid en natuurlike organiese materiaal, kan ook die sortering belemmer by sorteringsterreine (bv. ysteroksihidroksiede) of silwer wat aangewend word by die filterelement.
5	Veroudering of agteruitgang van die keramiekelement kan lei tot ‘n afname in die behandelingskapasiteit. Gate of krake in die keramiekelement kan daartoe lei dat deeltjies/troebelheid deur die filter beweeg.
6	As skuurmateriale gebruik word tydens die skoonmaak van die keramiekelement, kon die bedekte silwerlaag verwyder word, dit veroorsaak verlaagde behandelingsvermoë of verkort die leeftyd van die element en die filter.
7	Ope houers kan besmet word deur lugkontaminante of broeiplekke word vir insekte (bv. muskiete). Voorts kan direkte besoedeling en vreemde materiaal ook lei tot hoë chlooraanvraag en minder beskerming teen siekte wat veroorsaak word deur mikroörganismes.
8	Metalhouers wat gebruik word as bergingsplek kan korrodeer/roes en metale laat uitloog in die watervoorraad.
9	Houers word blootgestel aan onhigiëniese toestande, bv. afval/afloop van die toilette, toegang deur diere, ens.
	Sonkrag
1	Bottels word nie blootgestel vir genoegsame tyd aan volle sonlig (6 uur). Die daling in sonbestraling, as gevolg van wolke/verandering in die weer lei tot onvoldoende ontsmetting.
2	Plastiek/glasbottels of sakke is geskraap en is dus minder ligdeurlatend of bottels kan baie vuil wees.
3	Bronwater het 'n hoë troebelheid of kleurvlak.
4	Mikrobiese heraktivering en teruggroei gedurende berging.

Table A6: Drinking Water Network possible hazards in Afrikaans

Verspreidingsnetwork	
	Potensiële gevare of gevaarlike gebeure
	Beskermende Diensreservoir (Bedekte opgaartenk)
1	Diere/voëls kan deur strukturele foute (bv. krake in die dak, mure of vloer) dring en kan die water besmet met hulle mis. Indien 'n dier verdrink, sal daar 'n hoë vlak van skadelike mikro-organismes teenwoordig wees.
2	Diere-/voël mis wat meng met die reënwater kan in die opgaartenke beland deur foute in die dak van die opgaartenk of van interne dreineringsdakke.
3	Ongemagtigde toegang, bv. mense wat swem in die opgaartenke, kan lei tot mikrobiese besmetting.
4	Oormatige druk wat opbou kan lei tot strukturele skade aan die reservoir.
5	Hoë chloorvlakke mag die verspreidingsnetwerk binnegaan indien daar swak vermengings is na die ontsmetting van stoortenke/reservoirs.
6	Hersuspensie van sediment (neerslae) wat slym en reukproduserende mikro-organismes bevat, mag voorkom.
7	Kwaliteit van die water kan verswak as gevolg van lae watergebruik of van onegalige hidroliese vermenging, ens.
8	Swak higiëne gedurende reservoirkonstruksie/herstelling/skoonmaak kan die voorsiening van water besmet.
9	Natuurlike rampe (bv. storms, aardbewings, vloede) mag die reservoir beskadig of vernietig wat kan lei tot besmette water/of geen watertoevoer.
10	Mensgemaakte insidente (bv. swaarvoertuigongeluk) mag die reservoir beskadig of verwoes wat kan lei tot besmette of geen watertoevoer.
11	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.
12	Swak monitering kan lei tot besmette of geen watertoevoer (bv. telemetrie kan faal, geen water monitering om die gehalte te bepaal).
	Onbeskermde Diensreservoir (ope opgaartenk)
1	Diere/voëls kan deur strukturele foute (bv. krake in die dak, mure of vloer) dring en kan die water besmet met hulle mis. Indien 'n dier verdrink, sal daar 'n hoë vlak van skadelike mikro-organismes teenwoordig wees.
2	Diere-/voëlmis wat meng met die reënwater kan in die stoortenke beland deur foute in die dak van die reservoir of van interne dreineringsdakke.
3	Groei van siano-bakterieë("cyanobacteria/blue-green algae") kan 'n probleem wees indien die stoortenke blootgestel word aan sonlig.
4	Spuitmiddels soos plaagdoders, landbouchemikalieë ens. van naburige boerderyaktiwiteite kan in stoordamme/reservoirs beland as gevolg van windverspreiding. Vuil stof van puinhope kan ook in stoordamme/reservoirs beland as gevolg van windverspreiding.
5	Veldbrande mag lei tot brandvertragers en groot hoeveelhede as wat in die stoordamme/reservoirs kan beland.
6	Ongemagtigde toegang, bv. mense wat swem in die stoordamme, kan lei tot mikrobiese besmetting.
7	Hoë chloorvlakke mag die verspreidingsnetwerk binnegaan, indien daar swak vermenging is na die ontsmetting van reservoirs.
8	Hersuspensie van sediment (neerslae) wat slym en reukproduserende mikro-organismes bevat, mag voorkom.
9	Kwaliteit van die water kan verswak as gevolg van lae watergebruik of van oneweredige hidroliese vermengning, ens.
10	Swak higiënie gedurende reservoir konstruksie/herstelling/skoonmaak kan die watervoorsiening besmet.

11	Natuurlike rampe (bv. storms, aardbewings, vloede) mag die reservoir beskadig of vernietig wat kan lei in besmette water/of geen water toevoer.
12	Mensgemaakte insidente (bv. trokongeluk) mag die reservoir beskadig of verwoes wat kan lei tot besmette/of geen watertoevoer.
13	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.
14	Swak monitering kan lei tot besmette/of geen watertoevoer (bv. telemetrie wat faal, geen watergehaltemonitering).
15	Ope tenks kan dien as broeiplekke vir muskiete of ander insekte.
16	Swak toestand van tenke, deksels, lekkasies en krake kan lei tot besoedeling.
17	Stoor- en netwerkstelsels is nie ontwerp vir die toepaslike waterkapasiteit wat nodig is vir die gemeenskap nie. Oorontwerp kan lei tot waterveroudering en verlies van oorstaande water. Onderontwerp kan lei tot onvoldoende watervoorsiening.
18	Staaltenke wat korrodeer kan roes veroorsaak in die watervoorraad en lei tot krake/lekkasies in of skade aan die struktuur.
	Pompstasie
1	Pompe wat faal (bv. pompwanfunksionering, inkorrekte verstellings) mag lei tot lae vloei/geen watertoevoer.
2	Natuurlike rampe (bv. storms, aardbewings, vloede) mag die pompstasie beskadig of vernietig wat kan lei tot besmette water/of geen water toevoer.
3	Mensgemaakte insidente (bv. swaar voertuigongeluk) mag die reservoir beskadig of verwoes wat kan lei tot besmette of geen watertoevoer.
4	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.
5	Swak higiëne tydens pompinstallasie, instandhouding of herstel kan die watervoorraad besoedel.
6	Swak monitering kan lei tot besmette of geen watertoevoer (bv. telemetrie kan faal, geen water monitering om die gehalte te bepaal).
	Kleppe en Meters
1	Kleppe of meter wat misluk (bv. slyt van meganiese dele, kragonderbreking, verkeerde verstellings) kan lei tot 'n lae vloei / geen watervoorsiening.
2	Swak higiëne tydens klep / meter aanleg, onderhoud of herstel kan die watervoorraad besoedel.
3	Swak druk bestuur (bv. wanfunksionering / mislukking van drukvermindering by kleppe) kan lei tot oormatige druk in die netwerk en die resultaat is dat kleppe beskadig of water gemors word, ens.
5	Pompafsluiting of klepsluiting wat per ongeluk plaasvind, kan lei tot oorgansdruk of “water hammer” wat weer tot gevolg kan hê tot vervelling/losraak van biofilms, loskom van afsaksels of pypbarste.
6	Oorstromings lei tot besoedeling van water wat moontlik toegang kon hê deur bogrondse brandkrane of lugkleppe.
7	Terugvloeiing van nie-drinkbare / besoedelde water (van onwettige aansluitings of huishoudelike loodgieterswerk) kan voorkom as gevolg van afwesigheid van ondoeltreffend nagaan-kleppe of by tye wanneer negatiewe druk voorkom. Kruisverbindinge tussen drinkbare- en nie-drinkbare waterstelsels (bv. brandbestrydingsprinkelstelsels, warmwaterstelsels, rioolstelsel) kan ook lei tot die besoedeling van drinkwater.
8	Oorstromings, staande water naby krane of onhigiëniese toestande as gevolg van onbehoorlike konstruksie (geen / onvoldoende voorskoot, geut / dreinering).
9	Storms, natuurrampe of ongelukke lei tot skade aan toerusting of infrastruktuur.
10	Onvanpaste materiale en bedekkings, kan kontaminante veroorsaak en mikrobiese groei ondersteun.
11	Lae vloei / stagnante water of aggressiewe bronwater (lae pH, hoë soutgehalte, lae alkaliniteit) loging/uitsaksels wat ontstaan by die soldeersel, koper aansluitings, gegalvaniseerde tenke of pype, lood pype kan kontaminante / besoedeling veroorsaak.

12	Operasionele foute (bv. onbehoorlike / oormatige druk, 'n gebrek aan inststandhouding) en eksterne spanning (bv. vries/ontdooiing, verkeersgewig, indringende boomwortels) kan lei tot pypbarste, breke of lekkasies sowel as skade aan tenke en reservoirs.
13	n' Gebrek aan instandhouding, stilstaande water of verhoogde ystervlakke kan lei tot die opbouing van slyk, sedimente, slyk- en slym-/ biofilmlaag.
14	Kleppe of koppelinge wat onbehoorlik verseël is of lek, kan lei tot indringing van patogene/kieme en die verlies van die aanbod.
	Verspreidingstelsels
1	Oormatige druk opbouing kan lei tot skade aan die struktuur van die reservoir.
2	Pyp barste en lekke kan die watertoevoer onderbreek. Kontaminasie kan plaasvind waar waterpype onder of naby stormwater-of rioolpype of in 'n gebied met septiese tenke is, dit kan lei tot mikro-organiese en chemiese kontaminasie. Grond wat in die pype beland kan troebelheid verhoog.
3	Mikrobiese of chemiese kontaminante kan die watertoevoerstelsel binnedring deur middel van kruisverbindings, ongemagtigde aansluitings of water wat terugvloei (bv. drukskommelinge, onderbroke toevoer).
4	Swak higiëne tydens klep / meter aanleg, onderhoud of herstel kan die watervoorraad besoedel.
5	Tydens die herstel en instandhouding van pype kan grond in die pype beland wat troebelheid en besoedeling in die water kan verhoog.
6	Onvoldoende ontsmetting of spoel voor die ingebruikneming van nuwe hoofwaterlyne kan chemiese en mikrobiese besoedeling tot gevolg hê. Die teenwoordigheid van grond kan troebelheid verhoog.
7	Besoedelde water kan tot die stelsel binnedring tydens oorstromings, veral deur middel van bogrondse brandkrane (hydrants) en lugkleppe. Mikrobiese en chemiese kontaminasie is moontlik en die teenwoordigheid van grond kan troebelheid verhoog.
8	Hoe temperature (bv. 25-30ºC) op die lang duur, kan die bogrondse pypleidingsgroei van sommige organisme ondersteun.
9	Loging (lekkasies) van sementpype, veral gedurende periodes van lae vloei, kan 'n hoë pH veroorsaak.
10	Verandering in die vloei of verhoogde konsentrasies van ontsmettingsmiddel kan modderighieid (“slouch”) en die herverspreiding van die biofilm in die stelsel veroorsaak.
11	Oop en toemaak van kleppe/verandering van vloei in die stelsel, versteur die deposito/biofilm en bring ou water navore wat in die stelsel is.
12	Derdepartytoegang tot brandkrane, veroorsaak kontaminasie as gevolg van terugvloei (“backflow”), verhoog dan verder die neerslae wat in ‘n rustende vorm was.
13	Hooflyne by doodloop ("dead-end") wat lae watervloei het, kan die stilstaande water stagneer by die einde van die lyn en dit veroorsaak 'n verlies van oorblywende vry chloor.
14	Verkeerde bedekkingslae ("coatings") en materiaal kan chemikalieë laat uitloog of bakteriële groei bevorder.
15	Verlies van pyp hidroliese kapasiteit as gevolg van laagvorming ("scaling") kan lei tot verlaagde/onvoldoende of geen watertoevoer.
16	Oor/onder-dosering van chloor by die chloor verhogingstasie("Chlorine Booster Station").
17	'n Gebrek aan veiligheidsmaatreëls by die chloor-verhogingstasie kan lei tot gevaarlike omstandighede/praktyke.
18	Vandalisme of sabotasie kan die water besoedel met chemikalieë of mikro-organismes of kan toerusting en infrastruktuur beskadig.
19	Swak druk bestuur (bv. wanfunksionering / mislukking van drukvermindering by kleppe) kan lei tot oormatige druk in die netwerk en die resultaat is dat kleppe beskadig of water gemors word, ens.
20	Swak monitering kan lei tot besmette of geen watertoevoer (bv. telemetrie kan faal, geen water monitering om die gehalte te bepaal).
21	Tussenpose voorsien van water deur pypleiding, kan lei tot 'n gebrek aan druk vir lang periodes of ‘n lae druk (weens te hoë aanvraag) kan lei tot indringing.

22	Tussenpose voorsien van lopende water deur pypleiding, kan lei tot gereelde snelheidsverander, verhoog die risiko's van skuur en vervelling/losraak van die biofilms en sedimente/afsak van deeltjies.
23	Waar lopende water met tussenpose voorsien deur ‘n pypleiding, kan verbruikers pompe gebruik om water uit te trek wanneer die verskaffer nie water verskaf nie. Dit skep 'n negatiewe druk en lei tot indringing deur ander partye.
24	Waar tussenpose voorsien van lopende water deur pypleiding, kan verbruikers oorskakel na ‘n bron van 'n laer gehalte of kan ‘n oneweredige voorsiening van die aanbod ervaar word.
25	Onvoldoende ontsmetting of spoel voor die ingebruikneming van nuwe hoofleiding/pypleiding of na herstel en onderhoudsaktiwiteite. Kontaminasie/besoedeling kan voorkom as gevolg van menslike toegang en/of onhigiëniese toestande gedurende die herstel en onderhoudsaktiwiteite.
26	Warm omgewingstemperature, verwarming van pype en hitte-oordrag van nabygeleë voorwerpe / omgewings kan lei tot hoë water temperature (bv. 25-30ºC+) wat die bevordering van groei / ontstaan van sekere mikro-organismes. Warm temperature sal ook lei tot vinniger opgebruik van die chloor residu.
27	Onbehoorlike installering van pype, toebehore, kleppe en ander komponente kan lei tot lekkasies en indringing. Onwettige konneksies kan ook lei tot lekkasies en indringing.
28	Organiese-besoedelingstowwe in die grond kan loog deur die rubber aanhegtings/verbindinge van pype of deur die pypwande van poliëtileen of PVC pype.
29	Lae vloei / stagnante/staande water of aggressiewe bronwater (lae pH, hoë soutgehalte, lae alkaliniteit) kan loging van plastiek / PVC pype en tenks veroorsaak.
30	Infrastruktuur (bv. reservoir, verspreidings-/netwerkpype) is oud en meer geneig om te breek of benodig herstelwerk.
31	Toegang tot reservoirs, pype of ander dele van die infrastruktuur is beperk as gevolg van swak paaie, swak toegang.
32	Ongepaste of onvoldoende netwerkmoniteringsdata as gevolg van mislukte toerusting of 'n gebrek aan kennis of opleiding van die operateur/moniteerder.
	Huishoudelike Aansluiting
1	Huishoudelike loodgieterswerk kan (i) chemikalieë uitloog wat ‘n invloed op die gesondheid of smake en reuke mag hê, (ii) mikrobiese groei wat ook smake en reuke kan veroorsaak bevorder.
2	Huishoudelike loodgieterswerk kan roes as gevolg van verkeerde installasie of die reaksie van watervoorsiening op waterpyponderdele (“fittings”) veroorsaak.
3	Terugvloeiing deur toestelle van huishoudelike loodgieterswerk of water stoortenke (bv. reënwatertenke, swembaddens, tuinpoele) kan die drinkwaterstelsel besoedel.
4	Water word oorgedra / onttrek / verskaf met vuil instumente (bv. emmers, koppies, gietpanne), vuil krane of hande.
	Gemeenskapstaanpype
1	Swak toegang tot staanpyp lei tot nie beskikbaarheid van water / onderbreking van watervoorsien.
2	Terugwas van tenkers wat staanpype verbind kan lei tot mikrobiese en chemiese besmetting van die water.
3	Water wat naby toegangpunte staan kan voëls en diere lok. Dit kan lei tot bekommernisse oor moontlike siektes wat kan uitbreek.
4	Skade/vandalisme by die vulpunt kan waterverskaffing/verspreiding onderbreek en is kwesbaar vir besmetting.
5	Houers wat gebruik word om die water te versamel en te vervoer mag besmet wees.
6	Chemiese storting (bv. petrol/skoonmaakmiddels wat lek van houers) in die omgewing van die staanpyp kan besmetting veroorsaak.
	Reënwateropvangs
1	Verfdak bevat chemiese besmettingsprodukte.
2	Blare (loof) wat versamel oor/langs geute en dakke.
3	Voël/diere mis wat die water besoedel.
4	Eerste wegspoel van water kan die stoortenk binnegaan.

	Huishoudelike behandeling en bewaring
1	Chloor onderdosering.
2	Chloor oordosering.
3	Besmetting van water a.g.v. inkorrekte/verkeerdelike gebruik van 'n kraanfilter.
4	Besmetting van water a.g.v. berging (stoor) in oop houers waar voëls/diere/stof/ maklike toegang het.
5	Besmetting van water a.g.v. onhigiëniese praktyke wanneer water van die stoortenk/houer gehanteer/getrek word.
6	Besmetting van water a.g.v. die gebruik van verkeerde houers (bv. metaaldromme) sowel as houers wat nie onderhou word in 'n skoon kondisie nie.
	Watervoertuig aflewering
1	Besmetting van water a.g.v storing in 'n tenkwa wat nie skoongemaak is van die vorige gebruik of nie ontsmet was nie.
2	Water kan besoedel word tydens die volmaak en verskaf van water deur die watervoertuig, as gevolg van vuil waterpype, toebehore of vulpunte. Lekke in pype, toebehore of tenke van ‘n wa, kan ook besoedeling word.
3	Die water van ‘n bron waarmee die vragmotor gevul word, mag nie geskik wees om gedrink te word.
4	Die tenkwa mag nie geskik wees vir die gebruik vir drinkwater, bv. tenkwa kon gebruik gewees het vir ander vloeistowwe, wat die tenk chemikalies kon besoedel het of vir menslike afval.
	Verbruikers
1	Onvoldoende watervoorsien vir die industrieë/nywerhede, dwing die industrieë tot waterbeperking of om produksie te stop.
2	Wateraanvraag deur nywerhede of landbou-bedrywighede bedreig kontinuïteit van aanbod vir die verbruik en higiëne van die huishoudelike verbruikers.
3	‘n Hoë, permanente bevolking kan lei tot aanvraag na water en dat die behandelingskapasiteit oorskry word.
4	Waar die aanvraag na water die behandelingskapasiteit oorskry, kan die kwaliteit van die water verlaag.
5	Nie genoeg water beskikbaar vir die verhoogde aanvraag van ‘n verbygaande/tydelike bevolkings nie.
6	Verhoogde gebruik van water en vloei, kan pype skuur en lei na uitlating van water.
7	Babas wat met bottel gevoed word (veral dié onder die ouderdom van 3 maande) is vatbaar vir verhoogde vlakke van nitrate.
8	Sommige mense is meer geneig om infeksies te kry as daar probleme is met watervoorsiening (kinders <6 maande, oumense, hospitaal pasiënte, persone met kanker, chroniese siekte, orgaanoorplantings, VIGS, of ander toestande van kompromie aangaan tot die immuniteitstelsel).
9	Renale dialise / nierdialise pasiënte is hoë-risiko pasiënte weens ter plaatse behandeling, omdat diegene sensitief is vir die verandering in water kwaliteite.
10	Die onttrek van water vir verskeie gebruike (industriële, drink, landbou) kan lei tot oorontginning en benutting van water.
11	Beperkte of geen toegang tot goeie gehalte waterbronne en onvoldoende kennis van / of toegang tot huishoudelike behandeling.

Table A7: Source Water possible hazards in Zulu

Ukuhlolwa Kwamathuba Okungcoliseka Kwemithombo Yamanzi	
	Izingozi Ezingaba Khona Noma Izenzakalo Eziyingozi
	Amanzi afumaneka ngaphezu komhlaba (Imifula nemifudlana)
1	Imfuyo, imisebenzi eyenziwa ngabantu emthonjeni wamanzi.
2	Amanzi adungekile ngemva kwezimvula ezinamandla. Angase abe nobulongwe bezilwane nemisimba yezinyoni.
3	Izilwane ezifele emanzini zingase ziwangcolise noma zingafaka amagciwane emanzini.
4	Indle yezilwane/izinyoni ingafaka emanzini amagciwane angabonakali ayingozi.
5	Ukugeleza kancane, amazinga aphakeme ama-nutrient nezimo ezifudumele - kungenza ukuthi kucishe kuvame impela ukukhula kwama-cynobacteria nama-alga.
6	Amazinga ehlile amanzi ngenxa yesomiso noma ukugeleza komfula wamanzi.
7	Ukucekelwa phansi kwempahla noma ukonakaliswa kwayo kungase kungcolise amanzi ngamakhemikhali noma ngamagciwane noma konakalise imishini nengqalasizinda.
8	Izisefo amanzi angena ngazo ziyavimbeka noma zilimale.
9	Imililo yasemahlathini ingagcina isifinyelele kwizivimbeli mililo emthonjeni wamanzi. Ukungabi khona kwezitshalo kungabangela ukudungeka kwamanzi nezintwanyana eziphilayo eziyingozi.
10	Imfucumfucu yasekhaya (amanzi angcolile, amathange endle asesizeni, udoti, udoti ochithwe ngumasipala, nokunye) kungawangcolisa amanzi.
11	Imisebenzi eyenziwa ngabezimboni nabezolimo ingawangcolisa amanzi (isib. izinto ezincanyana eziphilayo, amakhemikhali awushevu, izinto ezikhishwa umoya, ukungcoliswa komoya, ukusakazeka komquba ezweni, ukumuka kokudla kwemfuyo namanzi, nokunye).
12	Ukukhishwa kwamagesi ezingozini zasezimbonini noma imililo yamahlathi kungawangcolisa amanzi (isib. ukuqhuma, imililo, nokunye).
13	izingozi zemigwaqo zingaholela ekuchithekeni kukashevu noma amanye amakhemikhali, izinto eziyingozi, nokunye.
14	Amapayipi avuzayo angase angcolise izindawo ezigcine amanzi ngezintwanyana noma amakhemikhali ayingozi.
15	Ukuzamazama komhlaba, ukubhidlika kwenhlabathi kungangcolisa imithombo.
16	Ukungena kwamanzi anosawoti (isib. avela olwandle) kungangcolisa imithombo yamanzi ahlanzekile.
17	Amanzi emvula angcolile angawonakalisa umthombo.
18	Ingozi, ukulimala kwemishini, ukucisha kukagesi, ukonakaliswa kwempahla, ukucekelwa phansi kwempahla, nokunye kungaholela ekuhlulekeni komthombo olawula isistimu.
19	Ukuhlukaniseka kwamanzi ngezigaba (stratification) okubangelwa ukushintsha kwezinga lokushisa, ukugeleza kwamanzi kancane kanye nezinye izinguquko ezenzeka zangezinkathi ezithile zonyaka kungaholela ezingeni eliphansi lomoya mpilo emazingeni aphansi. Emanzini angaphezu komhlaba, lokhu kungenzeka kuphela emachibini amakhulu.
20	Ikhwalithi yamanzi omthombo iyikhwalithi ebekela inselele (isib. i-pH ephansi, ama-organics aphakeme, ukudungeka kwamanzi okuphakeme, amazinga okushisa ashintshashintshayo) kanye/noma njalo ngezikhathi ezithile zonyaka.
21	Amagciwane angabonakali aziphilela ngaphandle kokumunca igazi angagcina esengene emanzini.
22	Izimo zendawo ezingokwemvelo zingaholela ekubeni khona kwamakhemikhali abangela ukukhathazeka ngokusebenza nokuhlanzeka kokuphakelwa kwamanzi angaphansi komhlaba.
	Imigodi yamanzi embiwe (boreholes)
1	Imfuyo, imisebenzi eyenziwa ngabantu emthonjeni wamanzi. Ama-borehole angajulile ezindaweni ezineziphethu zamadwala avavekile amfimfisa amanzi, angangcoliseka kalula kakhulu.
2	Amanzi angaphansi komhlaba angase abe namakhemikhali ahlobene nezempilo (isib. i-arsenic, i-barium, i-fluoride, i-uranium, i-radium) ngenxa yesimo senhlabathi yendawo.
3	Amanzi angaphezulu angena kwi-borehole angandisa ukudungeka futhi/noma angase abe nendle yezilwane noma izinyoni equkethe amagciwane ayingozi.

4	Isiphethu samanzi esingawatholi ngokwanele amanzi singabangela ukushoda kwamanzi emithonjeni.
5	Ukucekelwa phansi noma ukonakaliswa kwempahla kungawangcolisa amanzi ngamakhemikhali noma ngamagciwane noma kulimaze imishini nengqalasizinda.
6	Amanzi angase abe ne ayoni (iron) ne-manganese eba khona ngokwemvelo.
7	Imfucumfucu yasekhaya (amanzi angcolile, amathange endle asesizeni, udoti, udoti ochithwe ngumasipala, nokunye) kungawangcolisa amanzi.
8	Imisebenzi yasezimbonini nakwezolimo ingayingcolisa i-borehole (isib. amagciwane ayingozi, amakhemikhali awushevu, okukhishwa umoya, ukungcoliswa komoya, iziteshi zikaphethilomu - ukungcolisa kwe-hydrocarbon contamination, ukusakazeka komquba ezweni, ukumuka nemvula kwamanzi emfuyo, nokunye).
9	imfucumfucu yasekhaya (amanzi angcolile, amathange endle asesizeni, udoti, udoti ochithwe ngumasipala, nokunye) kungayingcolisa i-borehole.
10	Izingozi zemigwaqo zingaholela ekuchithekeni kukashevu noma amanye amakhemikhali, izinto eziyingozi, nokunye.
11	Amathuna angawangcolisa ama-borehole.
12	Ukungena kwamanzi anosawoti (isib. avela olwandle) kungangcolisa imithombo yamanzi ahlanzekile.
13	Amanzi emvula angcolile angawonakalisa umthombo.
14	Ingozi, ukulimala kwemishini, ukucisha kukagesi, ukonakaliswa kwempahla, ukucekelwa phansi kwempahla, nokunye kungaholela ekuhlulekeni komthombo olawula isistimu.
15	I-hydrogen sulphide emithonjeni efudumele yomhlaba noma ukuzalana kwamagciwane ngenxa yokuntuleka komoya mpilo kungase kuveze amanzi asezingeni elingathandeki.
16	Imithombo engaphansi komhlaba (groundwater aquifers) ngaphambilini ebingcolisiwe ingaholela emathubeni amaningi okugcina ukungcola kunamanzi angaphezu komhlaba. Amanzi angaphansi komhlaba ngokuvamile ageleza kancane futhi kuba kuncane ukuxubana.
17	Ingqalasizinda (isib. idamu, iphampu edonsa amanzi ambiwe) indala futhi ingase iphuke kalula noma idinge ukulungisa.
18	Ukufinyelela emgodini wamanzi ombiwe, ukufaka amanzi noma enye ingqalasizinda ilinganiselwe ngenxa yemigwaqo engemihle, ukungafinyeleleki kwezindawo ezithile
19	Ukwaziswa okungelona iqiniso noma okungenele kokubekwa kweso emanzini omthombo ngenxa yokwehluleka kwezisetshenziswa noma ukuntuleka kolwazi noma ukqeqeshwa kuka-operator.
20	Lapho imithombo engasetshenzisiwe ingavaliwe kahle (umthombo oshiywe dengwane) kukhona ingozi enkulu yokuthi amanzi angaphezu komhlaba angangena emthonjeni angcolise isiphethu okuyoholela ekungcolisweni kweminye imithombo eye yambiwa esiphethwini esifanayo.
	Iziphethu
1	Isiphethu kumelwe sakhiwe ukuze kuvikelwe isiphethu emfuyweni, imisebenzi eyenziwa ngabantu emthonjeni wamanzi. Ama-borehole angajulile ezindaweni ezimfimfa kakhulu amanzi noma iziphethu ezisemadwaleni kusengozini kakhulu yokungcoliseka.
2	Amanzi angaphansi komhlaba/amanzi esiphethu angase abe namakhemikhali ahlobene nezempilo (isib. i-arsenic, i-barium, i-fluoride, i-uranium, i-radium) ngenxa yesimo senhlabathi yendawo.
3	Amanzi angaphezulu angena esiphethwini angandisa ukudungeka futhi/noma angase abe nendle yezilwane noma izinyoni equkethe amagciwane ayingozi.
4	Isiphethu samanzi esingawatholi ngokwanele amanzi singabangela ukushoda kwamanzi emithonjeni.
5	Ukucekelwa phansi kwempahla noma ukonakaliswa kwayo kungase kungcolise amanzi ngamakhemikhali noma ngamagciwane noma konakalise imishini nengqalasizinda.
6	Amanzi angase abe nensimbi (iron) ne-manganese eba khona ngokwemvelo.
7	Imfucumfucu yasekhaya (amanzi angcolile, amathange endle asesizeni, udoti, udoti ochithwe ngumasipala, nokunye) kungawangcolisa amanzi.

8	Imisebenzi yasezimbonini nakwezolimo ingasingcolisa isiphethu (isib. amagciwane ayingozi, amakhemikhali awushevu, okukhishwa umoya, ukungcoliswa komoya, iziteshi zikaphethilomu - ukungcolisa kwe-hydrocarbon, ukusakazeka komquba ezweni, ukumuka nemvula kwamanzi emfuyo, nokunye).
9	Imfucumfucu yasekhaya (amanzi angcolile, amathange endle asesizeni, udoti, udoti ochithwe ngumasipala, nokunye) kungawangcolisa amanzi.
10	Izingozi zemigwaqo zingaholela ekuchithekeni kukashevu noma amanye amakhemikhali, izinto eziyingozi, nokunye.
11	Ukungena kwamanzi angcolile kungayingcolisa imithombo yamanzi ahlanzekile
12	Amanzi emvula angcolile angawonakalisa umthombo.
13	Ingozi, ukulimala kwemishini, ukucisha kukagesi, ukonakaliswa kwempahla, ukucekelwa phansi kwempahla, nokunye kungaholela ekuhlulekeni komthombo olawula isistimu.
	Iziqukathi Zamanzi (Amadamu)
1	Izindawo zasemadolobheni kanye nokukhishwa kwamanzi angcolile (okuvunyelwe nokungagunyaziwe) kungaholela ekungcolisweni kwamanzi ngamagciwane ayingozi. Izinga lokungcola lizoncik ezingeni lokuhlanzwa nokulawulwa kwamasistimu okuchithwa kwendle nezinga lokuyihlanza emadanyini egcinwa kuwo (e.g. amasistimu okugcinwa kwendle esemigodini ezizeni zabantu).
2	Izindawo zasemadolobheni zingawangcolisa amanzi ngokukhishwa kwamakhemikhali ngendlela engagunyaziwe kumakhemikhali agciniwe.
3	Ezokungcebeleka zingabangela ama-microbial (ukungcola kwendle) nokungcoliswa kwamakhemikhali (ukuhamba ngesikebhe) nokuguguleka kwenhlabathi (izimoto ezingahambi emigwaqweni elungiselelwe).
4	Ukukhishwa kwamanzi angcolile kungaholela ekwandeni kwamazinga ama-nutrient emadanyini nasemathangeni okugcina amanzi.
5	Izindawo zasemadolobheni zingaba umthombo wokudungeka kwamanzi, udoti nemfucumfucu yezitshalo endaweni enamanzi (isib. ukulahlwa kokungcola kwasekhaya, udoti kamasipala).
6	Ukungena kukanoma ngubani kalula emathangeni amanzi kungaholela ekulimaleni okuyingozi kwengqalasizinda nokungcoliseka okwengeziwe okungadalwa ukuvuza.
7	Imisebenzi yezolimo ebandakanya imfuyo ingawangcolisa amanzi ngamagciwane ayingozi (isib. ukusakazeka kukamanyolo noma umquba). Ukunqwabelana kwezingcolisi kuncike ebuningini bomsebenzi namazinga okufinyeleleka kwendawo yokugcinwa kwamanzi.
8	Okwenziwa ezimbonini nakwezolimo kungaholela ekungcolisekeni kwamanzi okudalwa ngamakhemikhali ayingozi kubandakanya nezinto eziwushevu ezitshalweni, izibulali zilokazane, izinsimbi ezisindayo, izisetshenziswa zezokwelapha, ukuchithwa kukadizili nemikhiqizo ye-petroleum.
9	Ukukhishwa kwamagesi ezingozini zasezimbonini noma imililo yamahlathi kungawangcolisa amanzi (isib. ukuqhuma, imililo, nokunye).
10	Okwenziwa kwezolimo kungawandisa amazinga ama-nutrient emanzini ngenxa yokungena komanyolo noma izinhlanganisela ze-nitrogen ezihlobene nemfuyo (isib. ukumuka kokudla kwemfuyo namanzi emvula).
11	Amahlathi abandakanya ukutshalwa kwezingodo angaholela ekukhishweni kwezibulali zilokazane nezibulali zitshalo.
12	Okwenziwa kwezolimo nasemfuyweni kungabangela ukuguguleka kwenhlabathi edanyini lamanzi futhi kuholele ekwandeni kokudungeka kwamanzi.
13	Ezokutshalwa kwamahlathi zingabangela ukuguguleka edanyini lamanzi futhi kuholele ekwandeni kokudungeka kwamanzi.
14	Imvula enamandla, amanzi angena edanyini angase adungeke (inhlabathi, isihlabathi) futhi ibe nendle yezilwane/izinyoni, izingcolisi futhi ibe namazinga aphakeme kadoti onamagciwane (organic matter).
15	Izilwane ezifele emanzini zingase ziwangcolise noma zingafaka amagciwane emanzini.
16	Ukugeleza kancane, amazinga aphakeme ama-nutrient kanye nezimo ezifudumele - kungabangela ukuqhibuka kwama-cyanobacteria nama-alga/cishe kube nokukhula kwako.

17	Ukuhlelwa kwamanzi ngokwezigaba kungaholela ekuncipheni komoya mpilo emazingeni aphansi. Kukhuthaza ukukhula kwe-alga futhi kukhululula I ayoni (iron) ne-manganese kuma sedimenti.
18	Amazinga amanzi ehlayo ngenxa yesomiso noma ukuzika kwamanzi kunganomthelela ekungcolisekeni kwamanzi.
19	Imililo yehlathi ingagcina isifinyelele kuzinqanda mlilo emthonjeni wamanzi. Ukungabi khona kwezitshalo kungaphumela ekudungekeni kwamanzi nokungcola okunamagciwane.
20	Izingozi zemigwaqo zingaholela ekuchithekeni kukashevu noma amanye amakhemikhali, izinto eziyingozi, nokunye.
21	Ukucekelwa phansi kwempahla noma ukonakaliswa kwayo kungase kungcolise amanzi ngamakhemikhali noma ngamagciwane noma konakalise imishini nengqalasizinda.
	Ukungenisa Nokuhamba Kwamanzi Angaphezulu
1	Izithiyo ezibonakalayo endaweni yokungenisa kwamanzi zingabangela ukuntuleka/ukungatholakali kwamanzi.
2	Ukuhluleka kokungenisa kwamanzi kungabangela ukushoda/ukungatholakali kwamanzi
3	Ukwehluleka kwesistimu yokuphampa amanzi (isib. ukucisha kukagesi) kungabangela ukushoda/ukungatholakali kwamanzi.
4	Ukuqhuma kwamapayipi (ayinhloko, imihubhe yokuthutha) kungabangela ukuhluleka kwengqalasizinda/izimo eziwohlokile/izici zangaphandle ezingabangela ukushoda noma ukungatholakali kwamanzi.
5	Ingozi, ukulimala kwemishini, ukucisha kukagesi, ukonakaliswa kwempahla, ukucekelwa phansi kwempahla, nokunye kungaholela ekuhlulekeni komthombo olawula isistimu.
	Ukuphazamiseka Nokuhamba Kwamanzi Angaphansi
1	Izithiyo ezibonakalayo (izihlahla, izimpande, imifantu) kungalimaza indawo yokusefa bese kubangela ukushoda/ukungatholakali kwamanzi.
2	Ukwehluleka kwendawo yokusefa kungabangela ukushoda/ukungatholakali kwamanzi.
3	Ukwehluleka kwesistimu yokuphampa (isib. ukucisha kukagesi) kungabangela ukushoda/ukungatholakali kwamanzi.
4	Ukuqhuma kwamapayipi (ayinhloko, imihubhe yokuhambisa amanzi) kungabangela ukukhathala kwengqalasizinda/izimo ezingezinhle/izici zangaphandle okungabangela ukushoda/ukungatholakali kwamanzi.
5	Ingozi, ukulimala kwemishini, ukucisha kukagesi, ukonakaliswa kwempahla, ukucekelwa phansi kwempahla, nokunye kungaholela ekuhlulekeni komthombo olawula isistimu.
	Iindawo Yokugcinwa Kwamanzi (catchment)
1	Ukugcinwa nokulahlwa kukamanyolo kanye nokusetshenziswa kukamanyolo ezweni kungabangela ukungcoliswa kwamanzi
2	Ukungena kwemfuyo emthonjeni wamanzi
3	Ukusetshenziswa kwendle noma udaka lwendle ezweni kungabangela ukungcoliseka kwamanzi
4	Ikhwalithi yamanzi omthombo ibekelwa inselele (isib. i-pH ephansi, ama-organics aphakeme, ukudungeka kwamanzi okusezingeni eliphezulu, amazinga okushisa aphansi) kanye/noma iguquguquke ngezinkathi ezithile zonyaka.
5	Izikhukhula zingabangela ukwanda kwamanzi agelezayo emhlabathini nokukhukhula izinto.
6	Ukugcwala kwamanzi emvula emathangeni amanzi kungaholela ekungeneni kwezinsimbi ezisindayo.
7	Amagciwane aziphilela ngaphandle kokumunca igazi angagcina esengene endaweni ephakela ngamanzi.
8	Ukugugulwa kwenhlabathi/ukuphazamiseka kwezinhlabathi ezine-sulphate acid engabangela ukukhishwa kwensimbi, i-aluminiyamu kanye nezinye izinsimbi ezisindayo eziyobe sezigelezela emithonjeni yamanzi esemazansi.
9	Ukuncibilika kweqhwa kanye nemigelezo yasentwasahlobo ingabangela ukungena kwezinto ezingcolisayo emthonjeni wamanzi.

10	Izikhumulo zezindiza, kubandakanya nalezo ezishiyiwe, zingaba ngumthombo wokungcoliswa kwemithombo namadamu amanzi. Ngokuyinhloko, amakhemikhali okuncibilikisa, izibaseli (fuels), ikhemikhali yokucishwa komlilo, kanye namagwebu kanye nokungoliswa kwamanzi okuwumlando kungaba yizinkinga okuyobhekwana nazo.
11	Ezentengiselwano njengamagalaji kaphethilomu, izindawo zokukhenikhwa kwezimoto, izindawo zokuwasha izimoto, ama-dry clean angakhipha ukungcola okuqukethe izingcolisi eziyingozi kukho.
12	Ukusetshenziswa kukawoyela wokushisisa noma izibaseli emakhaya kungabangela ukuvuza kwezindawo zamanzi, ikakhulukazi emathangini agcinwe ngaphansi kwamanzi.
13	Izimpi zamasosha njengokusetshenziswa kwezinganono, ukusetshenziswa nokugcinwa kwezibaseli nokulungiswa kwemishini kungabangela ukukhishwa kwezinto ezingcolile emithonjeni yamanzi aphuzwayo.
14	Ukulahla okungekho emthethweni, udoti nenye imfucumfucu kungabangela ukuba lodoti obonakalayo ungene emanzini omthombo.
	Iindawo Yokugcinwa Kwamanzi (catchment)
15	Izindawo zokuhlaba izilwane zingakhipha ukungcola okunamagciwane okusezingeni eliphezulu.
16	Ukutshalwa nokufuywa kwezilwane nezitshalo zasolwandle (aquaculture practices), ikakhulukazi amanzi angcolile agelezayo kanye nokudla/umsoco wokondla okufuyiwe kungabangela ukukhishwa kwezingcolisi emithonjeni yamanzi. Ukufa kwenqwaba yezinhlanzi nakho kungabangela ukungcoliswa kwamanzi ahamba ngaphezulu.
17	Imisebenzi yasezimbonini ebandakanya ukucocwa kwezwe, ukugugula noma ukwakhiwa komgwaqo ingaholela ekugugulekeni, amanzi amaningi agelezayo kanye nokuntuleka kwamakhono okusefa (in-situ filtration capability).
18	Amanzi ageleza evela ezimbonini noma udaka kungabangela ukungcoliswa kwamanzi emithombo.
19	Ukulungisa kwabemboni yokuthunyelwa kwempahla ngomkhumbi njengokususwa kwezinsalela eziqinile ezibangelwa ngamakhemikhali (descaling) kanye nokususwa kwamagwebu amakhemikhali kungabangela ukungcoliseka kwemithombo yamanzi.
20	Ukususwa kodaka emanzini kungaphazamisa inzika kubandakanya nezindawo ezingcolisekile.
21	Ukugawulwa kwezingodo okungekho emthethweni kungaholela emazingeni andile okuguguleka kwenhlabathi endaweni egcine amanzi.
22	Abahleli ngokungemthetho noma izimboni ngokuvamile abawahlanzi amanzi angcolile.
23	Imigwaqo kanye nezinye izindawo ezipheviwe kungandisa ukugeleza ngamandla kwamanzi.

Table A8: Drinking Water Treatment System possible hazards in Zulu

Ukuhlolwa Kwengozi Yokuhlanzwa Kwamanzi Aphuzwayo	
	Izingozi Noma Izenzakalo Ezinobungozi Ezingaba Khona
	Jenerali
1	Indawo ayiphephile (i.e. akubiyelwe, awekho amasango, izihluthulelo, izimpawu zokuphepha/eziyisixwayiso, ukuphepha okunganele).
2	Awekho amadokhumenti atholakalayo endaweni yokunakekelwa kwamanzi (isib. i-Classification Certificate, i-Water Use Authorisation).
3	Izinkinga azisingathwa ngenxa yokuthi azibikwa ngokwanele (isib. izisetshenziswa ezingasebenzi, imibiko engahambisani nemithetho ebekiwe).
4	Ukuphepha kwabasebenzi akukhathalelwa njengoba bengenayo i-PPE efanele (izinto zokuzivikela zomuntu siqu(personal protective equipment).
5	Ukungagcinwa ngokwanele kwamakhemikhali kungakhinyabeza ukuphepha kwabasebenzi
6	Izinqubo zokuhlanzwa kwamanzi ezingenziwanga kahle zingaholela emanzini asezingeni eliphansi.
7	Amanzi angahlanziwe asezingeni eliphansi angaba nomthelela enqubweni yokuhlanzwa kwamanzi.
8	Ukugeleza kwamanzi ngokungenele kungaba nomthelela ongemuhle enqubeni yokuhlanzwa kwamanzi.
9	Amanzi athwalwa yithangi lokugcina amanzi awanele ukuhlangabezana nezidingo.
10	Izinto zokwakha zezinga eliphansi noma ezingafanele zingabangela ukuba kungaphumeleli ukuhlanzwa kwamanzi.
11	Ukwehluleka kwezisetshenziswa (isib. i-telemetry, i-SCADA) kungaholela ukulahleka kokulawulwa kwenqubo (process control).
12	Ukuqapha ukusebenza kwemishini okusezingeni eliphansi kungaholela ekwehlulekeni kokulondolozwa kwekhwalithi yamanzi (isib. ukuqapha okungasebenzi/okunganele ezindaweni ezihlukahlukene zokulawula).
13	Ukuphakelwa kukagesi kungaholela ekuphazamisekeni kokuhlanzwa kwamanzi/ukungalawuleki kahle kwenqubo.
14	Sebenzisani omunye umgudu ngamanzi angahlanziwe uma amanzi engahlanzekanga ngokwanele/kube nokuhluleka ukuhlanza amanzi.
15	Amathangi okugcinwa kwamanzi asezindaweni zokunakekelwa kwamanzi angashaywa indiva/angcoliswe.
16	Ukulungisa ngendlela engafanele kungabangela ukuba ukuhlanzwa kwamanzi kungaphumeleli.
17	Izinhlekelele ezingokwemvelo (isib. izikhukhula, ukuzamazama komhlaba) kungalimaza imisebenzi eyenziwa endaweni yokuhlanzwa kwamanzi.
18	Ukufinyelela emalabhorethri ukuze kuyohlaziywa amasampula ngesikhathi esifanele kulinganiselwe ngenxa yokuthi iqhele kakhulu indawo umphakathi ohlala kuyo.
19	Ingqalasizinda (isib. umshini wokuhlanza amanzi) usumdala futhi usuvame ukwephuka noma udinge ukulungiswa.
20	Ukutholakala kwamasistimu okuhlanza amanzi noma enye ingqalasizinda kulinganisele ngenxa yemigwaqo engemilhe, ukungafinyeleleki kalula.
21	Ulwazi ngqangi olunganele lokugadwa kwamanzi ahlanziwe ngenxa yokwehluleka kwemishini noma ukuntuleka kolwazi noma ukuqeqeshwa kuka-operator.
22	Ukuvimbeka esikrinini ngenxa kasayizi onganembile noma ukungahlanzwa ngokwanele.
23	Imimoya ephakeme nesimo sezulu esibandayo kungaba neqhaza ekukhinyabezeni ukusebenza kwesiqoqi sodaka. Ukunqwabelana ngokweqile kodaka/udoti ophathekayo kungakhinyabeza ukusebenza kwesicwengi samanzi, kubangele ukubuya futhi kwama-flocs.
	Ngaphambi Kokulumbanisa Umoya-mpilo (Pre-oxidation)
1	Ngaphambi kokufaka isilinganiso esithile somoya-mpilo ngenxa yokungasebenzi kahle kwesilinganiso, ukucisha kukagesi, ukuphakelwa komoya-mpilo kuyaphela noma kufune ukuba sandiswe isilinganiso samanzi angahlanzekile.

2	Ukuqunyeleka ngokweqile kwesilumbanisi nomoya-mpilo (oxidant) ngenxa yokungasebenzi kahle kwesistimu yokulinganisa noma ukuncipha kokufunwa kwamanzi.
3	I-pre-oxidation ibangela ukuba i-cyanobacteria iqhume ukuze idedele izinto eziwushevu.
4	Amakhemikhali okuhlanza amanzi asezingeni eliphansi/amakhemikhali okuhlanza angagunyaziwe.
	Ukushubisa (Coagulation), Ukuhlunga (Flocculation), Ukuzikisa (Sedimentation)
1	Ukungasetshenziswa kahle kwesilinganiso semithi yokuhlanza kunganciphisa ukwakheka kwe-floc ngaleyo ndlela angasuswa kahle amagciwane ayingozi, izinto eziwumkhiqizo walawo magciwane, umbala nokudungeka kwamanzi (turbidity).
2	Ukuphakelwa kwamakhemikhali kuyaphela, bese kuyama ukuhlanzwa kwamanzi.
3	Izinguquko ezinkulu ekugelezeni kwamanzi noma ukuvula/nokuvala indawo ethwala amanzi kungakhinyabeza ukushubisa nokuhlunga (flocculation).
4	Ukungalawulwa kahle kwe-pH nokuba khona kwe-alkaline kungakunciphisa ukwakheka kokushuba (coagulation) ne-floc.
5	Ukuhlunga (i-flocculation) nokususwa kwezinhlayiyana kungancishiswa uma ukuxutshwa kwamakhemikhali kunganele (ukuzanyazanyiswa kwamanzi okunganele). Asikho isikhathi esanele sokuthintana kwezakhi ukuze kwakheke i-floc noma i-floc ayiziki ngokwanele.
6	Ukungaziki ngokwanele kwe-floc kungabangelwa umoya/noma amazinga aphansi okushisa.
7	Ukushubisa, ukuhlunga (flocculation) nokuzikisa kungaphazamiseka uma ukwakheka kwe-biofilm kungalawulwa.
8	Izinguquko kwikhwalithi yamanzi angakahlanzwa kungenzeka ngezinkathi ezithile zonyaka noma ngemva kwezigameko ezinjengomlilo wasendle noma izikhukhula. Uma ukufakwa kwezilinganiso zesishubisi nezihlungo (flocculant) kungalungiswa ngokuvumelana nezinguquko zekhwalithi yamanzi, ukuhlanzwa kwamanzi kuzokhinyabezeka.
9	Ukusetshenziswa kwamakhemikhali okungewona kungakhinyabeza ukuhlanzwa kwamanzi futhi kungcolise amanzi awumkhiqizo.
10	Amakhemikhali okuhlanza amanzi ezinga eliphansi/amakhemikhali okuhlanza amanzi angagunyaziwe.
11	Ukuxuba ngokweqile kungase kubangele ukuba amanzi angahlungeki ngokwanele
12	I-pH engaphandle kwesilinganiso esamukelekayo ingaphumela ekutheni amanzi angahlungeki ngokwanele. outside of acceptable range can result in inadequate flocculation. Ukushubisa/ukuhlunga ngokuvamile kuphumelela kakhudlwana emazingeni aphansi e-pH.
13	Ukufaka isilinganiso semithi esingenele (ngenxa yokufunwa ngokwandayo kwamanzi angahlungiwe, inqubo ingazange ithuthukiswe ngokwanele, ukudungeka kwamanzi okusezingeni eliphezulu)
14	Ukufakwa kwesilinganiso semithi yokuhlanza ngokweqile (ngenxa yokuncipha kokufunwa kwamanzi angahlungiwe, inqubo ingazange ithuthukiswe)
15	Ukushuba kakhulu kwe-nitrite/nitrate emanzini omthombo
16	Ukushuba kakhulu kwamakhemikhali ancibilikisiwe (njenge-arsenic, ama-pesticide, ama-phosphate, amanye amakhemikhali ayingozi ayimikhiqizo yamagciwane (organic chemicals)) ngeke kususwe.
17	Inkathi enganele okuvumeleke ukuba izisefo ziyisebenzise (<1 hr noma >48 hr)
18	Usayizi wamagwebu ongafanele kanye kanye nokuphakama ngokweqile kwejubane ngenxa yezinga yokushintshashintsha kwezinga lokushisa kungabangela ukunganamathelani kahle kwama-floc namagwebu.
19	Amagwebu asakazeke ngokungalingene kahle ngenxa yokuminyana kwama-orifice nozzles angaguqulwa kungabangela ukunganamathelani kahle kwama-flocs namagwebu.
	Ukushubisa (Coagulation), Ukuhlunga (Flocculation), Ukuzikisa (Sedimentation)
20	Uma ingubo yegwebu incane kakhulu, ama-floc angase azike ngasemaphethelweni okuphuma kuwo amanzi. Isici esibaluleke kakhulu esikhinyabeza ukwakheka kwengubo yegwebu umoya ongena ngevolumu yeyunithi yamanzi angahlungiwe (isilinganiso sokungena komoya). Izimo zokusebenza njengezinga lokugeleza kwamanzi kanye nokuminyana kwevolumu yamagwebu kuyalithinta izinga umoya ofakwa ngalo.

	Ukusefa (isib. Okusheshayo, Okuthatha Kancane, i-Multimedia, MF/UF)
1	Ukwanda ngokushesha kokugeleza kwamanzi kungabangela ukuba kungasuswa ngokwanele ukudungeka emanzini (nezinhlayiya) kanye namagciwane ayingozi.
2	Ukujikeleza kwamanzi ngodlame ngenxa yokuvuleka nokuvaleka ngokushesha kwamavalvu kungabangela ukuba kungasuswa ngokwanele ukudungeka kwamanzi (nezinhlayiyana) kanye namagciwane ayingozi.
3	Ukuhlanzwa ngokuwabuyisela emuva amanzi okungazange kuphothulwe noma okungenele (okube kufushane kakhulu, obekucothoza kakhulu, ukugeleza komoya obekungenele) kungabangela ukungasuswa ngokwanele kokudungeka kwamanzi (nezinhlayiyana) namagciwane ayingozi.
4	Ukuqalisa ngokushesha ngemva kokuhlanza ngokubuyisela amanzi emuva kungabangela ukuba kungasuseki ngokwanele ukudungeka kwamanzi (nezihlayiyana) kanye namagciwane ayingozi.
5	Ukwehluleka ukunciphisa amazinga okugeleza kwamanzi ngesikhathi amanzi ehlanza ebuyela emuva kungabangela ukungasuseki ngokwanele kokudungeka kwamanzi (nezinhlayiyana) namagciwane ayingozi.
6	Ukuphazamiseka kwemigudu exhumene, ukwakheka kwemifantu noma ukulahleka kungabangela ukungasuswa ngokwanele kokudungeka kwamanzi (nezinhlayiyana) kanye namagciwane ayingozi.
7	Ukuvimbeka kwemigudu exhumene kubandakanya nezigaxa zodaka kungabangela ukungasuseki ngokwanele kokudungeka kwamanzi (nezinhlayiyana) kanye namagciwane ayingozi.
8	Ukubamba kwamagwebu okubandakanya nokubopha komoya kungabangela ukungasuseki ngokwanele kokudungeka kwamanzi (nezinhlayiyana) kanye namagciwane ayingozi.
9	Akukho okunye ukuhlanzwa kwamanzi okusetshenziswayo ngenkathi isisefo esisebenza ngayo kahle kakhulu (amasonto angu-2 – izinsuku ezingu-30 ngemva kokwakhiwa noma ukuhlanzwa kwesisefo)
10	Ukugqwala kwe-diffuser plate yensimbi kudala izimbobo ezinkulu kwi-plate; i-diffuser plate engasebenzi kahle kubangela isihlabathi esidungekile/esisakazeke ndawo zonke ngezansi kwe-plate, okuphazamisa i-biolayer, futhi kugcine sekungekho ukuxhumana okuhle kumasekethi kagesi wesisefo.
11	Ileveli yesihlabathi kungenzeka ibe phezulu kakhulu noma ibe phansi kakhulu ivimbele ukwakheka kwe-biolayer
12	Isisefo siyoma (ngokuphelele noma ingxenye engaphezulu yesihlabathi). Izimfa kwi-casting ye-concrete shell zingabangela izimbobo ezivuzayo ezingase futhi zibangele ukuba isisefo some futhi i-biolayer ife.
13	Ukudungeka kakhulu komthombo wamanzi (noma i-build-up/fouling ngokuhamba kwesikhathi) ingasithiya isisefo, kubangele ukwehla kokugeleza kwamanzi edlula esisefweni
14	Ukwehluleka kokuxhumana kwamasekethi kagesi esisefo (isikhathi esinganele sokuxhumana ukuze kuhlanzwe amanzi/kususwe amakhemikhali)
15	Ukudungeka kakhulu kwamanzi omthombo (noma i-build-up/i-fouling ngokuhamba kwesikhathi) kungathiya isisefo, kuphumele ekuncipheni kwamazinga okugeleza kwamanzi edlula esisefweni
16	Kuba nezimbobo ezakhekha kwi-screen kubangele ukungasuswa kahle kwezinhlayiya ezinkulu/udaka.
17	Kusetshenziswa kuphela i-coarse screening ngaphandle kolunye uhlobo lokuhlanzwa kwamanzi
18	Inqubo yokuqala ye-chlorination iyenziwa ngaphambi kokusefwa kwesihlabathi okuhamba kancane okuphumela ekubeni i-biolayer ingashukumiseki.
19	Ukususwa okungenele kwezingcolisi ezifunwayo.
20	Uma kuwumugqa owodwa kuphela wesisefo osendaweni efanele, khona-ke ukuphakelwa kwamanzi kuzophazamiseka ngesikhathi sokulungisa, ukuhlanza noma ukuvuselela.
21	Ukusetshenziswa kwenhlabathi yezinga eliphansi kungakunciphisa ukusebenza kwesisefo.
22	Umfutho wokugeleza kwamanzi ongemuhle emaphethelweni amapayipi kungabangela ukuba amanzi angaphandle abuyele emuva esisefweni.

23	Ukubhoboka kwemidiya ngenxa ye-high head loss noma imidiya engabekiwe ngokulingalingene kunganciphisa ukusebenza kwesisefo futhi kubangele ukungasuseki ngokwanele kwezinhlayiyana zokungcola.
24	Ukulungiswa ngokunganele kwesisefo, (isib. ukubuyiselwa kwenhlabathi, ukuhlanzwa kwama-nozzle adedela umoya, ukuthambisa, ukuhlanzwa kwemidiya, ukulungiswa kwephampu).
25	Ukujula kwemidiya okunganele noma uhlobo lwemidiya aluyifanelekele ikhwalithi yamanzi asefwayo kanye nezinga lokugeleza kwamanzi.
	Ikhabhoni Ewu-powder/Esazinhlayiya Eshukunyisiwe (Powdered/Granular Activated Carbon)
1	Ukungasebenzi kahle okubangela ukususwa ngokungenele kukashevu we-cyanobacteria (i-blue-green algae)
2	Ukungasebenzi kahle okubangela ukungasuswa ngokwanele kokunambitheka nezinhlanganisela zamaphunga (i-geosmin ne-MIB).
3	Ukungasebenzi kahle okubangela ukungasuswa ngokwanele kwezibulala zinambuzane nezinhlanganisela zokungcola okuphuma kuzo (organic compounds).
4	Ukungasebenzi kahle okubangela ukungasuswa ngokwanele kukuadoti ozivelela ngokwemvelo, kwandise ukudungeka kwamanzi.
5	Imiphumela enganele yomklamo (isib. isikhathi esinganele sokuxhumana se-empty bed) ekususweni okunganele kwezingcolisi ezithungathwayo.
6	Ukulungisa okunganele okubangela ukwanda kwe-head loss kanye nezinga lokukhiqiza elinganele.
7	I-backwashing enganele/ukulungisa okubangela ukwanda kwezinto ezinomthelela ezintweni eziphilayo ezisefweni nezinga eliphansi lamanzi.
8	Ukuphunyuka kwekhabhoni eshukunyisiwe ngenxa yokwehluleka noma ukungeneli kwamadivayisi agcina ikhabhoni.
9	Izinga lokukhiqiza elinganele ngenxa he-head loss eyandisiwe
10	Ukufaka ngokweqile amakhemikhali e-fluoride.
11	Ukulungiswa okunganembile kwe-pH ngenxa yokwehluleka ukusebenza kwemishini, amaphutha ka-operator noma izinguquko kwikhwalithi yamanzi angahlungiwe.
12	Ukudungeka okusezingeni eliphezulu emanzini omthombo (noma i-build-up/i-fouling ngokuhamba kwesikhathi) kungayithiya inhlaka eyingcina (resin) noma isisefo, kubangele amazinga ehlile okugeleza kwamanzi. Ukunqwabelana kwezinto ezikhiqizwa ngamagciwane enhlakeni eyingcina (resins) kungakhuthaza ukwanda kwamagciwane okunganciphisa ukuphumelela kokuhlanzwa kwamanzi.
13	Akukho ukuhlanzwa ngokwanele kwamanzi
	i-chlorination (Kubandakanya ne-Secondary Chlorination)
1	Ukungasebenzi kahle kwezilinganiso zemithi yokuhlanzwa kwamanzi ngenxa yokuhluleka kwezisetshenziswa noma ukwehluleka kukagesi. Ukuphazamiseka okungaba khona kwi-chlorination (ukufakwa kwe-chlorine enganele, ukufakwa kwe-chlorine ngokweqile).
2	Ukuphela kwekhemikhali yokubulala amagciwane.
3	Ukufakwa kwe-chlorine enganele (isikhathi sokuxhumana esinganele) kungenzeka ngenxa yokufunwa kwe-chlorine eyandisiwe emanzini angakahlanzwa noma ukugeleza kwamanzi okwandisiwe. Izinguquko kwikhwalithi yamanzi zingenzeka ngezikhathi ezithile zonyaka noma noma ngezenzakalo ezinjengezimvula ezinkulu noma imililo yasemahlathini.
4	Ukufakwa ngokweqile kwe-chlorine kungase kwenzeke ngenxa yokuncipha kokufunwa kwe-chlorine emanzini angakahlanzwa noma ukugeleza kwamanzi okuncishisiwe.
5	Izinsalela eziphansi ezingenayo i-chlorine kwisistimu yokusabalalisa zinciphisa isivikelo sokungcolisa kwendle nasemagciwaneni.
6	Amakhemikhali okuhlanza amanzi ezinga eliphansi/amakhemikhali okuhlanza amanzi angagunyaziwe.
7	Izindawo zokuthakwa kwe-chlorine ezingayihloniphi imithetho yokuphepha zingaholela ekuvuzeni kwegesi ye-chlorine.
	i-Ozonation

1	Imicikilisho eyenziwa ngaphambi kokuhlanzwa kwamanzi ingase ibangele izinhlayiya emanzini kanye nokususwa kwamagciwane ngendlela engaphumeleli.
2	I-Ozonation ingase iphazamiseke ngenxa yokungasebenzi kahle kwezisetshenziswa, ukusetshenziswa ngokweqile noma ukucisha kukagesi (isib. i-compressor yomoya ehlulekayo ukusebenza, ukuhluleka kokuphakelwa komoya-mpilo, ukwehluleka kwe-generator ye-ozone).
3	Ukwehluleka noma ukungalikali kahle imitha likagesi noma imitha le-ozone encibilikile kungaholela ekulinganisweni okuphansi kakhulu kwe-ozone.
4	Ukugeleza kwamanzi okwandisiwe kungaholela esilinganisweni esiphansi (isikhathi esinganele sokuxhumana).
5	i-pH ephezulu (> 8) noma ukudungeka kwamanzi okusezingeni eliphezulu kungaholela esilinganisweni esiphansi.
6	Kungenzeka kune-bromide emanzini angakahlanzwa.
	i-Ultraviolet Radiation
1	Imicikilishoengafanele yangaphambi kokuhlanzwa kwamanzi ingase ibangele izinhlayiyana emanzini kanye nokungabulaleki kwamagciwane ngemithi.
2	Imiphumela enganembile yendawo okufakwe kuyo isilinganiso semithi yokuhlanza amanzi esikhathini esifushane kakhulu sokufaka imithi yokubulala amagciwane.
3	Ukubulala amagciwane kungase kuphazanyiswe ukungasebenzi kahle kwezisetshenziswa, izisetshenziswa esezindala noma ukucisha kukagesi.
4	Ukuchayeka emisebeni (disinfection) kungase kudalwe ukudungeka kwamanzi okwandayo noma umbala emanzini angahlanziwe noma ukugeleza kwamani okwandayo.
5	Ukungalungisi kahle, njengokungawashintshi amalambu noma ukungayisusi inzika eshubhini le-quarts, kungabangela ukungasebenzi kahle kwelambu kanye nokungahlanzeki ngokwanele kwamanzi. Ngaphezu kwalokho, ukungasebenzi kahle kwemishini, ukungafakwa kahle kwamalambu noma ukusebenzisa amalambu anezilinganiso ezinganembile kungabangela ukungadluliswa kwemisebe ngokwanele.
	Ukuthambisa
1	Amanzi athanjisiwe angase abe akhumuzayo futhi asuse amakhemikhali emapayipini.
2	Ukuthanjiswa kwamanzi aqine kakhulu kusetshenziswa i-ion exchange kungaholela ekujiyeni okwandile kwesodiyamu emanzini.
3	Izinto eziwumkhiqizo wamagciwane zingase zinqwabelane kuma-resin (lapho zisetshenziswa khona) futhi zibe nesandla ekukhuleni kwamagciwane adala izifo.
4	Lapho kuthanjiswe khona ngomcako (lime) isilinganiso esinganembile noma ukulawulwa kwe-pH ngokunganele kunganciphisa ukusebenza ngempumelelo kwenqubo futhi kungase kuphazamisane nezinye izinqubo zokuhlanzwa kwamanzi (isib. uma kusetshenziswe ngokuvumelana nokushubisa, i-flocculation kanye nokuzikiza).
5	Lapho kusetshenziswe khona umcako, amakhemikhali okuhlanza amanzi angase abe ngawasezingeni eliphansi.
6	Uma ulwelwe lwe-NF lusetshenziswa futhi kukhona ukuphakelwe kukagesi okungenele, le nqubo ngeke isebenze.
7	Uma ulwelwe lwe-NF lusetshenziswa futhi amakhono akhona engenele kahle, kungase kube khona ukuhluleka kwesistimu.
8	Amanzi omthombo aqina kakhulu (> u-200 mg we-calcium carbonate).
	Ukusimamisa
1	Amanzi angabekiwe ezingeni elifanele angase abe ngakhumuzayo futhi asuse amakhemikhali emapayipini.
2	Lapho kusetshenziswe khona umcako ongekho ezingeni elifanele, isilinganiso esinganembile noma ukulawulwa kwe-pH okungenele/ukuntuleka kwe-CO_2 kungase kunciphise ukuphumelela kwale nqubo.
3	Lapho kusetshenziswe khona umcako ongekho ezingeni elifanele, amakhemikhali okuhlanzwa kwamanzi angase abe ngawezinga eliphansi.

4	Lapho kusetshenziswe khona umcako ongekho ezingeni elifanele, kungazange kwenziwe ukulungisa (isib. ukuflashwa kwephansi (bed)), ukwenezelwa komcako okwenziwa ngankathi kungabangela ukungasebenzi kahle.
5	Amanzi omthombo athambe kakhulu (u-0 mg we-calcium carbonate).
	Ukucwengwa ngolwelwe (Membrane Filtration)
1	Uma amalwelwe engasetshenziswa futhi engalungiswa kahle (i.e. ukukhinyabezeka kokuthutheleka kwamanzi, imicikilisho enganele yangaphambi kokuhlanzwa kwamanzi, ukungahlanzi kahle), kungase kube khona ukwehluleka kwesistimu.
2	Uma amalwelwe (membranes) esetshenziswa futhi amakhono akhona engenele, kungase kube khona ukuhluleka kwesistimu.
3	Uma amalwelwe esetshenziswa futhi kukhona izipele/izisetshenziswa ezigade umonakalo ezinganele, kungase kube nokuhluleka kwesistimu.
4	Amakhemikhali okuhlanza ulwelwe angase abe ngawezinga eliphansi noma amakhemikhali ayiphutha angase asetshenziswe ngenxa yokungagcinwa kahle noma ukungasetshenziswa kahle; ukufaka amalebula ayiphutha, izinkinga ngezikhathi kukhiqizwa, kuthuthwa noma kudilivwa; noma ukusetshenziswa kwamakhemikhali asephelelwe isikhathi.
5	Ukususwa ngokunganele kwamakhemikhali ahlanza ulwelwe ngemva kokulungisa nokubuyela kwisevisi.
6	Ukudabuka kolwelwe (membrane) noma kwenhlaka (resin), ukulimala noma ukwehluleka (ukudabuka noma ukuvuza) ngenxa yamaphutha enzeka lapho kukhiqizwa, ukwehluleka ukwenza ukuhlanzwa kwamanzi kokuqala (pretreat), ukwehluleka ukususa ama-oxidant asetshenziswa ekuhlanzweni kwamanzi kokuqala, ukungenziwa kokulunguisa noma amaphutha okusebenza (isib. umfutho oweqile wokubuyela kwamanzi emuva lapho ehlanzwa).
7	Ukuba matasa okukhinyabezayo/okwedlulele kwamagciwane (biological activity) ngenxa yalokhu: ukuncipha kwe-pH, amazing okushisa aphakeme amanzi, uhlelo olungaphumeleli kahle lokujikeleza kwamanzi abuyele emuva, ukugcinwa kwekhabhoni endaweni emanzi isikhathi eside ngaphambi kokuba isetshenziswe, ukugeleza kwamanzi ngejubane eliphansi kakhulu noma amanzi amile, ikhwalithi yamanzi angenayo, isimo esivumela amagciwane akwaziyo ukuphila umoya mpilo ungekho noma ukhona.
	Ukususwa kukasawoti emanzini
1	Uma kusetshenziswe amalwelwe e-RO futhi kunganele ukuphakelwa kukagesi, le nqubo ngeke isebenze.
2	Uma kusetshenziswe amalwelwe e-RO futhi engekho amakhono anele, kungase kube nokuhluleka kwesistimu.
3	Uma kusetshenziswe amalwelwe e-RO futhi zingenele izipele/izisetshenziswa ezigade umonakalo, kungase kube nokuhluleka kwesistimu.
	i-Ion Exchange
1	I-resin esetshenzisiwe iyachithwa ngendlela efanele.
2	Ukuphakelwa kwamakhemikhali okungenele (amakhemikhali avuselelwe kabusha) ngenxa yama-oda angenziwange ngesikhathi, ukutholakala noma ukukhiqizwa okunganele, ukuthutha noma ukubambezeleka kuma-custom noma ukunyuka kwamanani.
3	Imidiya yesisefo ingavaleka ngenxa yokungalungiswa/ukuvuselelwa kabusha ngokwanele.
4	I-pH engaphandle kwezilinganiso ezamukelekayo ngesikhathi kuhlanzwa amanzi (i-pH iphakeme noma iphansi kakhulu ukuthi ukuhlanzwa kwamanzi kungaphumelela – kuye ngesingcolisi esisuswayo).
5	Imidiya yesisefo iqedwe yinqubo yokuvuselela kabusha kwaholela kwivolume ye-bed encishisiwe kanye nesikhathi esincishisiwe sokusebenza kwesisefo phakathi kwezinkathi zokuvuselela kabusha.
6	Izinga lokugeleza kwamanzi alanele ngenxa yezinguquko kwikhwalithi yamanzi omthombo
7	Ukunezelwa komoya mpilo ongenele ngenxa yokungasebenzi kahle komshini (isib. ukuphuka kwamaphampu/izifuthi) noma ukugoqozwa/ukushukunyiswa okungenele (ekhaya) kuzoholela ekubeni khona komoya mpilo ongenele.

8	Asikho isigaba sokuzikisa/sokusefa esilandelayo esilungiselelwe amanzi achaywe kumoya mpilo (ane-Fe noma i-Mn)
9	Akukho okunye ukuhlanzwa kwamanzi ngemithi okuhlinzekwayo ngamanzi achaywe kumoya-mpilo (aerated)
10	I-Ion exchange resin iba nomswakama ngenxa yokungaluniswa ngokwanele/ukuvuseleleka okubangela inqubo yokwelapha engaphumeleli
	Ukubulawa Kwamagciwane (Disinfection)
1	Lapho amakhemikhali asetshenziselwa inqubo ye-oxidation esetshenziswa namanzi angahlungiwe anezinto eziningi ezikhiqizwa ngamagciwane (kanye neminye imikhiqizo eveza imiphumela engathandeki) kungaba nemikhiqizo engalindelekile engathandeki engakheka.
2	Ukusetshenziswa kwamakhemikhali asephelelwe yisikhathi.
3	I-pH okungeyona yokwenza i-chlorination ebangela ukungabulaleki ngokwanele kwamagciwane emanzini
4	Ukungafaki imithi eyanele ngenxa yokungasebenzi kahle kwemishini, ukufunwa ngokwandayo kwamanzi angakahlungwa, ukugeleza ngamandla kwamanzi, amaphutha ka-operator, ukuntuleka kokuphakelwa kwamakhemikhali noma ukungabikho kukagesi kungabangela ukuba zingeneli izihlanzi manzi ezifakiwe (insufficient disinfection) noma kube nezinsalela kwisistimu yokusabalaliswa kwamanzi.
5	Ukufaka imithi ngokweqile ngenxa yokungasebenzi kahle kwemishini, ukufunwa kwamanzi angakahlungwa okunciphile, ukugeleza kwamanzi okunciphile, amaphutha ka-operator noma ukungaqashelwa ngokwanele kwalezi zindawo kungaholela emazingeni aphakeme e-chlorine nawezinsalela zemithi yokuhlanza amanzi.
6	Ukwenziwa kwemicikilisho engafanele yangaphambi kokuhlanzwa kwamanzi ukuze kususwe izinhlayiyana zokungcola emanzini angakahlungwa kungaholela ekusebenziseni izibulala magciwane ezinganele.
7	Ukwakhiwa kwesistimu yokuhlanza amanzi okunganele noma ngendlela engafanele kungaholela esikhathini esinganele sokuthintana kwamanzi namakhemikhali okubulala amagciwane kubangele ukuhlanzwa kwamanzi okunganele namazinga aphakeme okusetsenziswa kwemithi yokuhlanza amanzi.
8	Ukuba khona kwe-bromide, ama-humic acid noma imikhiqizo yamagciwane emanzini angahlungiwe.
	Ukuhlanza Amanzi Ekhaya (Home Treatment)
1	Kuba nezimbobo entweni eyindwangu, indwangu inomluko (weave) omkhulu noma ayisongiwe izikhathi ezanele okubangela ukuba zingasuswa ngokwanele izinhlayiya ezinkulu.
2	Ukungayihlanzi noma ukungayigezi indwangu phakathi kwama-batch omthombo wamanzi kungavula amathuba okuba kungcoliseke namanye ama-batch alandelayo.
3	Ukuvonywa kwendwangu kwenziwa kodwa ngaphandle kolunye uhlobo lokuhlanzwa kwamanzi.
4	Isisefo siyavimbeka ngenxa yokunqwabelana kwezinto ngaphakathi naphezu kwe-elementi yesisefo (ngenxa yamanzi adungeke kakhulu noma ukungenziwa kokulungisa) okubangela ukuncipha kokugeleza kwamanzi. Ukudungeka kwamanzi kakhulu kanye nemikhiqizo yamagciwane engokwemvelo nakho kungawavimba ama-sorptive site (isib. iron oxyhydroxides) noma isilia elifakwwe kwi-elementi yesisefo.
5	Ukubola noma ukuwohloka kwe-elementi ye-ceramic kungaholela ezingeni elehlile lokuhlanzwa kwamanzi. Izimbobo noma imifantu kwi-elementi ye-ceramic ingaholela ekudluleni kwezinhlayiya ezingcolile/amanzi adungekile esisefweni.
6	Uma kusetshenziswe izinto ezihwayayo lapho kuhlanzwa i-elementi e-ceramic, upende wesiliva ungase ususeke kubangele ukungahlanzeki kahle kwamanzi noma kubangele ukuba i-elementi ihlale isikhathi esifushane kanye nesisefo.
	i-Solar
1	Amabhodlela angalahliwe ekukhanyeni kwelanga okuphelele isikhathi eside ngokwanele (6 hr) noma imisebe yelanga encishisiwe ngenxa yamafu/ukuguquka kwesimo sezulu kungabangela ukungasuswa ngokwanele kwamagciwane.

2	Amabhodlela noma izikhwama zepulasitiki/zengilazi ziyahwayeka futhi zingabe zisabonisa ngale futhi amabhodlela angcole kakhulu.
3	Amanzi omthombo adungeke kakhulu noma umbala wawo udungekile
4	Ukuvuseleleka noma ukukhula kabusha kwamagciwane ngesikhathi sokugcinwa kwamanzi

Table A9: Drinking Water Network possible hazards in Zulu

Ukuhlolwa Kwengozi Engaba Khona Yenethiwekhi	
	Izingozi Noma Izenzakalo Eziyingozi Ezingaba Khona
	Ithangi lokuphakela amanzi elivikelwe (Ithangi elivalwe phezulu)
1	Izilwane/izinyoni zingangena ngamaphutha (isib. ngemifantu esophahleni, ngezindonga noma phansi) bese zingcolisa amanzi ngemingqatha yazo. Uma izilwane zicwila emanzini, lizonyuka izinga lamagciwane akhona.
2	Imingqatha yezilwane/izinyoni ingase ikhukhulekele emathangini amanzi lapho kuna izimvula ezingena ngezimfa phezulu emathangini noma ukusuka ophahleni olugeleza amanzi.
3	Ukungena kwabantu abangagunyaziwe, njengalapho bebhukuda emathangini okugcina amanzi kungabangela ukungcolisa kwamagciwane.
4	Ukwakheka ngokweqile komfutho ngaphakathi ethangini kungaholela ekulimaleni kwesakhiwo sethangi.
5	Amazinga aphakeme e-chlorine angase angene kwisistimu yokusabalalisa amanzi uma kuba khona ukungaxubani kahle kwemithi ngemva kokufakwa kwezibulala magciwane emathangini okugcina amanzi.
6	Kungase kube khona ukuphazamiseka kwenzika nobishi nephunga elidala amagcinwane.
7	Ikhwalithi yamanzi ingase iwohloke ngenxa yokugqwala kwamanzi okubangelwa amazinga okuthutheleka kokuxubana kwamanzi ngamandla okusezingeni eliphansi, okushintshashintshayo, nokunye.
8	Inhlanzeko ephansi ngesikhathi kwakhiwa/kulungiswa/kuhlanzwa ithangi kungakungcolisa ukuphakelwa kwamanzi.
9	Izinhlekelele zemvelo (isib. izimvula ezinkulu, ukuzamazama komhlaba, izikhukhula) zingase zibangele amadameshi noma zilimaze ithangi kubangele ukungcoliseka kwamanzi/ukungaphakeleki kwamanzi.
10	Izigameko ezibangelwa umuntu (isib. izingozi zamaloli) zingase zilimaze noma zibangele umonakalo ethangini lamanzi emanzini angcolisekile/ukungaphakeleki kwamanzi.
11	Ukucekela phansi kanye nokonakalisa kungase kungolise amanzi ngamakhemikhali noma amagciwane noma kulimaze izisetshenziswa nengqala-sizinda.
12	Ukubekwa kweso okunganele kungabangela ukungcoliseka/ukungaphakelwa kwamanzi (isib. ukwehluleka kwe-telemetry, lingekho iso eliqaphe ikhwalithi yamanzi).
	Ithangi lamanzi lokusevisa elingavikelwa (Ithangi elingavaliwe)
1	Izilwane/izinyoni zingangena ngezindawo ezinamaphutha futhi zingcolise amanzi ngemingqatha yazo. Uma izilwane zicwila emanzini, kuzoba nezinga eliphakeme lamagciwane ayingozi emanzini.
2	Imingqatha yezilwane/yezinyoni ingase ikhukhulekele ezindaweni zokugcina amanzi ngamanzi emvula angena ngezindawo ezinamaphutha ophahleni lokugcina amanzi esuka ezimpahleni eziconsa amanzi ngaphakathi.
3	Ukukhula kwama-cyanobacteria (ama-algae aluhlaza okotshani okusasibhakabhaka) namanye ama-algae kungaba yinkinga lapho amathange okugcina amanzi evulekele elangeni.
4	Ama-spray drift avela emisebenzini yasemapulazini aseduze kubandakanya nezibulala zinambuzane (pesticides) kanye namakhemikhali ezolimo angangena ethangini lokugcina amanzi kanye nokungcola kanye nodoti opheshulwa umoya.
5	Bushfires may lead to retardants and large amounts of ash entering storage.
6	Ukungena kwabantu abangagunyaziwe, njengalapho bezobhukuda ethangini lokugcinwa kwamanzi kungabangela ukungcoliseka kwawo ngamagciwane.
7	Amazinga aphakeme e-chlorine angase angene kwisistimu yokusabalaliswa kwamanzi uma engazange axutshwe kahle ngemva kokufakwa kwemithi ebulala amagciwane emathangini.
8	Kungase kube khona ukuma kancane kwenzika enodaka olungcolile nephunga elibangela amagciwane.
9	Kungase kube khona ukuwohloka kwekhwalithi yamanzi ngenxa yokonakala kwamanzi okubangelwa ukungagelezi kwawo ngokwanele, ukuxubana kwamanzi okwenzeka ngamazinga aguquguqukayo, nokunye.

10	Izinga eliphansi lenhlanzeko ngesikhathi kwakhiwa ithangi/kulungiswa/kuhlanzwa ithangi lamanzi lingakungcolisa ukuphakelwa kwamanzi.
11	Izinhlekelele zemvelo (isib. isiphepho, ukuzamazama komhlaba, izikhukhula kungalimaza noma kuwohloze ithangi kubangele ukuba kube khona ukungcola noma angabi khona amanzi.
12	Izigameko ezidalwa ngumutu (isib. ingozi yeloli) zingase zilimaze noma ziwohloze ithangi lamanzi kubangele ukuba kube khona ukungcola noma angabi khona amanzi.
13	Ukucekelwa phansi noma ukonakaliswa kwempahla kungawangcolisa amanzi ngamakhemikhali noma amagciwane noma kulimaze izisetshenziswa nengqalasizinda.
14	Ukungagadwa kahle kwethangi kungabangela ukungcoliseka/ukungabikho kwamanzi (isib. ukwehluleka kokusebenza kwe-telemetry, inganakwa ikhwalithi yamanzi).
15	Amathange angavaliwe angasebenza njengesizinda sokuzalana komiyane noma ezinye izinambuzane.
16	Izimo ezingezinhle zamathange, izembozo, izimbobo ezivuzayo nemifantu kungaholela ekungcolisweni kwamanzi.
17	Amasistimu okugcina nokusabalalisa amanzi awaklanyelwe ukuqukatha amanzi afanele adingwa umphakathi. Ukuwaklama ngokweqile kungabangela ukuba amanzi agqwale kulahleke nezinsalela. Ukuwaklama ngezinga eliphansi kungabangela ukungatholakali kwamanzi anele.
18	Amathange akhie ngensimbi angase akhumuzeke kube nokugqwala emthonjeni wamanzi kubangele imifantu/ukuvuza noma kulimaze ithange ngokwalo.
	Isiteshi sephampu yamanzi
1	Ukwehluleka kwephampu (e.g. Ukungasebenzi kahle kwephampu, ukucisha kukagesi, amasethingi anganembile) kungabangela ukugeleza kwamanzi okusezingeni eliphansi/angabi khona amanzi.
2	Izinhlekelele zemvelo (isib. iziphepho, ukuzamazama komhlaba, izikhukhula) zingasilimaza noma zisicekele phansi isiteshi sephampu kubangele ukungcoliseka/angabi khona amanzi.
3	Izigameko ezidalwa ngumuntu (e.g. ingozi yeloli) kungasilimaza noma kusicekele phansi isiteshi sephampu kudale ukungcoliseka kwamanzi/angabi khona amanzi.
4	Ukucekelwa phansi noma ukonakaliswa kwempahla kungawangcolisa amanzi ngamakhemikhali noma ngamagciwane noma konakalise izisetshenziswa kanye nengqalasizinda.
5	Ukuntuleka kwenhlanzeko lapho kufakwa, kulungiswa noma kvuselelwa iphampu kungakungcolisa ukuphakelwa kwamanzi.
6	Ukungagadwa ngokwanele kwendawo kungabangela ukungoliswa kwamanzi/angabi khona amanzi (isib. ukwehluleka kwe-telemetry, ikhwalithi yamanzi ingaqashaywa mkhuba).
7	Ukucima kwamaphampu okwenzeka ngengozi noma ukuvaleka kwamavalvu kungabangela izinkinga zomfutho wamanzi noma ukuthutheleka ngamandla ngokwedlulele kwamanzi okungabangela ukuxebuka kwama-biofilm, ukuphakama kwenzika noma ukuqhuma kwamapayipi.
8	Izikhukhula ezibangela ukungena kwamanzi angcolile ngama-hydrant angaphezulu komhlaba noma amavalvu omoya.
	Amavalvu namamitha
1	Ukwehluleka kwamavalvu noma kwamamitha (isib. ukuguga kwezingxenye zalezi zinto, ukucisha kukagesi, amasethingi anganembile) kungabangela ukuba amanzi angagelezi ngokwanele/angabi khona amanzi.
2	Inhlanzeko esezingeni eliphansi ngesikhathi sokufakwa, ukulungiswa noma ukuvuselelwa kwamavalvu/amamitha kungakungcolisa ukuphakelwa kwamanzi.
3	Ukungalawulwa kahle komfutho wokugeleza kwamanzi (isib. ukungasebenzi/ukwehlulaka kwamavalvu anciphisa umfutho) kungabangela umfutho oweqile kwinethiwekhi bese kubangela ukulimala kwamavalvu, ukusaphazeka kwamanzi, nokunye.
4	Ukubuyela kwamanzi emuva (avela ezindaweni ezingagunyaziwe noma kwiplambingi yasendlini) kungenzeka ngenxa yokungabi khona noma amavalvu okuhlola angasebenzi kahle noma lapho izimo zomfutho wamanzi okhinyabezayo zenzeka. Ukuxhumana kwamapayipi kumasistimu amanzi akulungele ukuphuzwa nangakulungele (isib. amasistimu okucisha umlilo, amasistimu okushisisa amanzi ashisayo, amasistimu endle) nakho kungabangela ukungcoliswa kwamanzi aphuzwayo.

5	Izikhukhula, amanzi angahambi eduze kompompi noma izimo ezingahlanzekile ngenxa yokungakhi kahle (i-apron engekho/enganele, igutter/isitamkoko)
6	Izikhukhula, izinhlekelele ezingokwemvelo noma izingozi ezibangela ukulinyazwa kwempahla noma ingqalasizinda.
7	Izinto ezingafaneleki nezembozo zingaletha izingcolisi futhi zidale ukukhula kwamagciwane.
8	Ukugeleza okuncane/amanzi amile noma umthombo othutheleka ngamandla wamanzi (i-pH ephansi, usawoti omningi, i-alkalinity ephansi) kungabangela ukuvuza kwi-solder, kumafithingi ebrass, emathangeni noma amapayipi okhethe, amapayipi anomthofu futhi kungafaka izingcolisi.
9	Amaphutha okusebenza (isib. umfutho ongafanele/oweqile wokuthutheleka kwamanzi, ukungenziwa kokulungisa) kanye nezingcindezi zangaphandle (isib. ukwenza kube yiqhwa/ukuncibilikisa, isisindo sokugeleza kwamanzi, ukumila kwezimpande zemithi) kungabangela ukuqhuma kwamapayipi, ukudabuka noma ukuvuza kanye nokulimala kwamathangi amanzi.
10	Ukungenziwa kokulungisa, amanzi amile noma amazing ensimbi aphakeme angaholela ekunqwabelaneni kodaka, inzika, ubishi kanye nembucumbucu/ama-biofilm.
11	Amavalvu noma amafithinigi angavaliwe kahle noma avuzayo angaholela ekungeneni kwamagciwane ayingozi nokuntuleka kwamanzi.
	Isistimu yokusatshalaliswa kwamanzi
1	Ukunqwabelana ngokweqile komfutho kungabangela ukulimala kwethangi lamanzi ngokwalo.
2	Ukuqhuma kwamapayipi kungaphazamisa ukuphakelwa kwamanzi. Ukungcola kwamanzi kungenzeka lapho amapayipi amanzi engaphani noma eseduze namanzi esiphepho noma namapayipi endle noma esendaweni enemigodi egcina indle okungabangela ukungcola okudalwa ngamagciwane noma amakhemikhali. Ukungena kwenhlabathi kungakwandisa ukudungeka kwamanzi.
3	Izingcolisi ezingamagciwane noma amakhemikhali zingangena kwisistimu yokuphakelwa kwamanzi ngamapayipi aphambanayo, amapayipi axhunywe ngokungekho emthethweni noma ukugeleza kwamanzi ebuyela emuva (isib. ukushintshashintsha komfutho wesivinini sokuhamba kwamanzi, ukuphakelwa kwamanzi okuphazamisekayo).
4	Inhlanzeko esezingeni eliphansi ngesikhathi kulungiswa/kuhlanzwa amapayipi ingayingcolisa indawo ephakela amanzi.
5	Ukungena kwenhlabathi ngesikhathi sokulungisa nokuvuselela kungakwandisa ukudungeka kwamanzi kungcolise namanzi.
6	Ukungahlanzwa ngokwanele kwamanzi noma ukufulashwa kwamanzi ipayipi elisha eliyinhloko lingakakulungeli ukusetsheniswa kungabangela ukungcoliseka kwamanzi ngamagciwane nangamakhemikhali. Ukuba khona kwenhlabathi kungakwandisa ukudungeka kwamanzi.
7	Amanzi angcolile angase angene kwisistimu ngesikhathi sezikhukhula, ikakhulukazi ngama-hydrant angenhla komhlabathi nangamavalvu omoya. Kungenzeka kube khona ukungcola okubangelwa ngamagciwane nangamakhemikhali. Ukuba khona kwenhlabathi kungakwandisa ukudungeka kwamanzi.
8	Amazinga okushisa aphakeme kakhulu (isib. 25 - 30 deg C) emapayipini amade angaphezu komhlabathi kungaba nesandla ekwakhekeni kwamagciwane athile.
9	Ukuvuza okuvela emapayipini kasimende, ikakhulukazi ngezikhathi amanzi egeleza khona kancane, kungabangela i-pH ephakeme.
10	Izinguquko ekugelezeni kwamanzi noma ekuminyaneni kwezibulala magciwane kungabangela ukwebuka noma ukuphazamiseka kwama-biofilm.
11	Amavalvu avulekayo/avalekayo - ukugeleza kwamanzi okubuyiselwa emuva noma udoti ophazamisayo, kungabangela ukuba duma kwamanzi.
12	Ukungena kwabantu abangagunyaziwe kuma-hydrant - ukungcola kungabangelwa ukugeleza kwamanzi ebuyela emuva, ukugeleza ngamandla okuhambisana nodoti ongenayo oyisiphazamiso.
13	Ukuvimbeka kwamanzi epayipini eliyinhloko nokugeleza kancane kakhulu kwamanzi kungaholela emanzini amile nokuntuleka kwezinsalela ze-chlorine.
14	Izembozo nezinto ezingafanelekile ezisetshenziswe zingangenisa amakhemikhali noma zikhuthaze ukwakheka kwamagciwane.

15	Ukuntuleka kwamanzi ageleza emapayipini (ukulinganiswa kahle kwamanzi/ukwakheka kwe-tubercle) kungabangela ukuncipha/ukungabi khona kwamanzi anele noma ukungabi khona kwamanzi.
16	Ukuba phansi/ukuba sezingeni eleqile kwezinga le-chlorine kuma-Chlorine Booster Station.
17	Ukungathathwa kwezinyathelo zokuphepha kuma-Chlorine Booster Station kungaholela ezimweni eziyingozi.
18	Ukucekelwa nokonakaliswa kwempahla kungawangcolisa amanzi ngamakhemikhali noma ngamagciwane noma kulimaze izisetshenziswa kanye nengqalasizinda.
19	Ukungalawulwa kahle komfutho wokugeleza kwamanzi (isib. Ukungasebenzi kahle/ukwehluleka kwamavalvu anciphisa umfutho wokugeleza kwamanzi) kungabangela umfutho owedlulele kwinethiwekhi bese kuqhumisa amapayipi, kusaphaze namanzi, nokunye.
20	Ukungagadwa kahle kwamathangi kungabangela amanzi angcolisekile/ukungabi khona kwamanzi (isib. ukwehluleka kwe-telemetry, kungabi khona ukuqashwa kwekhwalithi yamanzi).
21	Ukufakwa kwemithi yokuhlanza okungenele noma ukuflasha ngaphambi kokugunyaza ukusetshenziswa kwepayipi elikhulu noma ngemva kokulungisa nokuvuselela. Ukungcoliseka kwamanzi kungenzeka ngenxa yokungena kwabantu kanye/noma izimo ezingahlanzekile ngesikhathi sokulungisa nokuvuselela.
22	Amazinga okushisa afudumele, ukushisa kwamapayipi nokudluliswa kokushisa kusuka ezintweni eziseduze/imvelo kungabangela amazing okushisa aphakeme amanzi (isib. 25-30 deg. C+) abangela ukukhula/ukuba khona kwamagciwane athile. Amazinga okushisa azobangela ukunyamalala ngokushesha kwensalela ye-chlorine.
23	Ukufakwa kwamapayipi, amafithingi, amavalvu nezinye izinto ngendlela engafanele kungabangela ukuvuza nokungena kwezinto ezingadingeki. Ukuxhuma okungekho emthethweni nakho kungabangela ukuvuza nokungena kwezinto ezingafanele.
24	Amanzi ahamba ngamapayipi aphakelwe okwesikhashana abangela ukuntuleka komfutho wokuhamba kwamanzi isikhathi eside kanye nomfutho ophansi ngenxa yokufunwa ngamandla lapho amanzi ephakelwa okubangela ukungena kwezinto ezingadingeki.
25	Amanzi ahamba ngamapayipi aphakelwa okwesikhashana angabangela izinguquko ejubaneni lokuthutheleka kwamanzi, kwandise izingozi zokukhuhleka noma ukuxebuka kwama-biofilm nama-sediment.
26	Lapho amanzi ahamba ngamapayipi ephakelwa khona okwesikhashana, abasebenzisi bangase basebenzise amaphampu ukuze bakhe amanzi lapho amanzi engaphakeliwe. Lokhu kungadala umfutho okhinyabezekile bese kungena nezinto ezingcolile ezingadingekile.
27	Lapho amanzi ahamba ngamapayipi ephakelwa okwesikhashana, abasebenzisi bangase bakhe emthonjeni wekhwalithi ephansi noma bangase babhekane nokuhlinzekwa okungalingani kwamanzi.
28	Izingcolisi ezikhiqizwa ngamagciwane emhlabathini zingase zivuzele emajoyintini erabha amapayipi noma odongeni lwepayipi lwe-polyethylene noma amapayipi e-PVC.
29	Ukugeleza okuphansi/amanzi angahambi noma athutheleka ngamandla (i-pH ephansi, usawoti ophezulu, i-alkaline ephansi) kungabangela ukuvuza okuvela kupulasitiki/amapayipi e-PVC namathangi.
30	Ingqalasizinda (isib. ithangi, amapayipi okusabalalisa amanzi) yindala futhi ithanda ukuwohloka noma idinga ukulungiswa.
31	Ukufinyelela emathangini, emapayipini noma kwezinye izingqalasizinda kulinganiselwe ngenxa yemigwaqo engemihle, ukungafinyeleleki.
32	Ulwazi lokugadwa kwwenethiwekhi olungafanele noma olungenele ngenxa yokwehluleka kwemishini noma ukuntuleka kolwazi noma ukuqeqeshwa kuka-operator.
	Amapayipi Axhunywe Endlini
1	I-plumbing yasekhaya ingase (i) ingenise amakhemikhali angase akhinyabeze impilo noma abangele ukunambitheka namaphunga athile, (ii) ikhuthaze ukwakheka kwamagciwane angase abangele ukunambitheka namaphunga athile.
2	I-plumbing yasekhaya ingakhumuzeka ngenxa yokungafakwa kahle noma ngenxa yokuphakelwa kwamanzi noma izinto ezifakiwe (fittings).

3	Ukubuyela emuva kwamanzi emapayipini noma ezintweni zokugcina amanzi zasekhaya (isib. amathangi amanzi emvula, amadamu okubhukuda, amaphondi ezingadi) kungawangcolisa amasistimu amanzi aphuzwayo.
4	Amanzi ayadluliswa/ahlungwe/asabalaliswe kusetshenziswa izitsha ezingcolile (isib. amabhaked, izinkomishi, izitsha zokukha), imikhombe yokukha (spigots) engahlanzekile noma izandla.
5	Izinto zokuphatha ezingavaliwe zingase zingcoliswe yizingcolisi ezipheshulwa umoya noma izindawo zokuzalela zezinambuzane (isib. omiyane). Kanye nokungcolisa okuqondile, izinto ezintsha nazo zingase zithathe i-chlorine eningi kube nokuvikelela okuncane ekuguleni – kubangele amagciwane.
6	Izitsha zokuphatha zensimbi ezisetshenziselwa ukugcina izinto zingakhumuzeka zivuzisele izinsalela zensimi emanzini.
7	Izinto zokuphatha zichayekela ezimweni ezingahlanzekile, isib. udoti/okugeleza kusuka emigodini egcina indle, ukungena kwezilwane, nokunye.
	Amapayipi Asezizeni Zomphakathi
1	Ukungafinyeleleki kalula kwamapayipi asezizeni kungaholela ekuntulekeni kwamanzi/ekuphazamisekeni kokuphakelwa kwamanzi.
2	Ukubuyela emuva kwamanzi esuka emathangini axhuma emapayipini eziza kungabangela ukungcoliswa kwamanzi ngamagciwane nangamakhemikhali .
	Amapayipi Asezizeni Zomphakathi
3	Amanzi ame ezindaweni zokungena angase adonse izinyoni nezilwane kubangele ukukhathazeka ngamagciwane nezifo.
4	Umonakalo/ukucekela phansi okwenzeka endaweni amanzi athululeka kuyo kungaphazamisa ukuphakelwa kwamanzi futhi kuvumele ukungena kokungcola.
5	Izitsha zokuphatha ezisetshenziselwa ukulanda nokuthumela amanzi zingangcoliswa.
6	Ukuchitheka kwamakhemikhali (isib. izibaseli (fuel)/amakhemikhali okuhlanza avela ezintweni ezivuzayo) eduze kwamapayipi asezizeni kungabangela ukungcoliswa kwamanzi.
	Ukukhongozelwa Kwamanzi Emvula
1	Upende wophahla lwaphezulu unezingcolisi ezingamakhemikhali.
2	Ukuqoqana kwamacembe ngaphezulu/ngakumagatha nasophahleni phezulu.
3	Imingqatha yezinyoni/yezilwane ingcolisa amanzi.
4	Amanzi okuqala ngqa afulashwayo angangena ethangini lokugcinwa kwamanzi.
	Ukuhlanzwa Nokugcinwa Kwamanzi Asendlini
1	Ukuthela isilinganiso esiphansi se-chlorine.
2	Ukuthela isilinganiso eseqile se-chlorine.
3	Ukungcoliseka futhi kwamanzi ngenxa yokungasetshenziswa kahle/ngokungafanele kwesisefo esikumpompi.
4	Ukungcoliseka futhi kwamanzi ngenxa yokugcinwa ezitsheni ezivulekile ezingase zivakashelwe yizinyoni/izilwane/uthuli/ukungcola.
5	Ukungcoliseka futhi kwamanzi ngenxa yemikhuba engahlanzekile lapho kusingathwa/kukhiwa amanzi ezitshenzi zokuwagcina.
6	Ukungcoliseka futhi kwamanzi ngenxa yokusetshenziswa ukugcinwa esitsheni esingafanele (isib. amadramu enzimi) futhi isitsha singagcinwa sisesimweni esihlanzekile.
	Ukuthutha Amanzi Ngamathangi Eloli (tanker truck)
1	Ukungcoliseka futhi kwamanzi ngenxa yokugcinwa ethangini leloli elingazange lihlanzwe ngesikhathi lisetshenzisiwe esikhathini esidlule.
2	Amanzi angase angcoliswe ngesikhathi edluliswa eyiswa futhi ebuyiswa ezinqoleni ngenxa yamapayipi angcolile, amafithingi noma izindawo zokuwagcwalisa. Izimbobo ezivuzayo emapayipini, kumafithingi noma amathange ahlangene nezinto zokuphakela ngamaloli nakho kungabangela ukungcoliseka kwamanzi.
3	Umthombo wamanzi wokuphakela ngamaloli kungenzeka ungakulungeli ukuthwala amanzi aphuzwayo.
4	Iloli/ithangi lamanzi kungenzeka alikufanelekeli ukuthwala amanzi aphuzwayo, Isib. lisethenziselwa ukuthwala olunye uketshezi olunamakhemikhali ayizingcolisi noma indle yabantu.

	Umsebenzisi (Consumer)
1	Amanzi angenele aphakelwa imboni ebaphoqelela ukuba banciphise noma bakumise ukukhiqiza.
2	Ukufunwa kwamanzi yimboni noma ezolimo kusongela ukuqhubeka kokuphakelwa nokuhlanzeka lapho esetshenziswa emakhaya.
3	Umphakathi omningi kakhulu ohlala endaweni ungabangela ukufunwa ngokweqile kwamanzi.
4	Lapho ukufunwa kwamanzi kweqa izinga lokuhlanzwa kwawo, ikhwalithi yamanzi ingase yehle
5	Awekho amanzi anele atholakalayo okuhlangabezana nokufunwa kwawo ngokwandayo yimiphakathi yesikhashana.
6	Ukusetshenziswa ngokwandayo kwamanzi nokugeleza kwawo kungahwaya amapayipi futhi kugcine ukungcola.
7	Izinsana ezinceliswa amabhodlela (ikakhulu lezo ezinezinyanga ezingaphansi kwezingu-3) zingaba sengozini yamazinga aphakeme ama-nitrate.
8	Abanye abantu bangase bangenwe kakhudlwana yizifo uma kukhona izinkinga ngokuphakelwa kwamanziy (izingane < 6 izinyanga, abantu abadala, iziguli zasesibhedlela, abantu abanomdlavuza, izifo ezingamahlalakhona, ukufakelwa izitho, ingculaza, noma ezinye izimo ezingabeka engozini ukuvikelwa amasosha omzimba).
9	Iziguli ezenza i-renal dialysis zisengozini enkulu ngenxa yokuhlanzwa kwamanzi endaweni okungase kuphazamise izinguquko zekhwalithi yamanz.i
10	Ukugodlwa kwamanzi ngenxa yokusetshenziselwa izinjongo ezihlukahlukene (izimboni, ukuphuza, ezolimo) kungaholela ekudonsweni ngokwedlulele noma ekupheleni kwamanzi.
11	Ukungatholakali ngokwanele noma ukungabi khona kwamanzi asezingeni elifanele nolwazi olungenele / noma ukutholakala kokuhlanzwa kwamanzi asendlini.

APPENDIX B

Table B1: Possible Control Measures

A	Policies, Plans and Procedures
A1	Water Master Plan prepared
A2	Sewage Master Plan prepared
A3	Stormwater Master Plan prepared
A4	Water Services Development Plan (WSDP) prepared
A5	Integrated Development Plan (IDP) prepared
A6	Water treatment works operating procedure and maintenance schedule prepared
A7	Reservoir operating procedure and maintenance schedule prepared
A8	Distribution network operating procedure and maintenance schedule prepared
A9	Sewage system operating procedure and maintenance schedule prepared
A10	Wastewater treatment works operating procedure and maintenance schedule prepared
A11	Human resources policy, plans and procedures prepared
A12	IT systems policy, plans and procedures prepared
A13	Institutional memory policy, plans and procedures prepared
A14	Emergency plans, plans and procedures prepared
A15	Disaster management policy, plans and procedures prepared
A16	Financial management policy, plans and procedures prepared
A17	Supplier/contractor contracts prepared
A18	Customer contracts prepared
A19	Customer information sharing policies, plans and procedures prepared
A20	Customer complaints policies, plans and procedures prepared
A21	Introduce and enforce codes of practice for: • Fuel storage • Spill management • Nutrient management • Erosion management • Use of pesticides or herbicides • Intensive livestock activities • Manure storage, land application or disposal • Land application of sewage sludge • Land clearing and excavation activities
A22	Develop incident management plans

B	Appointments
B1	Appropriate Municipal Manager appointed
B2	Appropriate Technical Manager appointed
B3	Appropriate Heads of Department appointed (number and skills)
B4	Appropriate Supervisors appointed (number and skills)
B5	Appropriate water treatment works process controllers appointed (number and skills)
B6	Appropriate wastewater treatment works process controllers appointed (number and skills)
B7	Appropriate plumbers/field technicians appointed (number and skills)
B8	Appropriate mechanical repairs staff or contractor appointed (number and skills)
B9	Appropriate electrical repairs staff or contractor appointed (number and skills)
B10	Appropriate laboratory staff or contractor appointed (number and skills)

C	Redundancy/Alternatives/Back-ups
C1	Redundant water source(s) (e.g. surface, ground)
C2	Redundant water intake structure(s)
C3	Redundant raw water transfer pump(s)
C4	Redundant raw water transmission line(s)

C	Redundancy/Alternatives/Back-ups
C5	Redundant water treatment chemical tank(s) and dosing pump(s)
C6	Redundant water treatment unit process(es) (e.g. settling tanks, filters)
C7	Redundant treated water clear well(s)
C8	Redundant treated water transfer pump(s)
C9	Redundant treated water transmission line(s)
C10	Redundant treated water storage option(s)
C11	Redundant raw sewerage line(s)
C12	Redundant wastewater treatment chemical tank(s) and dosing pump(s)
C13	Redundant wastewater treatment unit process(es) (e.g. settling tanks, tanks)
C14	Redundant treated effluent tertiary treatment/storage
C15	Alternative disinfection chemicals
C16	Alternative treatment chemicals
C17	Alternative vendors (e.g. chemical suppliers)
C18	Back-up of key documents
C19	Back-up of key IT applications
C20	Back-up of key data/information

D	Physical Detection Measures
D1	Guard(s)
D2	Signage
D3	Site lighting
D4	Manual remote access permission (e.g. intercom linked to camera)
D5	Card-key badge system
D6	Entry code or pin input system
D7	Periodic local and entry code changes
D8	Alarmed cameras
D9	Fixed cameras
D10	Manual pan-tilt-zoon cameras
D11	Fence associated sensors
D12	Free standing sensors
D13	Boundary penetration sensors
D14	Glass-break sensors
D15	Interior motion sensors
D16	Proximity sensors
D17	Security escort service
D18	Inspection of packages
D19	Metal detector “doorways”
D20	Security awareness program
D21	Continuous process monitoring
D22	Chlorine measurement systems
D23	Pressure sensors in distribution network
D24	Antivirus software installed and up to date
D25	IT application monitoring (e.g. accounting package)
D26	IT systems configuration management (e.g. use approved hardware/software)
D27	Firewalls
D28	IT network intrusion detection
D29	Use secure IT service provider
D30	Physical access control to IT systems
D31	IT referential integrity (e.g. check current/new applications to verify not tampered with)
D32	Secondary user ID & password (e.g. two people make changes to critical applications)
D33	Separation of IT system duties (i.e. not one person controls)

D	Physical Detection Measures
D34	Technical audits of IT systems
D35	Data/information encryption (e.g. on network)
D36	Access to and monitoring of weather conditions (e.g. storms, floods)
D37	Vendor screening process
D38	Employee screening process
D39	Chain of custody enforcement with chemical deliveries
D40	Inspection of all packages
D41	Co-ordination with local hospitals/clinics
D42	Disgruntled employees monitoring (email and network access)
D43	ID check procedure
D44	Information classification procedure
D45	Landscaping maintenance checks
D46	Telephone call monitoring
D47	Explosive mixture detectors (VOC)
D48	Biological water contamination sensors
D49	Chemical water contamination sensors
D50	Total organic carbon analyzers
D51	Chemical detection sensors (e.g. gases)
D52	Explosive detection sensors
D53	Toxicity monitoring/metering equipment
D54	Radiation detection equipment for monitoring personnel/Radiological contamination sensors

E	Physical Delay Measures
E1	Razor mesh fence
E2	Chain link fence
E3	Barb wire fence
E4	Hardened doors
E5	Hardened gates
E6	Hardened ladder access
E7	Hardened windows
E8	Perimeter concrete wall
E9	Bollards (concrete or other material post)
E10	Jersey barriers/concrete barriers
E11	Bullet resistant windows
E12	Films for glass shatter protection
E13	Backflow prevention devices – commercial
E14	Backflow prevention devices – fire hydrants
E15	Backflow prevention devices – residential
E16	Outfall entry barrier
E17	Secured fill and vent pipes
E18	Secured fire hydrants
E19	Secured manholes
E20	Secured wellheads
E21	Doors and windows locking procedure enforced
E22	Maintain vehicular setback from buildings

F	Physical Response Measures
F1	Boil water notice
F2	Public address or other warning system
F3	Media (TV, radio, news) contact
F4	Automatic flow gates

F	Physical Response Measures
F5	Alternate electric switching equipment
F6	Alternate power sources
F7	Back-up power generation on-site
F8	Personal protection equipment (PPE) for employees
F9	Mitigation protection equipment (e.g. spray mace)
F10	Alternative water supply
F11	Remotely monitored “panic switch”
F12	Emergency operating procedural plan
F13	Evacuation plans (e.g. fire, bomb)
F14	Co-ordination with local police
F15	Co-ordination with fire department
F16	Decontamination procedural plan
F17	HAZMAT procedural plan
F18	Development and maintenance of calibrated hydraulic models (flow)
F19	Isolation and flushing procedure within distribution network
F20	Scripted public relations documents
F21	Off-site storage of duplication keys
F22	Regional spare parts/critical equipment inventories
F23	Training in all procedures (e.g. drills)

G	Water System Design, Operation and Maintenance	
	Component	**Possible Control Measure**
G1	Source	Variable depth intakes
G2	Source	Destratify source using mixers near intakes
G3	Source	Apply algaecides for green/non-toxic algal blooms.
G4	Source	Monitor water quality
G5	Source	Test soil for hazards
G6	Source	Consider blending with other sources
G7	Source	Establish/extend source water protection zones
G8	Source	Determine maximum sustainable demand
G9	Source	Monitor rainfall
G10	Source	Conduct regular patrols to remove dead animals
G11	Source	Conduct education/awareness programs with communities, farmers and industry to ensure awareness of impacts on water sources
G12	Source	Maintain fire access roads.
G13	Source	Minimize storage and use of chemicals, diesel and petrol within the catchment.
G14	Source	Ensure proper storage to contain spills
G15	Source	Ensure permits (and associated fines) are in place for discharges and related activities
G16	Source	Identify contaminated sites
G17	Source	Characterize leachate from waste sites
G18	Source	Ensure landfills are properly lined
G19	Source	Ensure garbage dumps are covered
G20	Source	Ensure rehabilitation after site is closed
G21	Source	Have toilets with sewage management and trash collection in recreational areas
G22	Source	Limit abattoir activity
G23	Source	Limit aquaculture activity
G24	Treatment	Ensure regular and preventative maintenance
G25	Treatment	Ensure a pre-treatment step occurs to reduce organic matter and other disinfection by-product precursors
G26	Treatment	Ensure chemical supplier is certified

G	Water System Design, Operation and Maintenance	
	Component	**Possible Control Measure**
G27	Treatment	Ensure chemicals meet approved standards
G28	Treatment	Supervise chemical delivery
G29	Treatment	Clearly label chemical supply tanks
G30	Treatment	Ensure regular equipment calibration
G31	Treatment	Adjust dose rate to water quality
G32	Treatment	Install flow proportional dosing
G33	Treatment	Install alarms for low levels in chemical tanks, low residuals and /or dose interruption
G34	Treatment	Install an automatic shut-down in the event of dosing failure
G35	Treatment	Ensure availability of back-up power
G36	Treatment	Ensure availability of spare parts
G37	Treatment	Ensure trained staff
G38	Treatment	Ensure sufficient chemical stocks are maintained
G39	Treatment	Inspect and maintain screens regularly
G40	Treatment	Ensure regular maintenance and desludging of the clarifier, sludge collector, and clarifier rake systems
G41	Treatment	Ensure adequate mixing at all flow rates
G42	Treatment	Orient the settling basin flow parallels to winds and/or install wave breakers
G43	Treatment	Cover the basin to protect from high winds or sandstorms
G44	Treatment	Establish procedures for start-up and shut down
G45	Treatment	Develop and follow operational procedures
G46	Treatment	Monitor flow rate
G47	Treatment	Ensure regular cleaning of nozzles
G48	Treatment	Install continuous monitoring and alarms for turbidity and head loss.
G49	Treatment	Conduct jar tests to determine appropriate dose rates
G50	Treatment	Have field test kits available to test water quality on-site.
G51	Treatment	Ensure that the sand level inside the filter is appropriate
G52	Treatment	Regenerate the filter media.
G53	Treatment	Apply air scouring/backwashing process to the filter
G54	Network	Ensure adequate drainage and venting along network
G55	Network	Monitor disinfectant residuals
G56	Network	Ensure adequate disinfection residual
G57	Network	Ensure tankers/vehicles used for transporting/distributing drinking water only used for that purpose (e.g. not for transporting waste)
G58	Network	Regular inspection and maintenance of pumps
G59	Network	Flush pipes during low flow
G60	Network	Increase flows through sections of pipe
G61	Network	Reduce dead ends
G62	Network	Install drainage points for stagnant water
G63	Network	Implement flushing program
G64	Network	Ensure slow opening of valves or pumps
G65	Network	Maintain positive pressure in the distribution system
G66	Network	Install backflow prevention devices
G67	Network	Provide adequate pressure at all consumer points
G68	Network	Ensure continuous supply
G69	Network	Control illegal connections
G70	Network	Avoid cross connections
G71	Network	Maintenance of valves
G72	Network	Use only approved materials for construction/repairs
G73	Network	Undertake a water audit to ensure water use is effective and efficient