Guidelines on Water Services Infrastructure Risks Management

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on behalf of

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The publication of this report emanates from a project titled *Guidelines on Determining the Vulnerability and Risk of Water Services Infrastructure* (WRC Project No. K5/1893).

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EXECUTIVE SUMMARY

Considering the Millennium Development Goals, there is currently a strong emphasis on ensuring sustainable water services provision to all communities serviced by Water Services Institutions (WSIs). Recent national studies have highlighted that the operation and maintenance of water services related infrastructure is in many cases not ideal; for example 65% of Water Services Authorities (WSAs) are performing maintenance on a crisis management basis (i.e. no scheduled maintenance). **Infrastructure Asset management (IAM)** has been identified as an effective means of enabling such WSIs to efficiently monitor and manage their systems within the constraints of limited resources (e.g. insufficient funding, insufficient staff numbers). In particular, water services related infrastructure needs to be managed within an integrated social, economic and environmental context, and the **IAM** principles and methods help to introduce discipline and logic processes into planning activities of the water services sector (see typical **IAM life cycle** below).

In essence, IAM is focussed on maintaining the desired level of service from your assets at the lowest life cycle cost. IAM generally includes both a documented asset management plan and is implemented through an asset management program. As a starting point, and to guide WSIs with no previous experience in asset management, it is recommended that the WRC document entitled "*Asset Management for the Water Services Sector in South Africa"* (WRC Report No 897/1/01) is first reviewed, as this document provides guidance to all of the major activities associated with asset management.

However, despite the availability of numerous asset management texts, a general current lack of effective asset management (and associated water service delivery) still exists at many WSIs. A need therefore exists to further support WSIs through provision of simple, easy-to-use guidelines and associated tools which enables WSIs to initiate asset management good practice at their institutions. In addition, there is also a clear need to capture and transform broad sector information into sector intelligence which is able to contribute towards regional and national water services infrastructure management strategies. To address these needs, this guidelines document (and associated software tools) emanating from the study "*Guidelines on Determining the Vulnerability and Risk of Water Services Infrastructure"* (WRC Project No. K5/1893) has been developed to assist WSIs to conduct vulnerability and risk assessments with the purpose to identify, prioritise and manage vulnerabilities and risks associated with their water services infrastructure.

Although vulnerability assessments and risk assessments are similar, they differ in scope as follows:

a) **Vulnerability assessment** – an assessment to determine an exploitable weakness or deficiency within the water services infrastructure. That is, it is the assessment of *probability* or *likelihood* of a threat or challenge occurring to the asset.
b) **Risk assessment** – an assessment of both the *probability* or *likelihood* of a threat or challenge occurring to the asset and the *consequence* should this happen.

Therefore, in some instances vulnerability assessments might be more appropriate to risk assessments, and vice versa. Nevertheless, the main purposes of both vulnerability and risk assessments are to:

- Safeguard public health and safety.
- Improve safety and prepare for emergencies.
- Reduce the potential for disruption of a reliable supply of safe water.
- Assist with managing storm water and wastewater.
- Provide measures to minimize insider threats (e.g. disgruntled staff).
- Provide a secure workplace for employees.
- Provide security to management practices.
- Protect computers/databases, data and communications.
- Protect the public from the negative outcomes of threats.

These guidelines are supported by two software tools, namely:

1. **WATERVUL** (Water Infrastructure Vulnerability Assessment) – This tool is aimed at rapidly identifying vulnerabilities at and threats to physical water services infrastructure, including: (i) Water Source, (ii) Water Treatment Works, (iii) Storage/Reservoirs, (iv) Water Distribution, (v) Sewage System and (vi) Wastewater Treatment Works.

2. **WATERRISK** (Water Infrastructure Risk Assessment) – This tool is aimed at identifying and analysing risks to the water services systems. This tool not only considers physical infrastructure but also supporting functions which could have a significant impact on sustainable service delivery. Assets considered include: (i) Water Services Planning, (ii) Physical Assets (combined assessment for water source, water treatment works, storage/reservoirs, water distribution, sewage system and wastewater treatment works, power), (iii) Operations and Maintenance Support, (iv) Human Resources, (v) IT Systems, (vi) Institutional Memory, (vii) Financial Resources and Management and (viii) Suppliers and Customers.

The software tools are available for download and use from both the Water Research Commission (www.wrc.org.za) and the electronic Water Quality Management System (eWQMS) (www.wqms.co.za). WSIs are encouraged to use both the guidelines that follow and the associated software tools in both asset management planning/implementation and addressing identified issues of concern.

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ABBREVIATIONS

CSIR	Council for Scientific and Industrial Research
DWA	Department of Water Affairs
EPA	Environmental Protection Agency
ERP	Emergency Response Plan
IAM	Infrastructure Asset Management
IDP	Infrastructure Development Plan
OHS	Occupational Health and Safety
PPE	Personal Protective Equipment
SAQA	South African Qualifications Authority
WHO	World Health Organisation
WRC	Water Research Commission
WSAs	Water Service Authorities
WSDP	Water Services Development Plan
WSI	Water Service Institution
WSPs	Water Service Providers
WTW	Water Treatment Works

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PURPOSE OF THE GUIDE

This guide has been developed with the purpose of providing assistance with:

- Identifying and understanding typical risks related to water services infrastructure, with a strong focus on design, operation and maintenance aspects.
- Planning and implementing measures to control and manage risks associated with water services infrastructure.

This guide can be used in conjunction with other water sector reference reports and/or guides. Details and links to accessing such useful reference materials are provided as part of this guide.

HOW TO USE THE GUIDE

To assist the reader in navigating this guideline document, the colours used in the main diagram will be used throughout the guideline document. A colour coded bar on the right hand side of the page will indicate the current section the user is on. The adjacent key indicates the various colour codes used for the different sections.

Planning, Budgeting and Evaluation
Design
Procurement/Construction
Operations
Maintenance
Refurbishment/Rehabilitation
Vulnerabilities and Risks Assessment/Evaluation

WHO SHOULD USE THIS GUIDE?

The guide has been developed to largely assist water services institutions teams to improve identification and associated improved management of risks associated with water services infrastructure. The guide therefore is aimed at:

Technical Management personnel (including, for example: Technical Managers, Heads of Department, etc)

Operation and Maintenance Technical personnel (including for example: Supervisors, Superintendents, Foremen, Process Controllers, Plumbers, Electricians, Mechanical Repairs personnel, Laboratory personnel, etc)

The guide will aim to answer the following typical water services institutions questions:

- What are the main issues that make our water services infrastructure vulnerable?
- What can we do to prevent vulnerability and associated risks?
- What material is available to help me to respond to typical system failures?

SECTION 1: INTRODUCTION TO ASSET MANAGEMENT AND VULNERABILITIES AND RISKS ASSESSMENT

1 INTRODUCTION

The Water Research Commission project K5 1893 “Guidelines on Determining the Vulnerability and Risks of Water Services Infrastructure” aims to establish a methodology to manage the vulnerability and risks of water services infrastructure and the means by which Water Services Institutions (WSIs) are better able to manage these. This included development of both best practice guidelines and software tools.

This guideline document provides the reader with information pertaining to fundamental principles of water services infrastructure asset management. Specific aspects discussed include:

- Planning, budgeting and continuous evaluation of status and performance
- Design
- Procurement and Construction
- Operations
- Maintenance
- Refurbishment and rehabilitation

To aid the reader further, the document indicates both good and bad practice, and also provides guidance how to identify and reduce water services infrastructure related vulnerabilities and risks.

However, prior to such discussions it is first necessary to familiarise oneself with the fundamental principles of infrastructure asset management (IAM).

2 INFRASTRUCTURE ASSET MANAGEMENT (IAM) BASICS

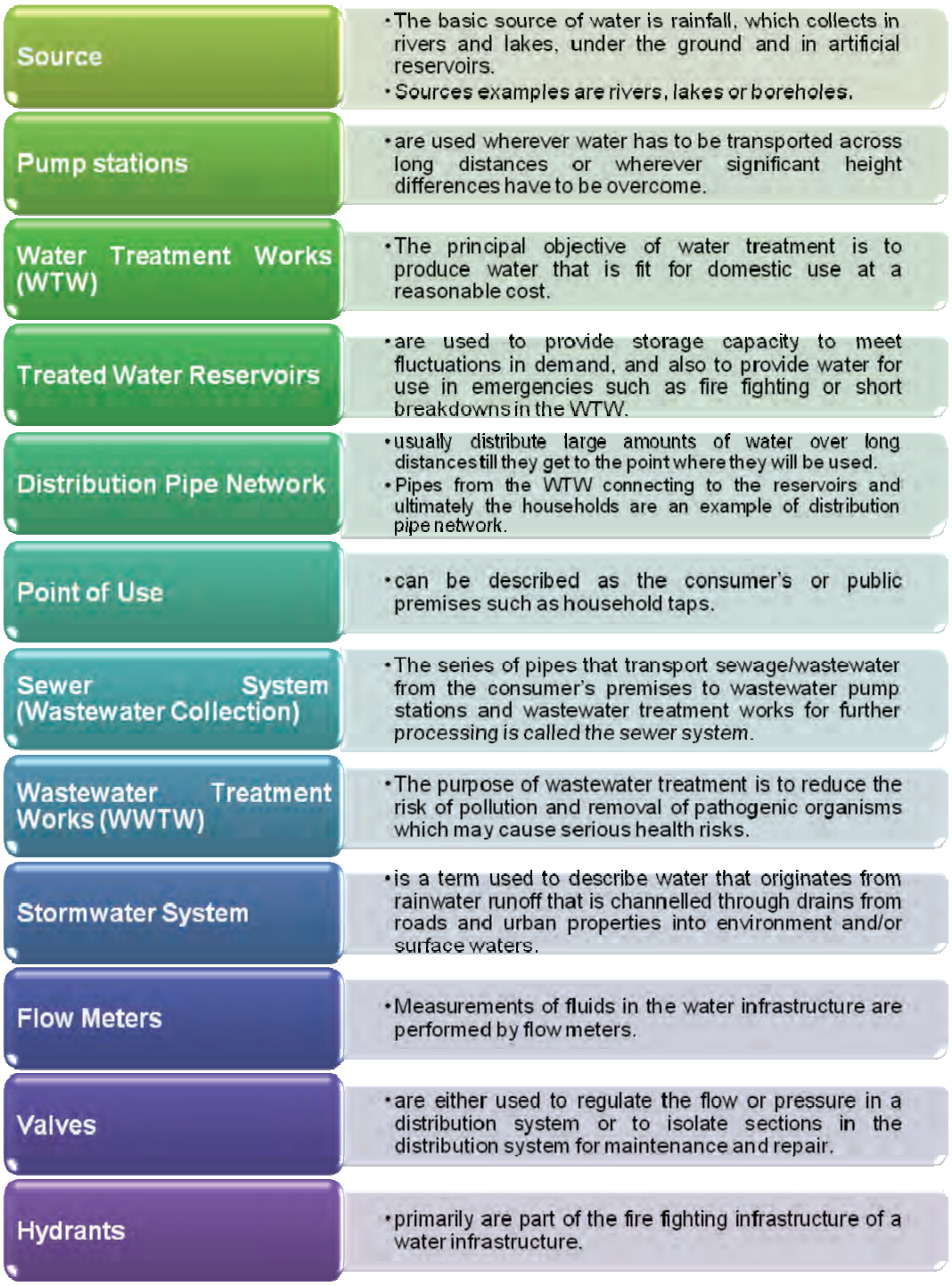
2.1 Introduction

Infrastructure Asset Management (IAM) refers to the ability to maintain a desired level of service of available assets at the lowest life cycle cost. IAM is generally implemented through an Asset Management Programme which includes a documented Asset Management Plan.

As water services infrastructure needs to be managed within an integrated social, economic and environmental context, the conventional focus on technical reliability is no longer sufficient to keep water services systems operational, profitable and sustainable. Importantly, IAM principles and methods can help introduce discipline and logical processes into water services related activities (and in particular planning, which is a current weakness) within South Africa. The sections below define IAM principles and key components to manage the assets.

2.2 Typical Water Services Assets

When asset management is spoken about in water services, most focus is given to the physical infrastructure listed below:



It is, however important to also consider other assets within WSIs that without due consideration, would prevent the traditional physical assets from functioning effectively. These additional water services assets are often "non-physical" in nature, and examples include:

- Plans (e.g. Master Plan)
- Operations and Maintenance (O&M) Support (e.g. offices, workshops, tools, vehicles)
- Human Resources (e.g. process controllers)

- IT Services and Management (e.g. computers, servers)
- Institutional Memory (e.g. knowledge)
- Financial Resources (e.g. cash in bank)
- Suppliers (e.g. chemical, contractors)
- Customers (e.g. served communities, industries)

A good starting point for understanding asset management for any water/wastewater system is to review the framework for asset management as described by Stephenson et al (2007). This framework provides guidance for all major activities associated with asset management, provides the foundation for many asset management best practices, and importantly can be implemented at the level of sophistication that is appropriate to the system in question.

2.3 Asset Management Plan

An asset management plan is a programme that details the capital works and other expenditure associated with maintaining the condition and performance of the water services institutions assets. A typical asset management plan focuses on physical assets and is comprised of Stephenson et al (2007):

- Procedures for preparing and updating the asset management programme.
- A statement of the water services authority (or provider) relevant standards and policies.
- A list and description of all asset sub-systems and their use (e.g. water supply, water distribution, sewage, sewage treatment and disposal).
- Physical infrastructure asset register containing information on the performance and condition of the principal components of each sub-system.
- A short term (say 5 year) relatively detailed investment plan to meet shortfalls in the performance and conditions determined for each sub-system.
- A medium to long term investment estimate for on-going sustainable services (considering both current and future demand).

2.4 Infrastructure Asset Management Principles

The five main elements of infrastructure asset management (IAM) are (Global Water Research Coalition, 2009):

Figure 1: *Key elements of Infrastructure Asset Management*

This guide is focusing on the risk assessment and determination element of asset management. Important guiding principles for IAM adapted from DWA (2008) and Global Water Research Coalition (2009) include:

- ***Systems approach***
  - Consider the entire delivery chain, identify system constraints, and then methodically address these (prioritizing the most serious constraints).

- ***Infrastructure Asset Management is an integral part of ongoing service delivery***
  - Continuous process and not a once-off project or an event.
  - Improvement is planned, with progressive improvement tracked.
  - As demands, performance objectives, technologies, etc. change with time, the process is not static but must be adapted to meet changing requirements.
  - Should be a day-to-day activity of infrastructure owners.

- ***Water services focus***
  - Focus on improving water services infrastructure asset management, and not the management of water resource infrastructure or other municipal infrastructure (e.g. roads, electricity, etc.).

- ***Infrastructure Asset Management focus***
  - Formulate priority actions to address infrastructure asset management specific issues.

- ***Recognition that water services delivery is both a human right and commodity-based***
  - Water services infrastructure is utilized to treat, convey or store water.
  - The quality of water services is directly linked to the protection of the resource, and the quality of water supplied/effluent discharged, and its associated impact on the health and safety of consumers and/or the environment.

- ***Outcomes-based***
  - Each priority must be outcomes-based and measurable.

- ***An appropriate mix of short term successes and long term sustainability***
  - Recognition that although the full establishment of infrastructure asset management practices (and associated benefits) has a medium to long term horizon, short term successes are not only possible, but are essential to establish credibility, harness support and improve already failing service standards.

- ***Promotion of an integrated, inter-disciplinary and inter-sectoral approach***
  - As infrastructure asset management operates at the interface of several functional disciplines (e.g. accounting, town planning, engineering, political leadership), an integrated, inter-disciplinary and inter-sectoral approach is essential for success.

- ***Focus on the key challenges, and prioritise***
  - Acknowledge that not all challenges can be addressed simultaneously, and therefore identify key challenges and prioritise those.

- ***Adoption of the Pareto (80/20) Principle***
  - The 80/20 Principle (or rule) considers that a small proportion of the full effort (20%) is generally required to achieve close to the desired result (80%), and that further efforts are often subject to diminishing returns.
  - The 80/20 Principle is usually valid for infrastructure asset management, where a first order assessment can be used to rapidly determine the most critical issues. Implementation of first steps to resolve these issues can already lead to significant improvement.

- ***No one size solution fits all***
  - Recognize that no water services institution is alike, and that appropriate infrastructure asset management will differ from institution to institution.

- ***Start with the basics, and get them right***
  - The approach must be incremental, with initial focus on ensuring that the basics are right, before proceeding with further improvements.

- ***Political, management and operational focus***
  - All levels within water services institutions (e.g. politicians, municipal manger, technical manager, supervisors, process controllers, technicians, etc.) must commit to infrastructure asset management in order for it to be successful.

2.5 Asset Life Cycle

Traditionally, asset management focuses on management of physical infrastructure (e.g. water treatment works, pipelines, etc.). In such projects, the typical life cycle generally includes the following steps:

- ***Policy formulation and implementation*** – Developing a policy (statement of what is intended) and implementing that policy.

- ***Planning*** – What activities or tasks are required; how will they be done?

- ***Design*** – What will the structure look like; how will it function, etc.?

- ***Construction*** – Building the components.

- ***Commissioning*** – Making the new structure operational; training staff to use new structure, etc.

- ***Operation*** – Day-to-day running of the structure.

- ***Maintenance*** – Day-to-day upkeep of the structure.

- ***Upgrading and/or refurbishment*** – Delaying replacement of the structure by adding new functionality or overhauling existing structures.

- ***Decommissioning and/or replacement*** – Where upgrading or refurbishment is no longer possible, a structure may need to be replaced.

Considering the above, a typical asset life cycle is shown in the following figure.

Figure 2: *Typical Asset Life Cycle*

In order to assist with ensuring maximum usefulness and lifespan of the asset, consideration must be given to all of the above elements.

Most importantly, the first step in managing assets is understanding their current state. As some of this information may be difficult to find, estimates can be used when necessary. For example, the pumps age can be estimated by determining the maintenance cost. If the maintenance cost is closer or even higher than the new pump cost, then it has reached its life span and it needs replacement. In addition, water services institutions should ideally ensure that all projects are planned for the full life cycle of the asset, and that all life cycle elements and costs are considered.

Stephenson et al. (2007, Appendix A) provides practical examples for evaluating assets. By way of example, the table below indicates useful life for typical assets.

Table 1*: Example of recommended values of useful life for assets of typical WSI*

Asset	**Useful life (years)**
Storage Reservoirs/dams	20
Treatment works: civil	60-70
Treatment works: Mechanical/electrical	15-25
Service reservoirs	50-80
Pumping stations: Civil	60-70
Pumping stations: mechanical/electrical	25
Distribution pipes	65-95
Manholes	20-50

2.6 Asset Management

Although water service institutions may have developed asset management plans, it has been widely reported that implementation of asset management plans is still a great challenge in the water sector in South Africa (Keuris, 2006; Wall, 2007 and CSIR, 2007). Byrne (2006) and the recent Blue and Green Drop reports (2010) have reported that the key causes and challenges associated with failure to implement asset management include:

- Water services institutions allow asset management activities to be completed by their consultants and never take ownership of the outcomes.

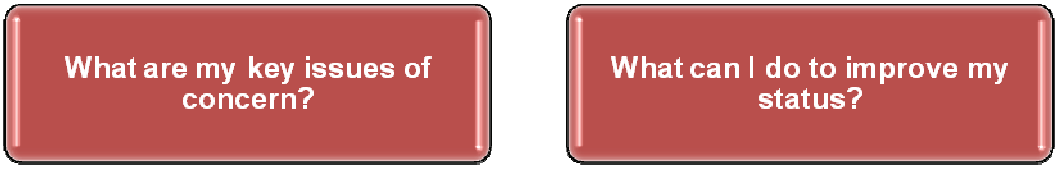
- Inadequate training is undertaken to raise the awareness and understanding of asset management across the entire organisation.
- As benefits associated with asset management are often only of a long term nature, there is a difficulty in quantifying immediate benefits of asset management and, more importantly, convincing the elected councillors that asset management is indeed beneficial.

In terms of understanding the requirements and approach for asset management, South Africa is on the same level as those considered national best practice models (Australia and New Zealand). This is verified by the fact that South Africa launched the International Infrastructure Asset Management (IIMM) in 2006, which was developed by participation from various countries.

Considering the previous sections, this guideline aims to empower and assist technical personnel at water services institutions with improved infrastructure asset management, and in particular assist with:

- Analysing the existing situation, and
- Identifying what corrective actions can be taken.

To facilitate the above, the following sections describe each of the main components of the typical asset life cycle in sequence, and assist with determining:



3 VULNERABILITY AND RISK ASSESSMENT

3.1 What Is A Threat? What Is Vulnerability? What Is Risk?

Before we begin, it is important to have an understanding of the terminology.

Threats can be defined as an indication or warning of probable trouble. Identifying the threat level is a critical step in understanding the level of protection required in a water supply system. There are many threats that may put at risk the ability to provide reliable and safe supply of water to customers. In South Africa, internal municipal challenges to effective water service delivery can also be defined as threats.

Vulnerability is an exploitable weakness or deficiency. The vulnerability of assets is generally defined as the *probability or likelihood* of a threat or challenge occurring, while considering:

- Prior history (i.e. has the event occurred in the past?).
- Control/intervention measures (e.g. do we have a fence in place?).
- Redundancy (e.g. do we have more than one reservoir to service an area?).
- Back-ups (e.g. do we have a stand-by generator to deal with power failures?).
- Alternatives (e.g. do we have access to a different chemical supplier?).

It is of importance to note that vulnerability and risk assessments are subjective, and therefore need (a) to be completed by a competent individual (preferably more than one person), and (b) require careful consideration. It is therefore best to include comments as far as possible to indicate how a decision was made.

Risk is usually expressed as a function of the probability of the occurance of an adverse condition and the consequence on the ability to maintain function. As such, risk can be calculated by considering:

- The *vulnerability* of the asset (*i.e. the probability or likelihood of an undesirable occurance to that asset*), and
- The resulting *consequence or impact* to the asset (i.e. the potential damage to or loss of an asset).

Probability/Likelihood is a way of expressing knowledge or belief that an event will occur or has occurred. It is a chance of an event occurring.

Consequence/Impact is the effect, result, or outcome of something occurring earlier.

3.2 Objectives of Vulnerability and Risk Assessments

A vulnerability and risk assessment is a step by step evaluation of the system and its operations that assesses the ability to reduce vulnerability and/or risk of different threats and identify corrective actions that can reduce or minimise the risk of serious impact from challenges or threats. Such an assessment for a water system takes into account the vulnerability and risk of the water supply system including distribution, drinking and wastewater treatment, storm water, etc. An effective vulnerability and risk assessment identifies the WSA's critical assets. The vulnerability and risk assessment provides a framework for developing risk reduction options and determining associated costs to enable this.

The objectives of vulnerability and risk assessments are to:

- Identify threats to the water system assets (e.g. infrastructure, employees, information, finances, etc.).
- Identify the specific assets that may be impacted by the identified threats and relative criticality of these assets (e.g. do we have back up?)
- Determine the likelihood that a threat may materialize (e.g. has this happened before?)
- Calculate the impact of losing part or all of the water system assets (e.g. is it only one item of equipment that will not function or will the whole system be affected such that water cannot be provided?)
- Evaluate existing corrective actions (e.g. do we have measures in place to prevent this from happening?)
- Analyse current risks associated with threats and assets (e.g. water quality will be compromised)

- Identify additional corrective actions and prioritise based on a risk reduction analysis (i.e. identify what changes will have the biggest positive impact).

It will be helpful to remember throughout the assessment process that the ultimate goal in conducting vulnerability and risk assessments is to:

- Safeguard public health and safety
- Reduce the potential for disruption of a reliable supply of safe water
- Properly manage storm water and wastewater
- Improve safety and prepare for emergencies
- Provide a secure workplace for employees
- Provide security to management practices
- Provide measures to minimize insider threats (e.g. disgruntled staff)
- Protect computer access, data and communications
- Protect the public from negative outcomes of threats

Municipalities can use a variety of existing information as part of reviewing their current organisational security strategies. In addition to these, and through this project: *Guidelines on Determining the Vulnerability and Risks of Water Services Infrastructure*, vulnerability and risk assessment tools were developed to assist in assessing vulnerabilities and risks associated with water services infrastructure. Although the tools will be discussed in detail at a later stage, some screenshots are included indicating how the typical steps of a vulnerability and risk assessment are captured within the tools.

3.3 Vulnerability and Risk Assessment Approach

The basic elements of a vulnerability and risk assessment include the following process:

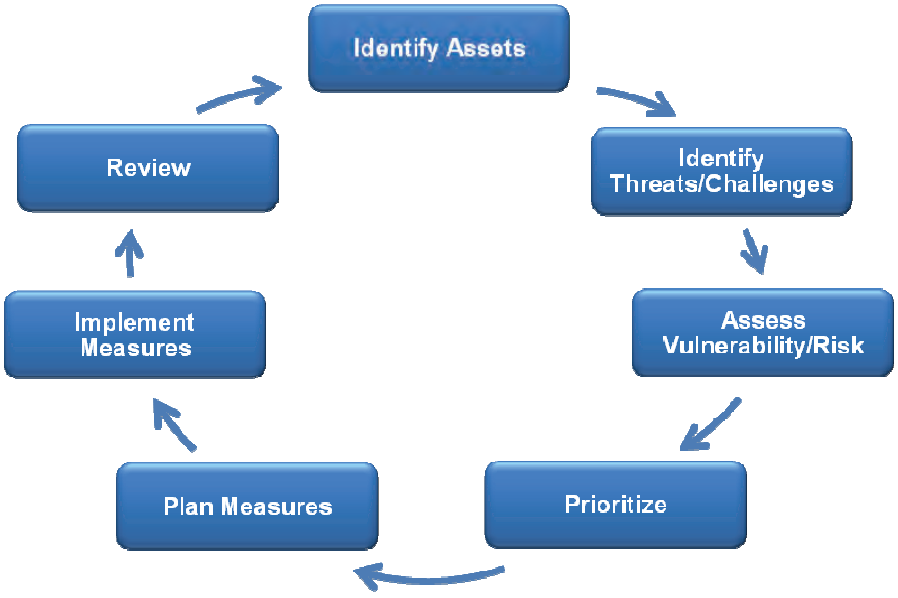


Figure 3: *Stepwise flow for using the Vulnerability and Risk Assessment*

Examples of typical steps in conducting vulnerability and risk assessments are presented below.

1) Asset Register/inventory – include characterisation of the water system

A list of components that are applicable to the water services infrastruture should be made. Physical assets details could include information such as location, age, value, condition, performance, etc. The list could also consider non physical assets such as water services planning, institutional memory, human resources, finances, etc.

2) Identify threats – include identifying and prioritizing undesirable conditions to avoid

As previously noted, internal municipal threats to effective water service delivery can also be defined as challenges. The table below lists examples of top threats and/or challenges in water services.

Table 2: *Examples of threats and challenges facing water system assets*

	Examples of Threats and Challenges Facing WSAs
1	No/insufficient staff (e.g. staff numbers)
2	Unqualified/inappropriate staff (e.g. lack of technical skills or system knowledge)
3	No/insufficient budget/funds
4	No/insufficient maintenance (e.g. no scheduled maintenance)
5	No/insufficient planning (e.g. unplanned development, rapid growth)
6	Political interference in day to day operation/Lack of support from political leaders
7	Inadequate billing and revenue collection practices
8	Insufficient correlation of IDP, WSDP, budget and actual execution

3) Assess likelihood – includes assessing the likelihood of a certain threat or challenge from happening

Probability/Likelihood is a way of expressing knowledge or belief that an event will occur or has occurred. It is a chance of an event occurring. Examples of considering likelihood are:

- Prior history (i.e. has the event occurred in the past?)
- Control/intervention measures (e.g. do we have plans or physical barrier in place to prevent the threat from occurring?)
- Redundancy (e.g. do we have more than one unit or component?)
- Back-ups (e.g. do we have stand-by equipment)
- Alternatives (e.g. is there a different supplier?)

4) Consider consequence/impact – includes determining critical assets that might be subject to certain threats or challenges

Consequence/Impact is the effect, result or outcome of something occurring earlier. Examples of impacts include:

- A shortfall of drinking water
- Illness or deaths
- Public panic and fear of drinking the water from the system
- Costs of rehabilitating, rebuilding or decontaminating the water supply system
- Long term contamination of a water supply system
- Interruption of fire-fighting capability

- Interruption of sanitary services
- Inability to provide water
- Equipment damage
- Legal non-compliance

5) Evaluate actions – includes evaluation of existing corrective actions

Using the list of typical control/intervention measures, identify which already exist. Examples of possible control/intervention measures are provided below.

Control/Intervention Measure
Preparation of Water Master Plan
Preparation and implementation of operating procedure and maintenance schedule
Appoint appropriate wastewater treatment works process controller
Alternative water source
Install a razor mesh fence

6) Plan to reduce vulnerabilities/risks – includes analysis of current vulnerabilities/risks and development of a prioritised plan for vulnerabilities/risk reduction

Using the list of typical control/intervention measures, identify what is still required and estimate associated cost. That is, propose new and/or improved existing control measures. Example of such an exercise is provided below.

Control/Intervention Measure	Units Required	Cost per unit (R)	Cost (R)
Preparation of Water Master Plan	1	100, 000	100,000
Preparation and implementation of operating procedure and maintenance schedule	2	-	
Appoint appropriate wastewater treatment works process controller	3	70, 000	210, 000
Alternative water source	1		
Razor mesh fence	2	7, 000	14, 000
TOTAL			**324 000**

NOTE: Risk is best assessed and analysed if quantified because risk is related to the likelihood of occurrence and the severity of the impact. To generate a quantified result, both probability and criticality should be stated.

In summary, basic elements of a vulnerability and risk assessments are presented in the table below.

Table 3: *Basic elements of a vulnerability and risk assessment*

	Elements	Points to consider
1.	Identify assets	➢ Look at the entire system, including customers served and system components. Define the highest priority services provided by the water services. ➢ Identify the most important facilities, processes and assets of the system for achieving the desired function and avoiding undesired consequences.
2.	Identify threats	➢ Identify types of threats that could substantially disrupt the ability of the system to provide a safe and reliable supply of drinking water or otherwise present significant public health concerns to the surrounding community/environment. ➢ Identify and define ranges of these impacts for each of the events (e.g. magnitude of service disruption, economic impact, impact on public confidence, chronic problems arising, and number of illnesses).
3.	Consider consequences	➢ Consider undesirable acts that could reasonably cause undesired consequences. ➢ Consider how each identified threat could affect the system, from the smallest possible impact to the worst case scenario.
4.	Assess likelihood	➢ Determine possible modes of undesirable acts that might result in impact of significant concern especially for system critical assets (based on the critical assets of the water system).
5.	Evaluate existing counter measures	➢ Identify currently employed measures/strategies for detecting issues (e.g. alarm), delaying issues (e.g. access control) and responding to issues (e.g. emergency plans). ➢ Evaluate the effectiveness of these strategies to protect the system.
6.	Plan to reduce risks	➢ Develop a list of recommended actions that will reduce the system's vulnerability to threats. ➢ Rank the actions by the urgency for rectification. ➢ Consider short and long term solutions to each of the vulnerabilities identified in the system.

Once the vulnerability and risk assessment is complete, an indication as to which of the system components are most vulnerable against the specific identified threats becomes clear.

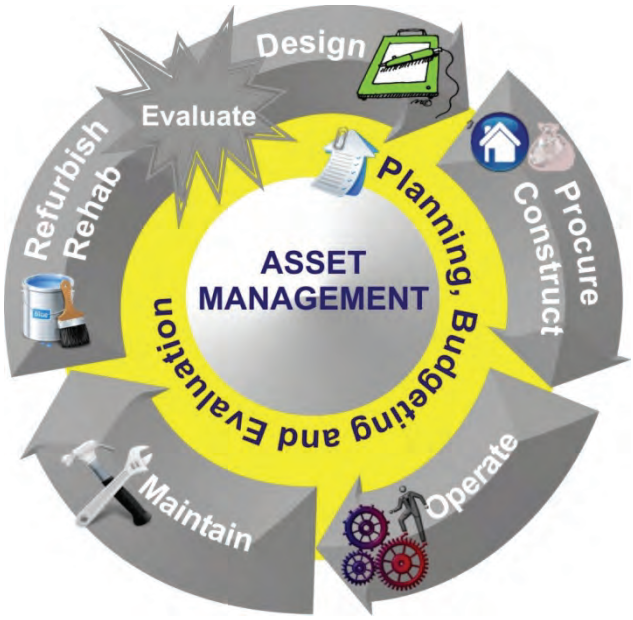
It is important that the above be considered and utilised within any asset management activity. In summary, the following actions should be considered in asset management:


PLAN
• Plan your activity
DO
• Carry out the activity
CHECK
•Evaluate whether you have achieved what you have set out to do and the efficiency and effectiveness
ACT
• Adjust your plan accordingly if you did not achieve what you set out to do, or improve on existing achievements

SECTION 2: WATER SERVICES INFRASTRUCTURE VULNERABILITIES AND RISKS MANAGEMENT GUIDELINES

PART 1

GENERAL PLANNING PRINCIPLES



1 PLANNING, BUDGETING AND continuous evaluation

The most effective means of consistently ensuring functional and effective water system infrastructure is through the use of a comprehensive risk assessment and management approach that encompasses all components in the water system. Fundamental to successful execution of such activities is proper planning. Furthermore, asset-based project planning should ideally consider all stages and components of the asset life cycle, and that all requirements are effectively budgeted for.

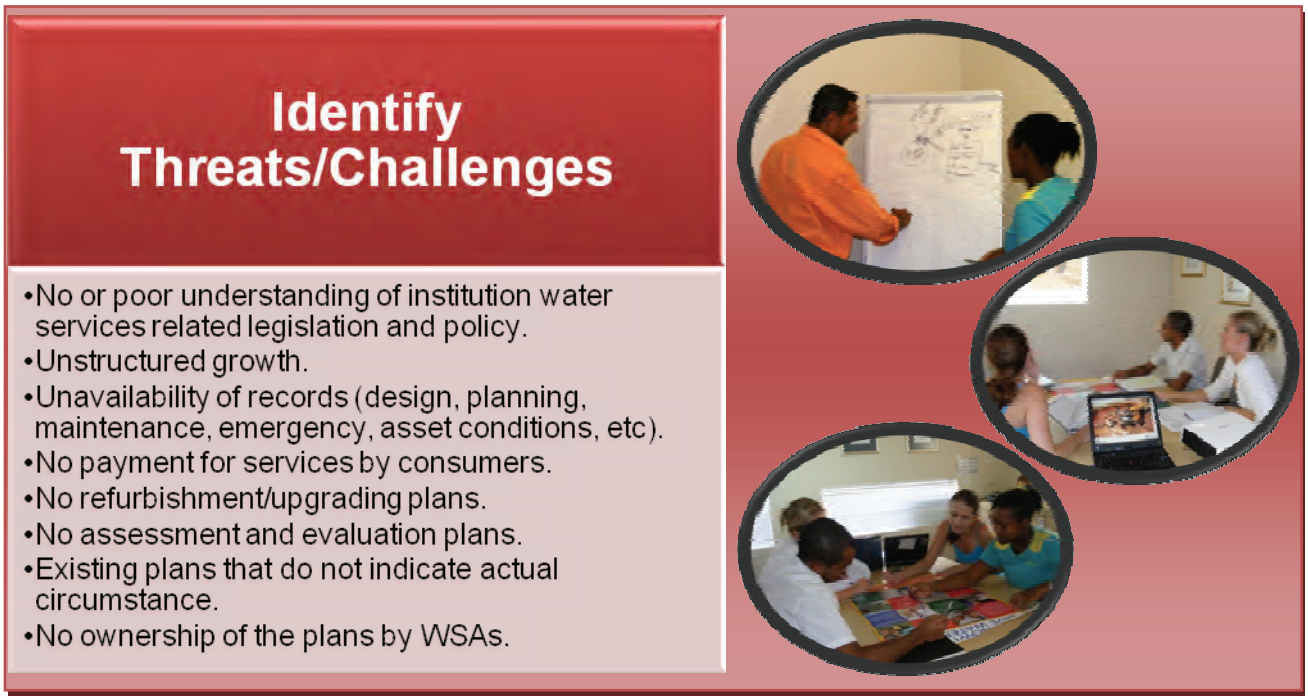
In terms of Section 84 of the Municipal Structures Act of 1998, the responsibility for providing water services rests with Water Services Authorities (WSAs). The **responsibilities of WSAs** include:

- Should ensure that all consumers have access to at least basic level of water and sanitation services.
- Should plan water services through a five year Water Services Development Plan (WSDP).
- Should develop policies and by-laws to regulate and govern delivery of water and sanitation.
- Should ensure effective water services provision – this function can be fulfilled by the WSA itself or it may contract a Water Services Provider (WSP). The **responsibilities of WSPs** include:

    - Daily operation of the water services infrastructure.
    - Repairs and maintenance.
    - Connecting customers to services (provision of water and sanitation).
    - Meter readings for house connections.
    - Billing and revenue collection.
    - Monitoring water services and reporting.
    - Conduct customer relations and awareness.

1.1 Typical Challenges and Threats – Infrastructure Planning and Budgeting

Typical examples of planning, budgeting and continuous evaluation threats/challenges include:

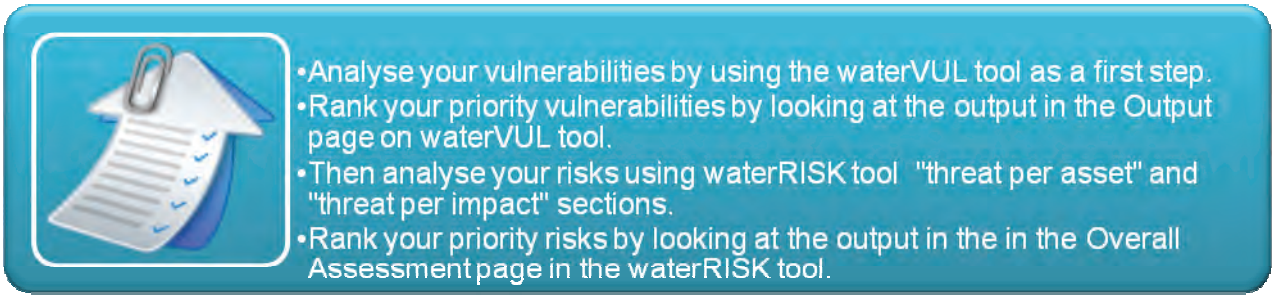


1.2 Rank/Prioritise Threats – Infrastructure Planning and Budgeting

Understanding impacts of the threats assist in prioritizing needs and actions. Below are typical impacts of identified planning, budgeting and continuous evaluation threats.

Threats	Possible Impacts
• Legislation/policy incompliance • Unstructured growth • Unavailability of records • Poor allocation of budget • Non payment for services by consumers • No refurbishment/upgrading plans • No assessment and evaluation plans • Existing plans that do not indicate actual circumstance • No ownership of the plans by the WSA	• Legal non-compliance • Inability to provide services • Illegal connections • Inability to effectively plan • Inability to effectively operate and maintain • Equipment failure • Limitation of plans implementation • Insufficient institution finances • Ineffective allocation of budget

1.3 Analyze Risks – Infrastructure Planning and Budgeting



1.4 Corrective Measures – Infrastructure Planning and Budgeting

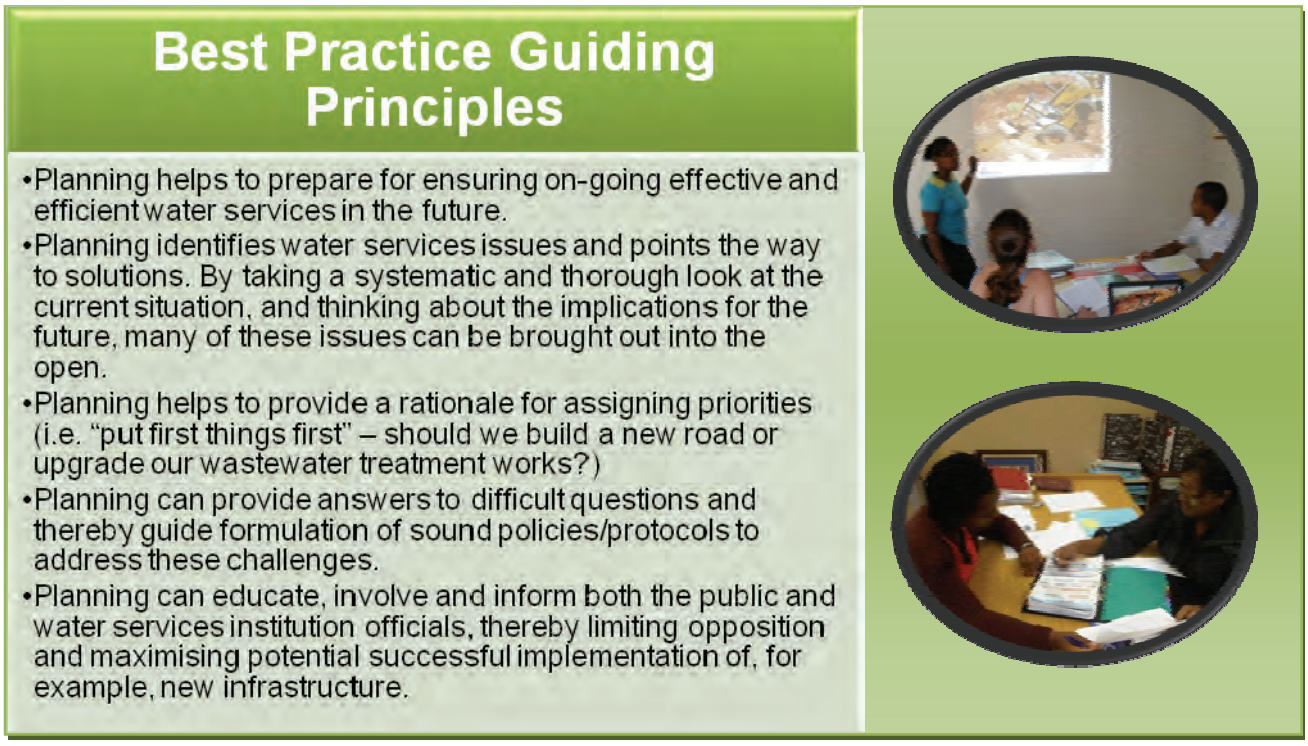
Planning corrective measures checklist is included in the following box. Do you have? ✓ ☐

- ☐ Water Master Plan prepared
- ☐ Sewage Master Plan prepared
- ☐ Stormwater Master Plan prepared
- ☐ Water Services Development Plan (WSDP) prepared
- ☐ Integrated Development Plan (IDP) prepared
- ☐ Water treatment works operating procedure and maintenance schedule prepared
- ☐ Reservoir operating procedure and maintenance schedule prepared
- ☐ Distribution network operating procedure and maintenance schedule prepared
- ☐ Sewage system operating procedure and maintenance schedule prepared
- ☐ Wastewater treatment works operating procedure and maintenance schedule prepared
- ☐ Human resources policy, plans and procedures prepared
- ☐ IT systems policy, plans and procedures prepared
- ☐ Institutional memory policy, plans and procedures prepared
- ☐ Emergency plans, plans and procedures prepared
- ☐ Disaster management policy, plans and procedures prepared
- ☐ Financial management policy, plans and procedures prepared
- ☐ Supplier/contractor contracts prepared
- ☐ Customer contracts prepared

- [ ] Customer information sharing policies, plans and procedures prepared
- [ ] Customer complaints policies, plans and procedures prepared
- [ ] Customer billing system implemented
- [ ] Evacuation plans (e.g. fire, bomb) prepared
- [ ] Backup of key documents kept
- [ ] Backup of data/information kept
- [ ] Back-up of key IT applications kept
- [ ] Water services infrastructure assessment and evaluation plans conducted
- [ ] Plans for unanticipated failures (e.g. theft, vandalism, hazardous material release, power or telephone service disruption, labour strike, etc.
- [ ] Boil water notice prepared
- [ ] Community awareness programmes implemented
- [ ] Public address or other warning systems prepared

1.5 Best Practice Guiding Principles – Infrastructure Planning and Budgeting

Key justifications for planning include:



Considering the above, the most important plans that need to be generated for water services include:

- Water Master Plan
- Sewage Master Plan
- Stormwater Master Plan
- Water Services Development Plan (WSDP) for inclusion into the Integrated Development Plan (IDP)
- Asset Register and associated Asset Management Plan
- Skills Development Plan (as per the requirements of Skills Development Act of 1998).
- Safety Plan (as per the requirements of the Occupational Health and Safety Act of 1993).
- Protocols, policies, procedures and work instructions for both day-to-day operations and maintenance (e.g. service schedules) and emergency situations

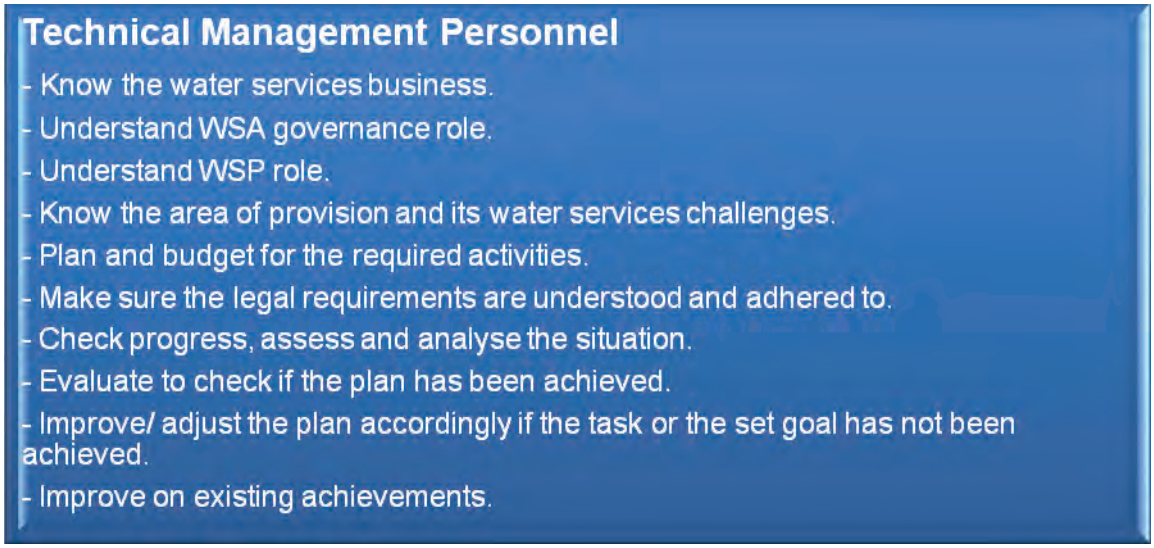
In developing and implementing the above plans, the following key principles of effective management should be noted:

- ***Plan generation and associated budgeting:*** Both managers and other technical staff need to understand what plans they should develop and implement. A wide variety of topics need to be planned for including, for example, the need to expand the water treatment works, a desire to improve the efficiency of the treatment process or to improve working conditions. The plan needs clear aims and objectives, how to deal with changing circumstances (issues and risks arising) and what resources (people, money, time) will be needed to implement the plan. If, for example, cash flow for the project is limited, progress with plan implementation will be affected. Finally, mechanisms should be established to periodically review and, where necessary, revise plans and budgets to reflect changing circumstances.
- ***Organising:*** Once the plan is in place the work force that will implement the plan should be mobilised. This includes, for example, setting up ways of doing things (procedures, protocols, work instructions), how shifts should be arranged, procedures for repairs and maintenance, systems for reporting, job descriptions for each employee, etc.
- ***Controlling (Monitoring):*** To ensure effective plan execution, control over staff, day-to-day operations and costs is essential. Each employee should know what is expected of him in terms of both performance and discipline. It is a good idea for a supervisor to meet with his subordinates at regular intervals to discuss progress and performance.
- ***Review:*** It is necessary to regularly review progress versus planned activities. If activities are not proceeding as planned, it is important to understand why this has occurred and implement suitable corrective actions to address the identified deficiencies. At the end of any project, with the objective achieved and task completed, there should be a final review so that any lessons learnt can be noted for future planning.
- ***Communication:*** One of the important factors in good management is the ability to communicate effectively with others. This includes both giving instructions and reporting activities or events to a senior person. Effective communication to communities through awareness programmes helps consumers to understand and contribute to improved water services (e.g. reduces vandalism, reduce water wastage, identifying leaks in the distribution system).

- ***Record keeping:*** Keeping records of all aspects of the construction, operation and maintenance of water services infrastructure assists with planning future needs. The records also reflect the overall efficiency of the assets. Record systems should be kept as simple and focused as possible. Maintenance records assist in timeously servicing and repair of equipment and vehicles. For controlling and budgeting of expenses, it is important to have records of what work was done, by whom and how much was spent on materials. From these records, management reports can be compiled which contain an interpreted summary of all data collected during the month. From this data, operating parameters reflecting performance of assets can be indicated which will assist in on-going process control.

1.6 Summarised Actions – Infrastructure Planning and Budgeting

In summary, the actions that need to be carried out include:



1.7 Available Resources – Infrastructure Planning and Budgeting

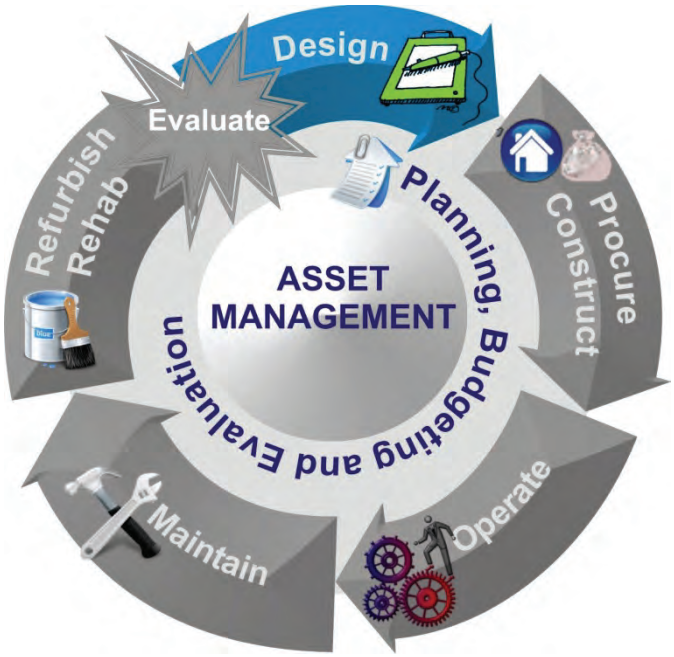
The following best practice resources are readily available to assist with infrastructure planning aspects:

Examples of other Available Resources

- National Water Act (Act No 36 of 1998) Republic of South Africa
- Water Services Act (Act No 108 of 1997) Government Gazette. Republic of South Africa
- van Zyl F, Manus N and Pensulo C (2008) Water Services: Infrastructure Asset Management for municipal managers and management. Municipal Indaba 2008
- Department of Water Affairs, Northern Cape (2007) Sanitation Operations&Maintenance Handbook
- Asset Register and associated Asset Management Plan - examples including case studies are available in Stephen et.al (2007) Asset Management for the water services sector in South Africa.
- Skills Development Plan - more information is available on www.saqa.org.za.
- Protocols, policies, procedures and work instructions for day-to-day operations and maintenance. Examples and templates are available in DWA, NC (2007) Sanitation, Wastewater and Solid waste services.
- Water Research Commission and DWAF (2006): *The applicability and economic consideration of various wastewater treatment technologies to effluents arising from water borne sewage technology evaluation model.* Golder Associates Africa and Zitholele Consulting

PART II

GENERAL DESIGN PRINCIPLES



2 DESIGN

Design is not a once-off task at the start of a project or an item only to be considered in the early stages of the life cycle of an asset. Periodic review of the existing design of the infrastructure is essential to determine whether the initial design principles are still relevant and whether the infrastructure is still capable of meeting its specified functional requirements. If these conditions are not met, re-design (followed by construction, etc.) may be required.

2.1 Typical Challenges and Threats – Infrastructure Design

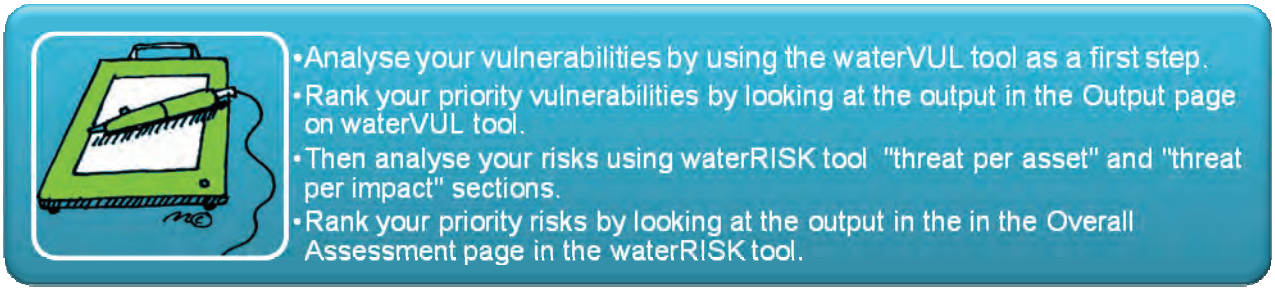
Typical examples of design related challenges and threats include:

2.2 Rank/Prioritise Threats – Infrastructure Design

Understanding impacts of the threats assists in prioritizing needs and actions. Below are typical impacts of identified design threats:

Threats	Possible Impacts
• Unqualified personnel • Incorrect material • Design specifications not followed • Lack of contamination prevention • Unsecure entry points • Unavailability of monitoring points • Safety and security not incorporated • Not considering future expansion • Not considering power backups	• Poor quality of the job • Delay in doing the job • Damage to structure • Equipment failure • Inability to provide service • Major health implications • Loss of life • Legal non-compliance • Inappropriate operation and maintenance

2.3 Analyze Risks – Infrastructure Design



2.4 Corrective Measures – Infrastructure Design

Design corrective measures checklist is included in the following box. Do you have? ☑

- ☐ Redundant water source(s) (e.g. surface, ground) provision
- ☐ Redundant water intake structure(s) provision
- ☐ Redundant raw water transfer pump(s) provision
- ☐ Redundant raw water transmission line(s) provision
- ☐ Redundant water treatment chemical tank(s) and dosing pump(s) provision
- ☐ Redundant water treatment unit process(es) (e.g. settling tanks, filters) incorporation
- ☐ Redundant treated water clear well(s) incorporation

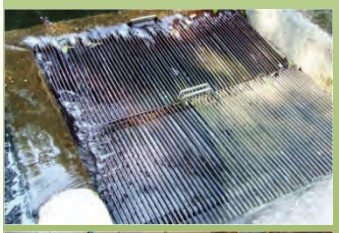
- [ ] Redundant treated water transfer pump(s) provision
- [ ] Redundant treated water transmission line(s) incorporation
- [ ] Redundant treated water storage option(s) provision
- [ ] Redundant raw sewerage line(s) provision
- [ ] Redundant wastewater treatment chemical tank(s) and dosing pump(s) provision
- [ ] Redundant wastewater treatment unit process(es) (e.g. settling tanks, tanks) incorporation
- [ ] Redundant treated effluent tertiary treatment/storage provision
- [ ] Alternate electric switching equipment incorporation
- [ ] Alternate power sources provision
- [ ] Back-up power generation on-site provision
- [ ] Knowledge of possible natural threats in each area availability
- [ ] Knowledge and/or consultation of National Standardized Specifications for Engineering Construction availability.
- [ ] Locate structures where natural conditions such as floods, storms, etc. are avoided
- [ ] Structures materials of construction to withstand storms, floods, etc.
- [ ] Proper selection of materials of construction as described in SANS 1200:1996 series and SANS product specifications
- [ ] Proper construction of a system according to SANS 1200:1996
- [ ] Pollution prevention practices (e.g. source water protection, final treated water protection)
- [ ] Compliance with environmental protection guidelines and regulations ensured
- [ ] Accessibility of structures by vehicles consideration
- [ ] Protection from interference from human activities consideration (e.g. reservoir covers, manhole covers, etc.)
- [ ] Population increase consideration incorporation
- [ ] Water quality monitoring points within structures incorporation
- [ ] Appropriate operation and maintenance structures/equipment installation (e.g. meters, isolation valves, scour valves, etc.)
- [ ] Knowledge of wastewater lines location when installing drinking water lines availability
- [ ] Safety features incorporation (e.g. safety rails,
- [ ] Signs incorporation (e.g. “no entry”)

2.5 Best Practice Guiding Principles – Infrastructure Design

The following best practice guiding principles should be considered for all components:

Best Practice Guiding Principles

- Appoint qualified and skilled designers (i.e. proven track record).
- The design should consider local geological and climatic conditions (e.g. stability, frequency of flooding).
- The design should ensure that envisioned future increased needs (e.g. from population increases) are met for the lifespan of the infrastructure.
- The design should consider need for future expansion (e.g. sufficient land available).
- Water services assets should be designed to cater for fluctuations (e.g. changes in raw water quality entering a water treatment facility).
- Availability of power and associated frequency of power failures should be catered for (e.g. need for auxiliary power, on-site generators).
- Engineering design drawings of all water services assets must be developed and appropriately archived.
- Ensure that the component to be constructed considers local circumstance (e.g. construct a membrane based water treatment facility but replacement components (e.g. membranes) are not locally available).
- Ensure that the infrastructure design does not potentially result in contamination (e.g. pooling of stagnant water in valve chamber).
- Adequate access control (e.g. security fences, locked manhole covers, etc) to prevent unauthorised people gaining access.
- Critical control points to allow subsequent monitoring (e.g. water quality monitoring points at each unit process).








"Good design is a lot like clear thinking made visual." — Edward Tufte

2.6 Summarised Actions – Infrastructure Design

In summary, the actions that need to be carried out include:

Technical Management Personnel

Appoint qualified and skilled designers.

- Consider local geological and climatic conditions.
- Ensure design caters for possible unplanned events (e.g. emergencies, power failures), fluctuations (e.g. raw water quality change) and population growth (e.g. new developments).
- Understand design specifications.
- Understand what equipment and associated materials of construction are appropriate.
- Ensure proper record keeping of all engineering design drawings.
- Ensure design considers access control and security.
- Ensure design considers critical control points to allow subsequent monitoring of performance.

Operations and Maintenance Technical Personnel

- Provide practical, on-the-ground inputs to managers to improve designs.

2.7 Available Resources – Infrastructure Design

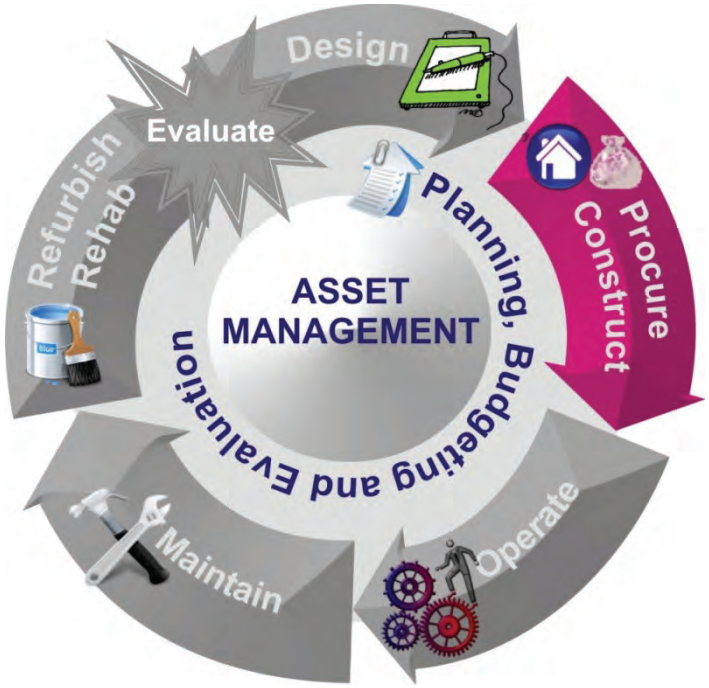
The following best practice resources are readily available to assist with infrastructure design aspects:

Available Resources

- CSIR Building and Construction Technology (2000), Pretoria; *Guidelines for Human Settlement Planning and Design*
- EPA (2002) Critical Infrastructure: Protecting America's Drinking Water Systems. Available online:http://www.awwa.org/awwa/science/wise/report/AWWA_Securiti
- Goulburn Valley Water (2007) Sewage Pump Station Design manual. Goulburn Valley Region Valley Region Water Authority, Australia
- Metcalf and Eddy (1991) *Wastewater Engineering*, 3rd Edition. Treatment, Disposal, and Reuse. McGraw-Hill, Inc. Singapore
- National Environmental Training Centre (2002) Protecting Your Community's Assets: *A Guide for Small Wastewater Systems developed*
- Qasm R Syed (1998) *Wastewater Treatment Plants: Planning, Design and Operation*. CRC Press
- Van Duuren (1997) Water Purification Works Design, *Water Research Commission Report No TT 92/97*
- Water Research Commission and DWAF (2006) Draft Report: *The applicability and economic consideration of various wastewater treatment technologies to effluents arising from water borne sewage technology evaluation model.* Golder Associates Africa and Zitholele Consulting

PART III

GENERAL PROCUREMENT/CONSTRUCTION PRINCIPLES

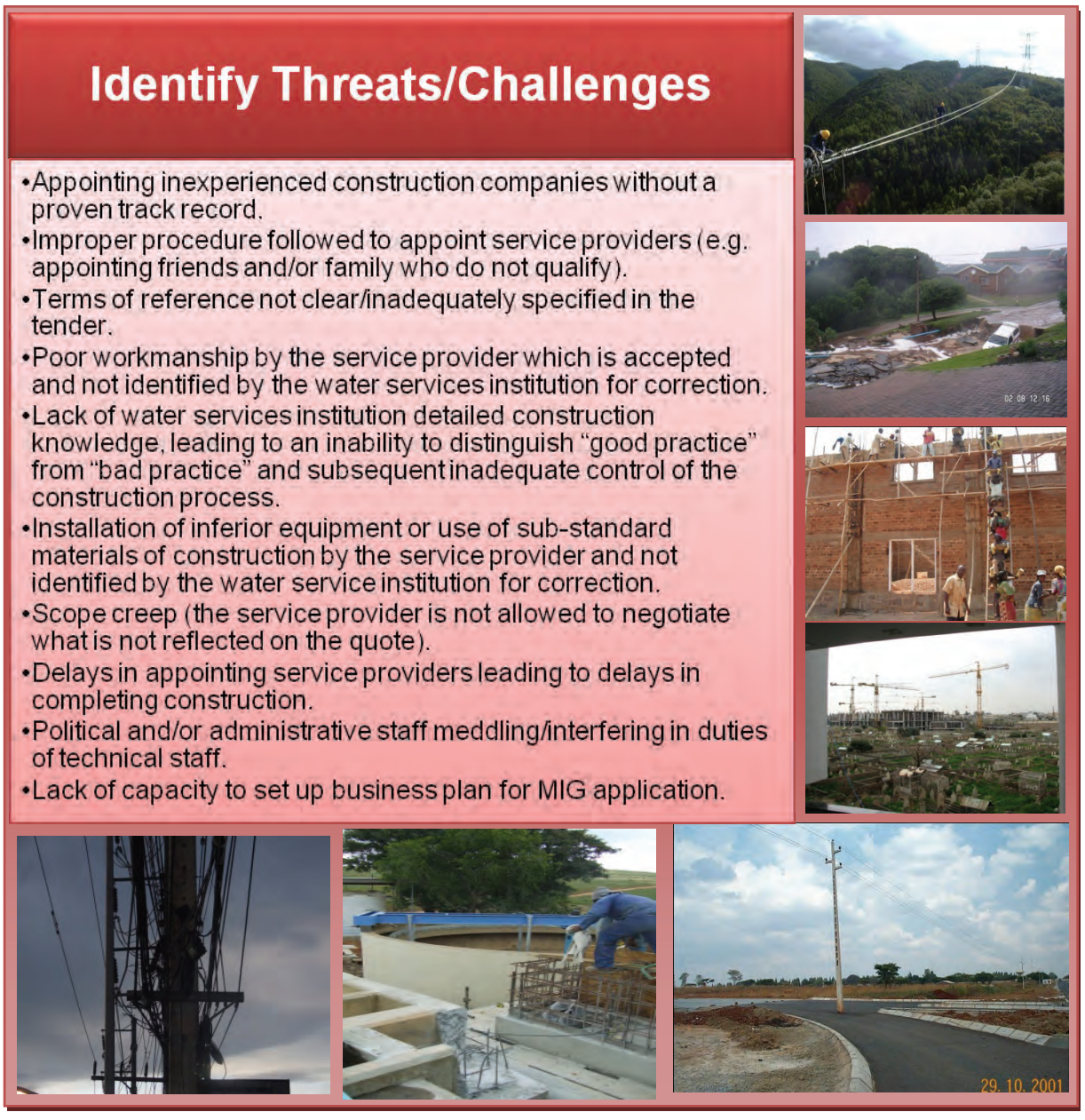


3 PROCUREMENT AND CONSTRUCTION

Once the infrastructure design requirements have been specified, the water services institution is in the position to develop a better understanding of the tasks to be performed, skills required, budget, etc. to construct the desired structure. In most instances, a construction will be via professional service provider appointed via a tender process.

3.1 Typical Challenges and Threats – Infrastructure Procurement and Construction

Typical examples of procurement and construction related challenges and threats include:

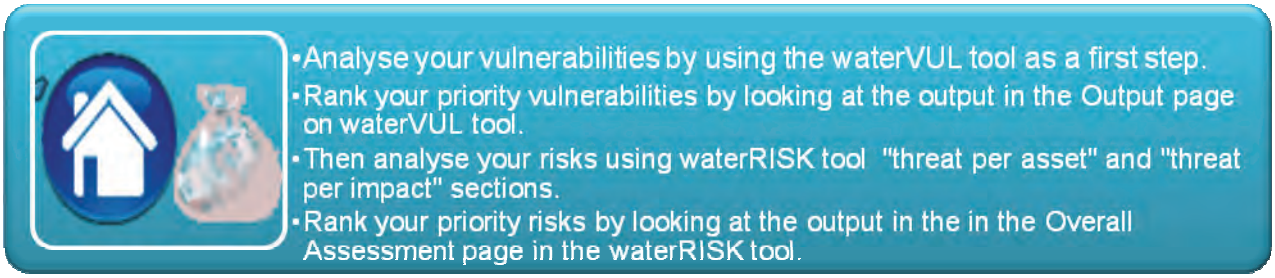


3.2 Rank/Prioritise Threats – Infrastructure Procurement and Construction

Understanding consequences of the threats assist in prioritizing needs and actions. Below are typical impacts of identified procurement/construction threats:

Threats	Possible Impacts
• Inexperienced companies • Installation of inferior equipment • Poor workmanship • Delays in appointments • Unclear terms of reference • Improper procedures followed • Scope creep • Political interference • Lack of capacity for MIG application	• Poor service quality • Delays in doing the job • Failing/collapsing structures • Equipment failure • Inability to provide service • Failure to provide services • Unsatisfactory service quality • Legal non-compliance • Misuse of funds • Poor allocation of budget • Inappropriate operation and maintenance

3.3 Analyze Risks – Infrastructure Procurement and Construction



3.4 Corrective Measures – Infrastructure Procurement and Construction

Procurement/Construction corrective measures checklist is included in the following box. Do you have or have you considered? ✓

- ☐ Understanding and corrective implementation of the institution procurement protocol
- ☐ Development of institution tendering process
- ☐ Assessment of tendering companies
- ☐ Compliance with environmental protection guidelines and regulations ensured
- ☐ Population increase consideration incorporation
- ☐ Safety features incorporation (e.g. safety rails)
- ☐ Knowledge of possible natural threats in each area availability
- ☐ Knowledge and/or consultation of National Standardised Specifications for Engineering Construction availability.
- ☐ Locate structures where natural conditions such as floods, storms, etc. are avoided

- [ ] Structures materials of construction to withstand storms, floods, etc.
- [ ] Proper selection of materials of construction as described in SANS 1200:1996 series and SANS product specifications
- [ ] Proper construction of a system according to SANS 1200:1996
- [ ] Pollution prevention practices (e.g. source water protection, final treated water protection) incorporation
- [ ] Supplier/contractor contracts prepared and signed.
- [ ] Customer contracts prepared and signed.

3.5 Best Practice Guiding Principles – Infrastructure Procurement and Construction

The following best practice guiding principles should be considered for all components:

Best Practise Guiding Principles

- Strictly adhere to municipal tendering procedures.
- Develop a detailed terms of reference/tender specification document that will ensure that the project is constructed to desired standards and ensure that preliminary designs are appropriate/adequate for tender process.
- Ensure all relevant project documentation is in place (e.g. general conditions of contract, terms and conditions, tender document, project schedule (GANTT chart), budget, etc).
- Adequately assess and manage the evaluation of proposals/tenders and associated facilitation of awards. By way of example, during tender evaluation, the capacity of all prospective service providers should be thoroughly assessed to ensure that the service provider has the necessary skills, expertise and resources to execute the project.
- The project contract should describe each side's (i.e. municipality and service provider) rights and responsibilities, type of fee (fixed fee, performance based, etc) payment frequency, etc.
- Appoint service provider, track and manage performance, ensure adherence to contract requirements and best practices in project execution.
- During tender evaluation, confirm that the service provider has staff available with necessary skills for the contract as stipulated in the *Guidelines for the Implementation of Labour-Intensive Infrastructure Projects* (2005).
- The service provider should certify that the works have been completed in accordance with the requirements of the terms of reference and contract.
- Service provider should take reasonable steps to ensure that the working environment is healthy and safe.

3.6 Summarised Actions – Infrastructure Procurement and Construction

In summary, the actions that need to be carried out include:

Technical Management Personnel

- Ensure that preliminary designs are appropriate/adequate for tender process.
- Ensure tender documents are comprehensive and complete.
- Ensure proper procurement procedures are adhered to.
- Evaluate proposals/tenders and implement projects.
- Ensure project is on time, within budget and to the required quality.
- Monitor and control supplier relationships. Communicate progress with council (when necessary).
- Approve variation orders (when necessary).
- Ensure uninterrupted service delivery to the local community.

Operations and Maintenance Technical Personnel

- Ensure technical input into tender (practical/on-the-ground experience).
- Provide technical input with respect to the tender evaluation process.
- Conduct regular site meetings with the service provider.
- Monitor project schedule and ensure project is up-to-date/on-time.
- Monitor expenditure vs. progress.
- Ensure that the service provider adheres to the water services institutions protocols, policies and procedures.
- Request quotes for required day-to-day operations including equipment (pumps, valves, pipes), tools, consumables, water treatment chemicals, etc

3.7 Available Resources – Infrastructure Procurement and Construction

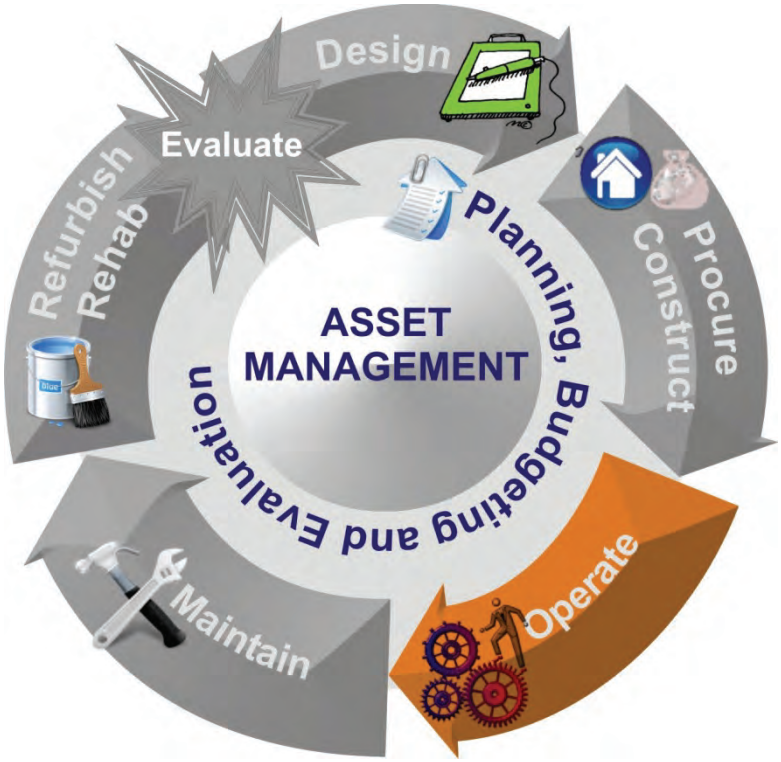
The following best practice resources are readily available to assist with infrastructure operation aspects:

Other Available Resources

- Municipal Finance Management Act, Act No 56 of 2003
- Municipal Systems Act, Act No 32 of 2000
- Public works (2005) Guidelines for the implementation of labour-intensive infrastructure projects under the expanded public works programme (EPWP)
- DPLG (2006) National MIG Management unit programme management process and procedures
- DPLG (2007) A guide for the establishment of a project management unit (PMU) by municipalities

PART IV

GENERAL OPERATIONS PRINCIPLES



4 OPERATIONS

To ensure provision of efficient, effective and consistent good quality drinking water and associated sanitation services infrastructure needs to be well operated. Good operation begins by closely adhering to operational procedures, protocols and manuals developed for the various unit processes or infrastructure components. This will ensure that the units/components function effectively and also last its intended life span.

4.1 Typical Challenges and Threats – Infrastructure Operation

Examples of operation related threats on which this section is focusing on include:

4.2 Rank/Prioritise Threats – Infrastructure Operation

Understanding consequences of the threats assist in prioritizing needs and actions. Below are typical impacts of identified operation threats:

Threats	Possible Impacts
• Insufficient staff	• Inability to do the job, poor standard operation, work delays.
• Unqualified staff	• Inability to do the job, poor standard operation, work delays.
• Lack of spare parts	• Poor standard operation, inappropriate operating procedures, unacceptable water quality, inability to provide services.
• Unavailability of manuals and operation procedures	• Inability to do the job, poor standard operation, inappropriate operating procedures.
• Lack of knowledge about operation procedures and expected outcomes	• Inability to do the job, poor standard operation, inappropriate operating procedures, lack of corrective measure plans.
• Lack of emergency operational procedures	• Lack of corrective measure plans, inability to provide services.
• Inappropriate equipment used	• Inappropriate operation procedures, damage to equipment, inability to provide service.
• No performance monitoring	• Lack of corrective measure plans, inappropriate operating procedures, unacceptable water quality.
• Procurement protocol hamper operations	• Delay in equipment maintenance, inappropriate operation procedures, inability to provide service.
• Political interference	• Legal incompliance, poor services quality.
• Lack of communication between management and technical staff	• Poor standard operation, inappropriate operating procedures, lack of corrective measure plans, unacceptable water quality, poor reporting.
• Lack of historic data	• Lack of corrective measure plans, poor standard operation
• Lack of current data	• Poor standard operation, inappropriate operating procedures, unacceptable water quality, inability to provide services.
• Lack of legal framework implementation	• Poor standard operation, poor reporting, lack of corrective measures plans, lack of management guidance. Legal incompliance.
• Lack of PPE	• Major health implications, loss of life, inappropriate operation procedures, legal incompliance.

4.3 Analyze Risks – Infrastructure Operation

- Analyse your vulnerabilities by using the waterVUL tool as a first step.
- Rank your priority vulnerabilities by looking at the output in the Output page on waterVUL tool.
- Then analyse your risks using waterRISK tool "threat per asset" and "threat per impact" sections.
- Rank your priority risks by looking at the output in the Overall Assessment page in the wateRISK tool.

4.4 Corrective Measures – Infrastructure Operation

Operation corrective measures checklist is included in the following box. Do you have or have you considered? ✓

- ☐ Operation manuals implementation
- ☐ Operational data gathering
- ☐ Isolation and flushing procedure within distribution network implementation
- ☐ Emergency plan implementation
- ☐ HAZMAT procedural plan implementation
- ☐ Decontamination procedural plan implementation
- ☐ Personal protection equipment (PPE) for employees provision
- ☐ Emergency operating procedural plan development and implementation
- ☐ Training in all operation procedures (e.g. drills) conducted
- ☐ Operation records keeping
- ☐ Operation reports production
- ☐ Media (TV, radio, news) contact devices implementation
- ☐ Automatic flow gates installation
- ☐ Alternate electric switching equipment provision
- ☐ Alternate power sources provision
- ☐ Back-up power generation on-site provision
- ☐ Personal protection equipment (PPE) for employees provision

4.5 Best Practice Guiding Principles – Infrastructure Operation

Generally the following should be considered for all components:

4.6 Summarised Actions – Infrastructure Operation

In summary, the actions that need to be carried out include:

Technical Management Personnel

- Ensure sufficient budget for effective operation.
- Maintaining an adequate level of trained, experienced and motivated staff, ensures efficient operation.
- Records should be kept to allow proper management and control.
- Operational procedures should be put in place for operation staff.

Operations and Maintenance Technical Personnel

- Understand your responsibilities and duties.
- Carry out operations as per operation procedures.
- Develop or refer to existing checklists for operation.
- Make and keep water quality data.
- Make and keep records and data for operations conducted.
- Operational needs (such as broken equipment) should be communicated with the managers timeously.

4.7 Available Resources – Infrastructure Operation

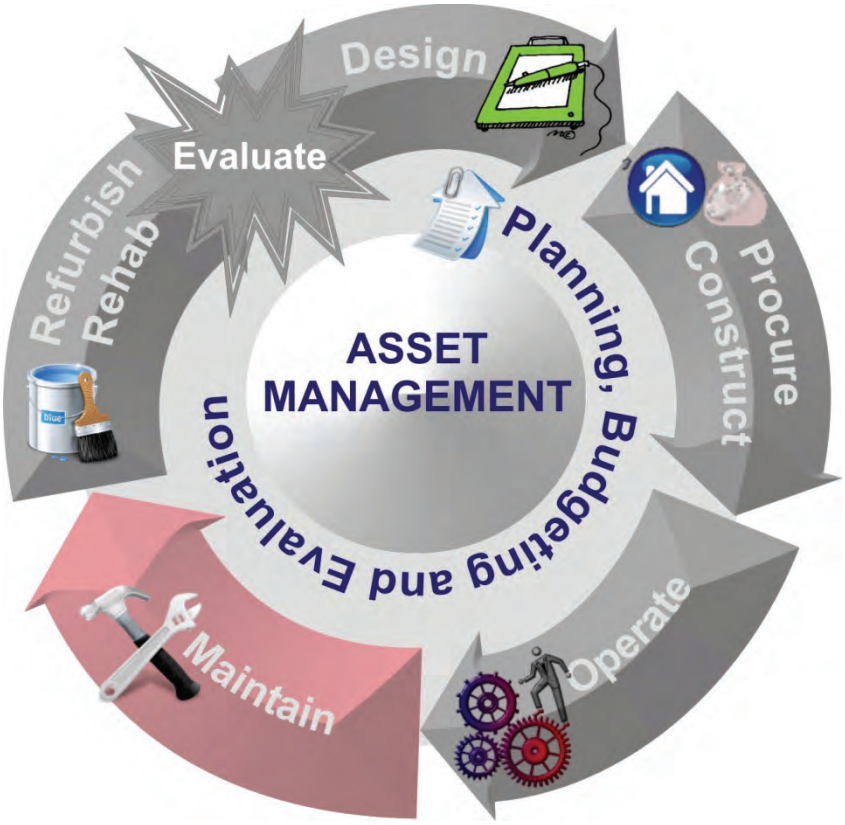
The following best practice resources are readily available to assist with infrastructure operation aspects:

Available Resources

- BTW consulting (2005) An illustrated guide to basic water purification operation: WRC report No TT 247/05
- CSIR (2007) The state of Municipal Infrastructure in South Africa and its operation and maintenance: an overview
- Department of Water Affairs, Northern Cape (2007) Sanitation O&M Handbook
- Department of Water Affairs and Forestry (2002) An illustrated guide to basic sewage purification operations
- Lee Boyd and A M Mbelu (2008) Guide for the inspection of Wastewater Treatment Works: WRC report No TT 375/08
- Mackintosh G and Jack U (2008) Assessment of the occurrence and key causes of drinking water quality failures within non-metropolitan water supply systems in South Africa, and Guidelines for the practical management thereof: WRC report No TT373/08
- Qasm R Syed (1998) *Wastewater Treatment Plants: Planning, Design and Operation.* CRC Press
- Schutte F (2006) Handbook for the operation of water treatment works WRC Report No TT 265/06
- Swartz Chris (2009) Small water treatment plants operation and maintenance training box available in disks 1, 2, 3 and 3b
- Water Institute of Southern Africa (WISA), WRC and East Rand Company (2002) Handbook for the operation of wastewater treatment works
- Metcalf and Eddy (1991) *Wastewater Engineering*, 3rd Edition. Treatment, Disposal, and Reuse. McGraw-Hill, Inc. Singapore
- South African National Standards (SANS) Edition 6

PART V

GENERAL MAINTENANCE PRINCIPLES

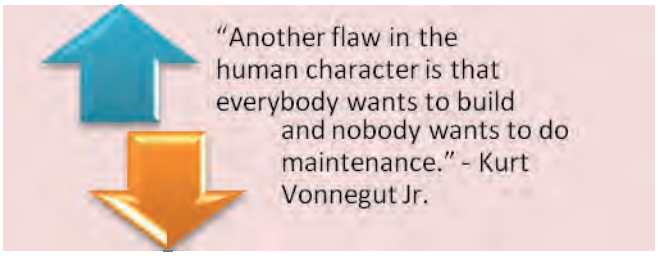


5 MAINTENANCE

To ensure efficient service delivery, on-going effective maintenance of water services related infrastructure is essential. Community awareness in terms of this challenge could reduce unnecessary wastage of water.

5.1 Typical Challenges and Threats – Infrastructure Maintenance

Examples of maintenance related threats on which this section is focusing on include:



5.2 Rank/Prioritise Threats – Infrastructure Maintenance

Understanding impacts of the threats assist in prioritizing needs and actions. Below are typical impacts of identified maintenance threats:

Threats	Possible Impacts
• Unavailability of maintenance manual and/or procedures • Lack of plans for scheduled maintenance • Insufficient staff and lack of trained staff • Lack of emergency operational procedures • Lack of clear procurement procedures • Lack of spare parts to conduct maintenance • Political interference • Lack of communication • Legal framework not implemented • Lack of motivation from sector personnel • Lack of community awareness	• Poor maintenance practices • Delay in conducting maintenance • Damaged equipment • Equipment failure • Inability to provide service • Inappropriate maintenance practices • Poor reporting • Legal non-compliance • Damaged structures • Major health implications • Loss of life • Ineffective allocation of budget

5.3 Analyze Risks – Infrastructure Maintenance

- Analyse your vulnerabilities by using the waterVUL tool as a first step.
- Rank your priority vulnerabilities by looking at the output in the Output page on waterVUL tool.
- Then analyse your risks using waterRISK tool "threat per asset" and "threat per impact" sections.
- Rank your priority risks by looking at the output in the Overall Assessment page in the wateRISK tool.

5.4 Corrective Measures – Infrastructure Maintenance

Maintenance corrective measures checklist is included in the following box. Do you have or have you considered? ✓

- ☐ Media (TV, radio, news) contact devices availability
- ☐ Automatic flow gates installation
- ☐ Alternate electric switching equipment installation
- ☐ Alternate power sources provision
- ☐ Back-up power generation on-site provision
- ☐ Personal protection equipment (PPE) for employees provision
- ☐ Mitigation protection equipment (e.g. spray mace) provision

- [ ] Alternative water supply provision
- [ ] Remotely monitored “panic switch” provision
- [ ] Emergency operating procedural plan provision
- [ ] Evacuation plans (e.g. fire, bomb) provision
- [ ] Co-ordination with local police communication means provision
- [ ] Co-ordination with fire department communication means provision
- [ ] Decontamination procedural plan provision
- [ ] HAZMAT procedural plan provision
- [ ] Isolation and flushing procedure within distribution network provision
- [ ] Off-site storage of duplication keys information provision
- [ ] Regional spare parts/critical equipment inventories well communicated
- [ ] Training in all procedures (e.g. drills) conducted

5.5 Best Practice Guiding Principles – Infrastructure Maintenance

Generally the following should be considered for all components:

5.6 Summarised Actions – Infrastructure Maintenance

In summary, the actions that need to be carried out include:

Technical Management Personnel

- Frequent (maybe yearly) water services system assessment to determine whether the infrastructure (up to the point of consumption) as a whole can deliver water of a quality that meets health-based targets is recommended.
- Maintain an adequate level of trained, experienced and motivated staff.
- Use maintenance reports to understand and improve.
- Plans for pro-active maintenance should be put in place for maintenance technical personnel.
- Maintenance team should be available for all departments (e.g. mechanical, electrical, plumbing, etc).
- Conduct community awareness.

Operations and Maintenance Technical Personnel

- Understand their roles and responsibilities.
- Have maintenance plan and schedule for components of your system.
- Carry out maintenance as per the schedule and maintenance plan.
- Conduct system checks for required maintenance (e.g. check leaks).
- Report findings to the managers.
- Keep records for every maintenance conducted.
- Develop maintenance reports for management.
- Communicate maintenance needs and reports with the managers.

5.7 Available Resources – Infrastructure Maintenance

The following best practice resources are readily available to assist with infrastructure maintenance aspects:

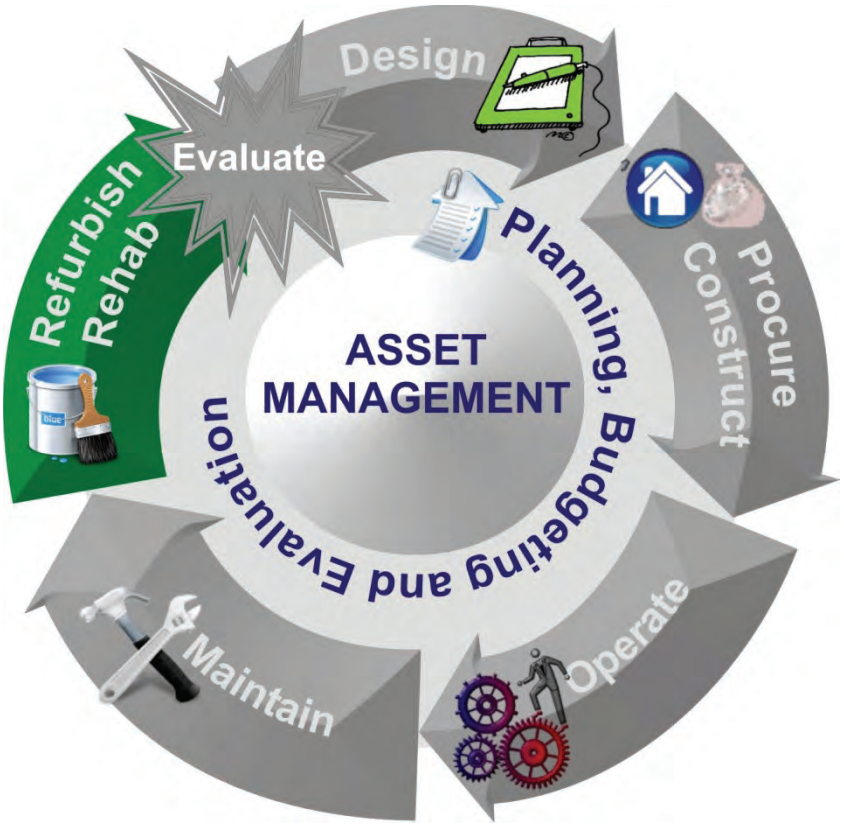
Other Available Resources

- CSIR (2007) The state of Municipal Infrastructure in South Africa and its operation and maintenance: an overview
- DWA, Northern Cape (2007) Sanitation O&M Handbook
- Keuris (2006) Repair and Maintenance of municipal infrastructure. 70th IMESA conference paper
- Lee Boyd and A M Mbelu (2008) Guide for the inspection of Wastewater Treatment Works: WRC report No TT 375/08
- Mackintosh G and Jack U (2008) Assessment of the occurrence and key causes of drinking water quality failures within non-metropolitan water supply systems in South Africa, and Guidelines for the practical management thereof: WRC report No TT373/08
- Qasm R Syed (1998) *Wastewater Treatment Plants: Planning, Design and Operation*. CRC Press
- Schutte F (2006) Handbook for the operation of water treatment works WRC Report No TT 265/06
- Swartz Chris (2009) Small water treatment plants operation and maintenance training box available in disks 1, 2, 3 and 3b
- United States Environmental Protection Agency (December 2004) Preventive maintenance card file for Small public water systems using Ground water: Log cards. epa 816-b-04-002
- Water Institute of Southern Africa (WISA), WRC and East Rand Company (2002) Handbook for the operation of wastewater treatment works

"It is the neglect of timely repair that makes rebuilding necessary." - Richard Whately

PART VI

GENERAL REFURBISHMENT/RREHABILITATION PRINCIPLES



6 REFURBISHMENT/REHABILITATION

Each asset has a life span. As the asset approaches the end of its useful life, it can either be decommissioned/dismantled and replaced or attempts can be made to refurbish/rehabilitate the asset, thereby extending its useful life. The ability to refurbish/rehabilitate an asset is directly proportional to the way the asset was operated and maintained over its useful life. In addition, evaluation of the existing assets at this stage will determine whether extension of the existing assets will suffice (e.g. add an additional filter to increase capacity) or whether completely new assets need to be designed and constructed. By way of example, if the cost to refurbish/rehabilitate an asset is higher than purchasing a new asset, replacement should be considered as the preferred option.

6.1 Typical challenges and Threats – Infrastructure Refurbishment/Rehabilitation

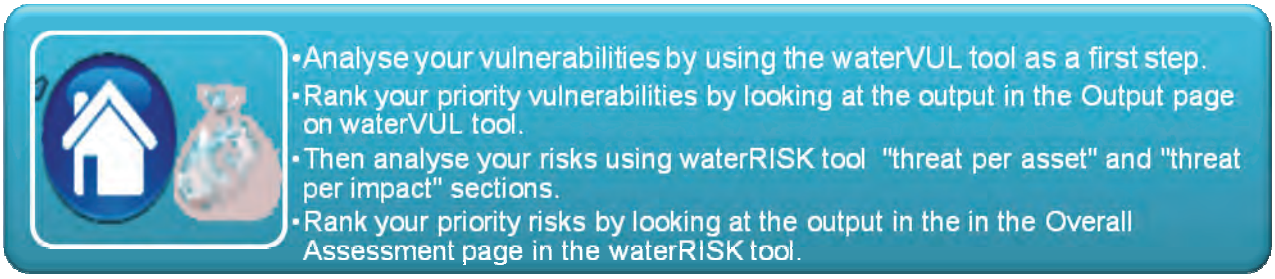
Typical examples of refurbishment/rehabilitation related challenges and threats include:

6.2 Rank/Prioritise Threats – Infrastructure Refurbishment/ Rehabilitation

Understanding impacts of the threats assist in prioritizing needs and actions. Below are typical impacts of identified refurbishment/rehabilitation threats:

Threats	Possible Impacts
• Lack of spare parts for refurbishment/rehabilitation • Lack of spare parts for effective operation and maintenance • Lack of records on existing water services infrastructure • Lack of future development planning • Negative political interference • Lack of skilled staff to understand what needs to be done • Low profile of operation and maintenance in the sector in general • Insufficient funds available to refurbish • Lack of knowledge around equipment life span • Lack of understanding the need for backup equipment • Inadequate tariff and collection system	• Poor quality of the job • Delay in refurbishment/rehabilitation • Inability to provide service • Poor operation and maintenance practices • Inability to draw refurbishment/rehabilitation plans • Inability to budget properly • Future budget constraints • Inability to effectively operate and maintain • Damaged structure • Equipment failure • Inappropriate budget allocation • Inadequate budget collected by the institution • Lack of funds to refurbish/rehabilitate • Insufficient funds to appoint staff

6.3 Analyze Risks – Infrastructure Refurbishment/ Rehabilitation



6.4 Corrective Measures – Infrastructure Refurbishment/ Rehabilitation

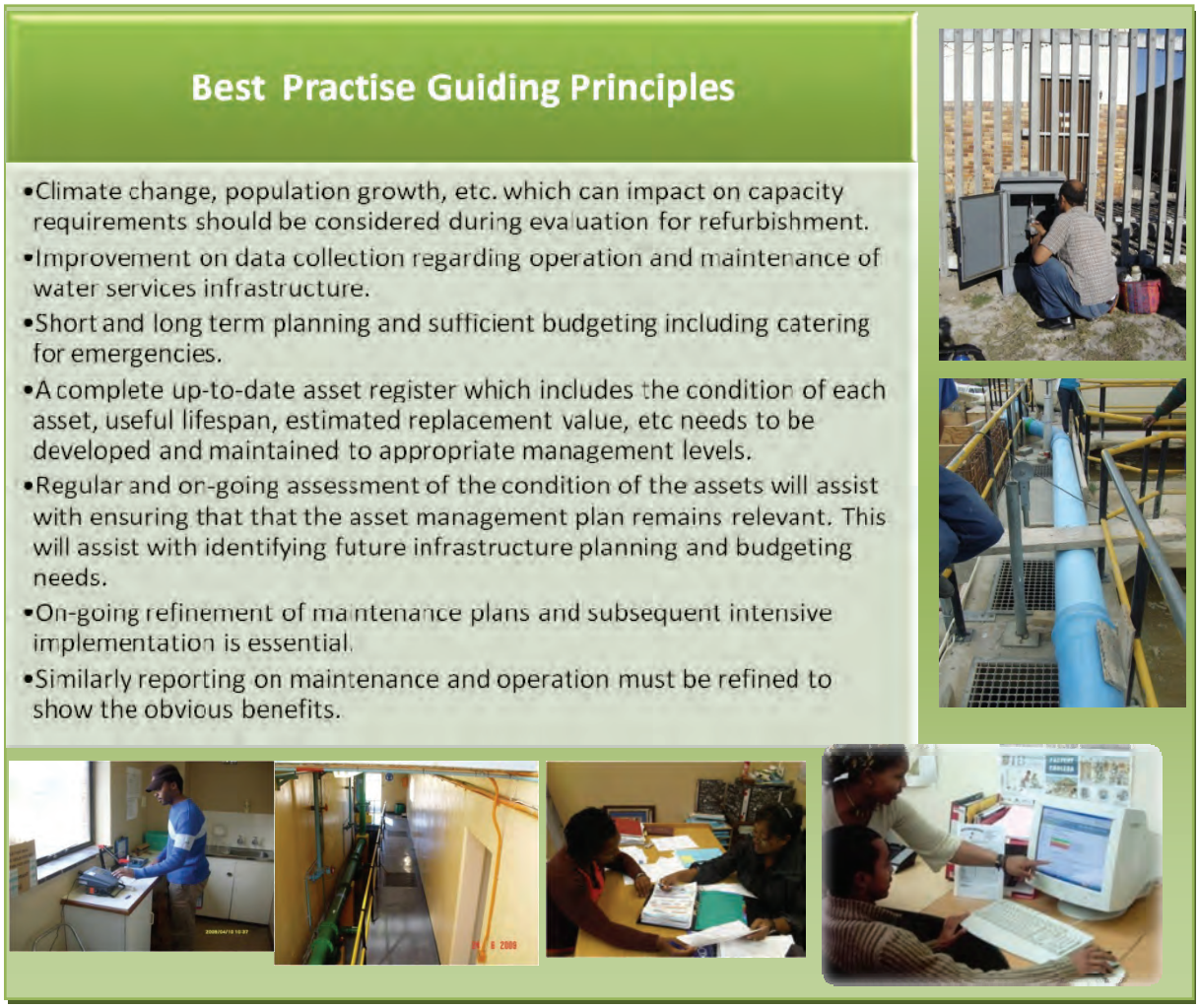
Refurbishment/Rehabilitation corrective measures checklist is included in the following box. Do you have or have you considered? ✓

- ☐ Refurbishment/rehabilitation plans development
- ☐ Alternative source water identification
- ☐ Infrastructure asset register development
- ☐ Infrastructure risk analysis conduction
- ☐ Infrastructure assessment records/reports collection

- [ ] Backup structures availability
- [ ] Population increase consideration
- [ ] Equipment disposal plans development
- [ ] Environmental impact assessment conduction for disposal
- [ ] Budget for refurbishment/rehabilitation allocation
- [ ] Recycling options investigation

6.5 Best Practice Guiding Principles – Infrastructure Refurbishment/Rehabilitation

Generally the following should be considered for all components:



6.6 Summarised Actions – Infrastructure Refurbishment/ Rehabilitation

In summary, the actions that need to be carried out include:

Technical Management Personnel

- Develop and maintain an up-to-date asset register for all assets.
- Develop an asset management plan.
- Determine and understand the condition of each asset and the vulnerabilities/risks associated with each asset.
- Prioritise assets requiring attention (short, medium and long term) and develop action plans to address (e.g. corrective actions/control measures).
- Evaluate the above and determine appropriate way forward (e.g. refurbish/rehabilitate or replace).

Operations and Maintenance Technical Personnel

- Provide information on the condition of all assets.
- Maintain assets as per maintenance plan and associated asset management plan.
- Regularly communicate maintenance needs and associated progress to managers.
- Keep records of all maintenance conducted.

6.7 Available Resources – Infrastructure Refurbishment/ Rehabilitation

The following best practice resources are readily available to assist with infrastructure refurbishment aspects:

Available Resources

- Department of Water Affairs: Directorate: Water Services – Planning and Information: Business Intelligence (2007/2008) Strategic Gap Analysis of Drinking Water Quality Management in Water Services Authorities in South Africa
- Global Water Research Coalition (November 2009) Compendium of Best Practices In Water Infrastructure Asset Management. ISBN 978-90-77622-22-3.
- Stephenson D; Barta B; Manson N (2007) Asset management for the water services sector in South Africa
- van Zyl F, Manus N and Pensulo C (2008) Water Services: Infrastructure Asset Management for municipal managers and management. Municipal Indaba 2008

Its total refurbishment will be £250,000, but the property could be worth £1 million when complete. - Stephen White

PART VII

ASSESSING YOUR RISK AND VULNERABILITIES

1 ASSESSING YOUR RISKS AND VULNERABILITIES

As noted in the previous sections, municipal assets not only relate to the physical infrastructure, but also include other components such as human resources, institutional knowledge management or institutional memory, IT systems, financial resources, etc. Each of these assets is vital for sustainable water services, and a negative impact on one of these assets can have serious consequences for the other assets. Considering the various assets, examples of negative impacts include:

- ***Water services plans*** (not all WSAs see the need/have resources for proper planning)
  - Potential negative impacts: unstructured growth, unable to meet service delivery targets, poor performance, etc.

- ***Source water*** (often remote and not typically secure)
  - Potential negative impacts: damage to structure and equipment (leading to disruption of service), toxins introduced into source or contamination of source water, drought, floods, vandalism of the dam wall, bomb threat, etc.

- ***Pump stations*** (sometimes remote and unmanned)
  - Potential negative impacts: unauthorised entry, damage to structures and equipment, cable theft, vandalism, overflows due to poorly maintained structure, flood, storm, arson, etc.

- ***Water treatment works*** (sometimes remote and often not secure)
  - Potential negative impacts: power source interruption, poor water quality produced due to lack of staff knowledge or skills, chemical overdose, unauthorised entry, destruction of property, release of chlorine gas, toxins introduced into water treatment works, disruption of service, theft, bomb threat, etc.

- ***Reservoirs*** (sometimes remote and often not secure)
  - Potential negative impacts: unauthorised entry, contamination from public activities (e.g. swimming), poor water quality due to lack of maintenance and monitoring at reservoirs, damage to structures and equipment, vandalism, toxins introduced into the reservoir, etc.

- ***Distribution systems*** (could be easily accessible and largely unmonitored)
  - Potential negative impacts: water hammer and/or vacuums in/on pipes leading to pipe breakages and disruption of service, contamination due to illegal connections, cross-connections, etc.

- ***Point of use*** (mostly in residential areas and easily accessible to consumers who often lack awareness)
    - Potential negative impacts: lack of awareness water waste, poor water quality supplied, adverse health effects from lack of water/consuming contaminated water, vandalism, illegal tampering with pipes, flow meters, taps, etc.

- ***Sewage system*** (could be easily accessible and largely unmonitored)
    - Potential negative impacts: poor design leading to mixing/cross-contamination of drinking and wastewater, leaking or burst pipes resulting in sewage run-off into the environment, poor maintenance and/ or long response time to failures, damage to piping, disruption of service, unauthorised entry, etc.

- ***Wastewater treatment works*** (sometimes remote and often not secure)
    - Potential negative impacts: poor effluent quality produced due to improper operation, unauthorised entry, damage to environment, destruction of property leading to disruption of service, theft, toxins introduced into raw sewage, etc.

- ***Operations and maintenance support*** (mechanical and electrical repairs staff, vehicles, workshops, tools, spares, communication devices, etc. often not available)
    - Potential negative impacts: maintenance not carried out, deteriorating assets leading to disruption of service unable to meet service delivery targets, , consumers not serviced, etc.

- ***Human resources*** (staff work in remote areas without security, limited staff per shift)
    - Potential negative impacts: lack of operational skills and knowledge, adverse health effects/death from chlorine gas leak, lack of understanding of legislated requirements and/or responsibilities, sabotage, assault, etc.

- ***IT services and management*** (systems often not managed correctly, irregular virus protection updates, limited firewalls)
    - Potential negative impacts: hacking of IT systems or websites, virus received via e-mail, loss of data/information, etc.

- ***Institutional memory (institutional knowledge management)*** (staff loss/replacement often results in loss of institutional knowledge if no written procedures, back-ups of key documents, etc.)
    - Potential negative impacts: limited information available on infrastructure, documents stolen, documents destroyed, documents copied without authorisation, limited data available, etc.

- ***Financial resources*** (often improper budget control, lack of funds, poor billing and revenue collection)
    - Potential negative impacts: services not rendered, inappropriate contracts, maintenance not carried out, no refurbishment, upgrading, incompetent staff hired, insufficient staff, safety measures not installed, equipment and chemicals not provided, non-payment by consumers

- ***Suppliers and customers*** (often limited due diligence in appointing competent suppliers with significant impact on successful service delivery, customers need to pay for services and in turn receive a quality service)
    - Potential negative impacts: services not rendered, incompetent suppliers/contractors appointed, non-payment by consumers resulting in poor service delivery, unable to meet service delivery targets, consumers not serviced, etc.

Considering the above, the water services institution should therefore:

1. Identify water services related assets
2. Identify what the potential threats or challenges are to the assets
3. Develop an understanding of the vulnerability and associated risk of the asset in relation to the identified threat/challenge
4. Develop an appropriate strategy and associated plan to minimize or prevent any identified weaknesses
5. Implement appropriate control or intervention measures (as per the plan)

Figure 4: *Stepwise flow for using the Vulnerability and Risk Assessment*

To assist water services institutions with the above tasks, two software tools were developed, namely:

- **waterVul** – Water Infrastructure Vulnerability Assessment Tool
    - Easy to complete (approximately 1 hour)
    - Quick indication of key areas of vulnerability
    - Focuses on physical infrastructure:
        - Water Source
        - Water Treatment Works
        - Storage/Reservoirs
        - Water Distribution
        - Sewage System
        - Wastewater Treatment Works

- **waterRISK** – Water Infrastructure Risk Assessment Tool
    - More traditional risk assessment approach

- Identify assets and associated criticality
- Identify and evaluate system threats, control measures, etc.
- Risk analysis

NOT only limited to physical assets, but also considers other non-physical assets:

- Water Services Planning
- Operations & Maintenance Support
- Human Resources
- IT Systems
- Institutional Memory
- Financial Resources & Management
- Suppliers & Customers

- Tools should preferably be independent of system size (i.e. all WSAs utilise the same tool)
- Recommend that WSAs use both tools (i.e. start by using the waterVUL Tool, and then proceed with the waterRISK Tool)
- Use information from tools to prioritize and plan improvements, develop associated budgets, allocate roles and responsibilities for improvements, etc. This would preferably be largely copy-paste from the tools into a report template.

Bearing the above in mind, the following sections will describe the two tools that were developed.

2 WATERVUL – WATER INFRASTRUCTURE VULNERABILITY ASSESSMENT TOOL

The following key aspects of this tool are noted:

The tool was developed in Microsoft Excel and is therefore spreadsheet-based. Most municipal officials that the tool is aimed at would be comfortable using a spreadsheet-based tool. In this tool, the user completes 5 questions per asset category.
Assets are limited to physical assets and include:

- Water Source
- Water Treatment Works
- Storage/Reservoirs
- Water Distribution
- Sewage System
- Wastewater Treatment Works

- The questions consider key aspects that can make assets vulnerable.
- The user answers the question by stating if they:
  - strongly agree
  - agree
  - neutral or not applicable
  - disagree
  - strongly disagree or don’t know

NOTE: "Don't know" is scored similarly as "strongly disagree" as not knowing the status of a component within the system could imply that it is in very poor condition/does not exist. Ideally the assessment should be completed by a competent individual who at least knows the status/condition of the system components).

- Based on the response, a "risk level" per asset category is calculated, with the results inserted into a table for easy reference.
- In addition, the results are also displayed on a "spider diagram" (which has been used in the past for displaying risk based results to municipal officials, and which they have found easy to understand and use).
- The tool is relatively easy to complete, and should take the user no longer than 1 hour to obtain a first order assessment of their key vulnerabilities.

NOTE: It is important to remember that the completion of the tool is only the start of the process. For the tool to be effective it needs commitment from management to plan, budget, implement required remedial measures, track improvements, etc. (i.e. PLAN – DO – CHECK – ACT).

The following screenshots indicate the components and associated questions of the tool (***NOTE:*** The tool has been completed with fictitious data to indicate a typical output).

Table 4: *General*

Name	Thabo Smit
WSA	ABC Municipality
Water System Assessed	Town D
Date Completed	12-10-2009

Table 5: *Vulnerability Scoring Rules*

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

Table 6: *Water Source and Water Treatment Works*

1. Water Source		
1.1	Water sources points of entry are secured with fences, locked gates, etc. and appropriate access control	**3**
1.2	Water system personnel regularly inspect the source and associated infrastructure (e.g. check for tampering)	**3**
1.3	The quantity of water available from the resource is sufficient for needs	**4**
1.4	Alternative water resources are available as back-up (e.g. transmission line failure)	**1**
1.5	The source water quality is in accordance with the design assumptions of the water treatment works	**1**

2. Water Treatment Works		
2.1	Water treatment works are secured with fences, locked gates, etc. and appropriate access control	**4**
2.2	An appropriate works operating procedure, maintenance schedule and emergency plan is available and implemented	**4**
2.3	The works has sufficient capacity and unit operations are in good working order (or if not, budgets have already been approved to upgrade/expand the works in the short term)	**3**
2.4	The works has sufficient chemicals/materials, standby/spare equipment, back-up power supply, etc. with any hazardous/flammable chemicals stored in a secure area	**4**
2.5	The works are operated by the appropriate number of staff with the correct skills/qualifications (as per Regulation 2834)	**4**

Table 7: *Storage/Reservoirs and Water Distribution*

3. Storage/Reservoirs		
3.1	Reservoirs points of entry are secured with fences, locked gates, covers, etc. and appropriate access control	**4**
3.2	An appropriate reservoir operating procedure, maintenance schedule and emergency plan is available and implemented	**4**
3.3	No leaks, corrosion or damage is evident on the reservoirs, inlets, outlets, etc.	**2**
3.4	No loss of water (e.g. no overflowing) or loss in water quality (e.g. booster chlorination practiced) experienced at reservoirs	**1**
3.5	Reservoirs are cleaned and maintained on a regular basis (e.g. annually and including regular housekeeping)	**3**

4. Water Distribution		
4.1	Points of entry to pipelines, booster / pump stations and associated valves are secured with fences, locked gates, etc. and appropriate access control	**4**
4.2	An appropriate distribution network operating procedure, maintenance schedule and emergency plan is available and implemented	**4**
4.3	All system valves, hydrants, booster stations and pump stations are maintained on a scheduled basis and are in good working order	**3**
4.4	There is a downward trend in number of pipe bursts experienced, and such incidents are repaired within 24 hours of being reported	**3**
4.5	There is no evidence of water quality deterioration from contamination at pipelines, booster/ pump stations, valve boxes/chambers, etc. within the network	**3**

Table 8: *Sewage System and Wastewater Treatment Works*

5. Sewage System		
5.1	Points of entry to sewage pipelines, pump stations and associated valves are secured with fences, locked gates, etc. and appropriate access control	**3**
5.2	An appropriate sewage system operating procedure, maintenance schedule and emergency plan is available and implemented	**2**
5.3	All pump stations, preliminary screens, etc. are maintained on a scheduled basis and are in good working order	**4**
5.4	Sewage system blockages are addressed within 24 hours of being reported	**4**
5.5	There is no evidence of potential sewage contamination of stormwater systems, rivers/streams or groundwater sources	**2**

6. Wastewater Treatment Works		
6.1	Wastewater treatment works are secured with fences, locked gates, etc. and appropriate access control	**4**
6.2	An appropriate works operating procedure, maintenance schedule and emergency plan is available and implemented	**4**
6.3	The works has sufficient capacity and unit operations are in good working order (or if not, budgets have already been approved to upgrade/expand the works in the short term)	**2**
6.4	The works has sufficient chemicals/materials, standby/spare equipment, back-up power supply, etc. with any hazardous/flammable chemicals stored in a secure area	**3**
6.5	The works are operated by the appropriate number of staff with the correct skills/qualifications (as per Regulation 2834)	**3**

Table 9: *Summarised Results – Vulnerability Rating per Asset Category*

Vulnerability Rating	Vulnerability
1. Water Source	**Medium**
2. Water Treatment Works	**Low**
3. Storage/Reservoirs	**Low**
4. Water Distribution	**Medium**
5. Sewage System	**High**
6. Wastewater Treatment Works	**High**

Key
Red – High Risk (i.e. very vulnerable)
Yellow – Medium Risk (i.e. somewhat vulnerable)
Green – Low Risk (i.e. Not really vulnerable)

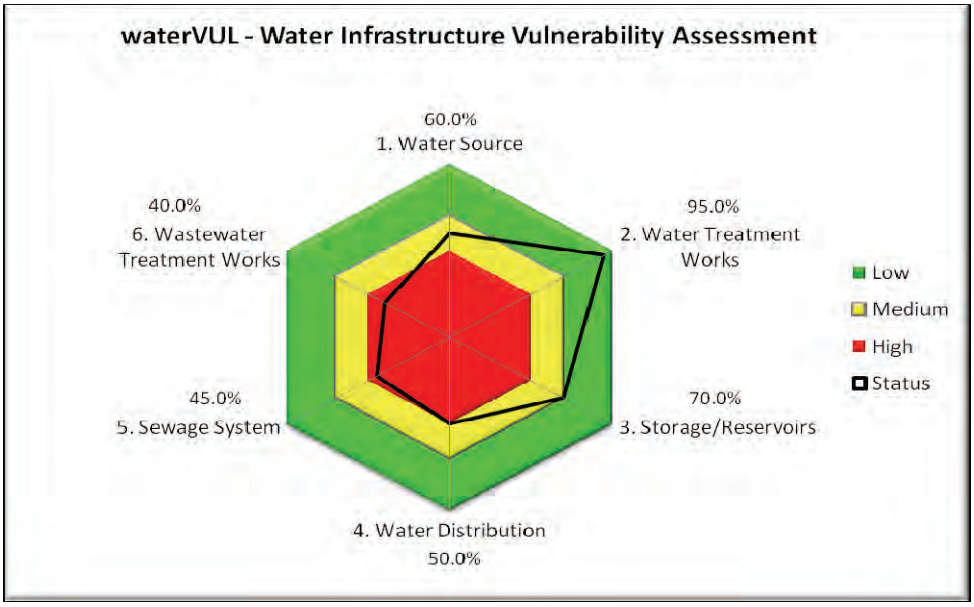


Figure 5: *waterVUL – risk rating representation in "spider-diagram" format*

Outputs from the assessment can be copied/pasted from the completed Microsoft Excel spreadsheet into the Vulnerability and Risk Assessment Report Template.

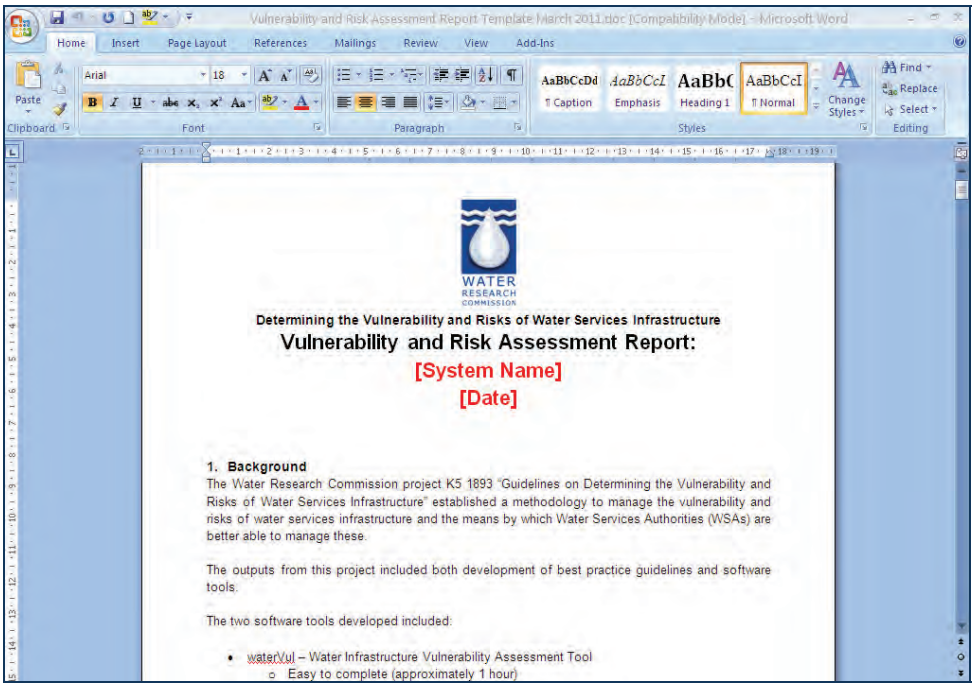


Figure 6: *Report template which can be used to insert completed worksheets (copy/paste)*

The aforementioned tool was piloted at selected WSAs. Through this process, and from input/feedback from the Reference Group and Technical Team, the tool was further refined.

3 WATERRISK – WATER INFRASTRUCTURE RISK ASSESSMENT TOOL

The following key aspects of this tool are noted:

The tool was developed in Microsoft Excel and is therefore spreadsheet-based. Most municipal officials that the tool is aimed at would be comfortable using a spreadsheet-based tool. This tool follows the more traditional approach to completing vulnerability and risk assessments. The tool is relatively easy to complete, and should take the user no longer than 1-2 days to identify their key vulnerabilities, and associated prioritised risks.

NOTE: It is important to remember that the completion of the tool is only the start of the process. For the tool to be effective it needs commitment from management to plan, budget, implement required remedial measures, track improvements, etc. The required cycle is best summarised as follows: (i) PLAN: (the tool largely assists with this, (ii) DO (budget and implement), (iii) CHECK (track improvements, is it working), and (iv) ACT (adjust the plan, etc. if not effective and re-start the cycle).

Considering the above, the following detailed steps are noted:

STEP 1 Capture the details of the assessor, the system assessed and the date of the assessment.

STEP 2 Choose your assets/components from the available list.

STEP 3 Identify (at least) the five most significant overall threats and/or challenges to sustainable water services in your WSA. ***NOTE:*** The tool allows a maximum of 25 threats and/or challenges to be evaluated for your water system.

STEP 4 Considering the likely threats/challenges, allocate a threat/challenge for each identified asset component (i.e. match threats/challenges to assets).

STEP 5 Consider the impact on the asset if the threat/challenge is realised (i.e. determine the consequence). This is performed for each asset category in order, including:

- Water Services Planning
- Physical (combined assessment for water source, water treatment works, storage/reservoirs, water distribution, sewage system and wastewater treatment works, power)
- Operations and Maintenance Support
- Human Resources
- IT Systems
- Institutional Memory
- Financial Resources and Management
- Suppliers and Customers

STEP 6 Identify existing control/intervention measures.

STEP 7 Consider the actual likelihood that a threat will materialise by considering system control/intervention measures, redundancy, alternatives, back-ups and the probability of such an event (e.g. has it happened in the past). This determines the vulnerability of the asset.

STEP 8 Considering the vulnerability and the consequence, a risk is automatically calculated. Rank and prioritize the risks from Very High → High → Medium → Low. Depending on WSA capacity (e.g. funds), the WSA could, for example, decide to initially only focus on "Very High" risk items.

STEP 9 Identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc. for proposed improvements.

STEP 10 Considering the findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be addressed. It is suggested that this be limited to 10 items, and have a short term action period (e.g. 3 months). It is essential that appropriate budget and responsibilities are assigned to address the top 10 identified items. Progress and outstanding issues could then be tracked and reviewed on a quarterly basis.

STEP 11 Copy and paste outputs from the completed Microsoft Excel spreadsheet into the Vulnerability and Risk Assessment Report Template.

STEP 12 Implement your plan, review the effectiveness of actions implemented and budget spent, etc. This last step is crucial to the successful reduction in water services related vulnerabilities and risks within the WSA.

The following screenshots indicate the components and associated questions of the tool (***NOTE:*** The tool has been completed with fictitious data to indicate a typical output).

Step 1: Capture the details of the assessor, the system assessed and the date of the assessment

Record of Vulnerability Self-Assessment Completion

The following information should be completed by the individual conducting the self-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
Town	Town D
Province	Eastern Cape
Postal Code	7500
Telephone	+2742123456
Mobile	+2783456789
Fax	+2742123456
Email	tsmit@abc.gov.za
Date Completed	Monday, January 12, 2009
Date Revised	
Date Revised	
Date Revised	
Date Revised	
Date Revised	

Step 2: Choose your assets/components from the available list available. The form is completed by selecting answers from simple drop down menus (see below).

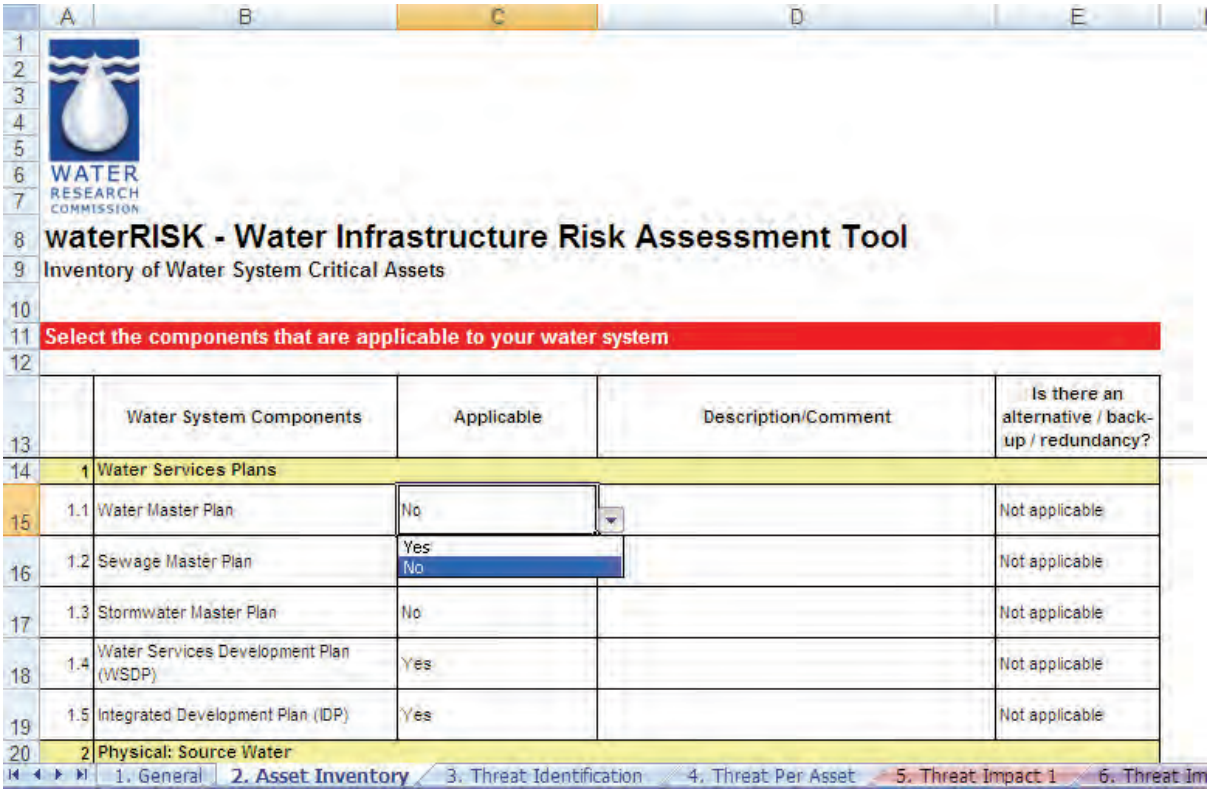


Figure 7: *Selecting assets from the available list*

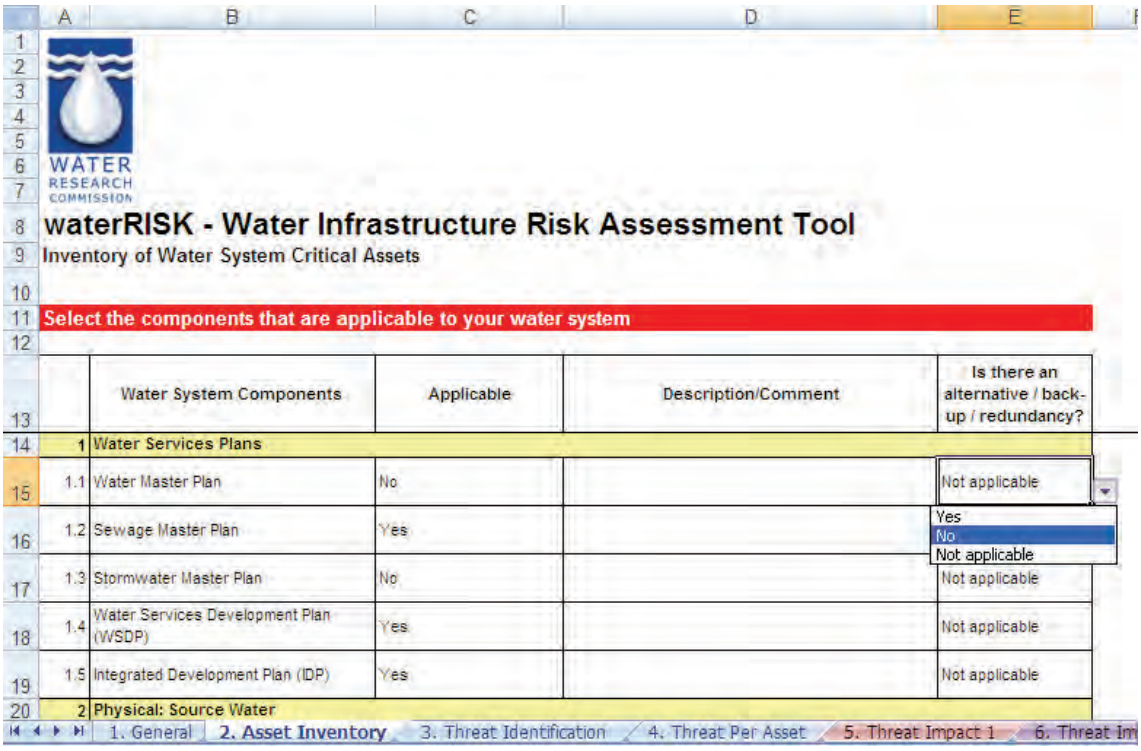


Figure 8: *Identifying if there is an alternative/back-up or redundancy to the asset*

The complete list of assets included within the tool is shown below (***NOTE:*** Some selections have been made for reference purposes and to show how the tool could be completed):

Inventory of Water System Critical Assets

Select the components that are applicable to your water system

	Water System Components	Applicable	Description/Comment	Is there an alternative / back-up / redundancy?
1	**Water Services Plans**			
1.1	Water Master Plan	Yes		Not applicable
1.2	Sewage Master Plan	Yes		Not applicable
1.3	Stormwater Master Plan	No		Not applicable
1.4	Water Services Development Plan (WSDP)	Yes		Not applicable
1.5	Integrated Development Plan (IDP)	Yes		Not applicable
2	**Physical: Source Water**			
2.1	Groundwater	No	-	Not applicable
2.2	Surface water	Yes	ABC River	**No**
2.3	Sea water	No	-	Not applicable
2.4	Purchased water	No	-	Not applicable
	Water System Components	**Applicable**	**Description/Comment**	**Is there an alternative / back-up / redundancy?**
2.5	Secondary/tertiary sewage effluent	No	-	Not applicable
2.6	Pre-treatment (at source)	No	-	Not applicable
3	**Physical: Water Pump Stations**			
3.1	Buildings	Yes		Yes
3.2	Pumps	Yes		Yes
4	**Physical: Water Treatment Works**			
4.1	Buildings/structures	Yes		Yes
4.2	Pumps	Yes		**No**
4.3	Flow measurement	No		Not applicable
4.4	Pre-treatment (e.g. aeration)	No		Not applicable
4.5	Flocculation/coagulation (e.g. alum)	Yes		Yes
4.6	Sedimentation or flotation (e.g. settling tanks or DAF tank)	Yes		**No**

4.7	Filtration (e.g. rapid sand filter)	Yes		Yes
4.8	Stabilisation (e.g. lime & carbon dioxide)	No		Not applicable
4.9	Disinfection (e.g. chlorination, UV)	Yes		Yes
4.10	Advanced treatment	No		Not applicable
4.11	Sludge management	No		Not applicable
4.12	Process control/instrumentation	Yes		**No**
4.13	Treatment chemicals and storage	Yes		Yes
4.14	Laboratory	No		Not applicable
4.15	Laboratory chemicals and storage	No		Not applicable
5	**Physical: Storage/Reservoirs**			
5.1	Storage tanks/reservoirs	Yes		Yes
5.2	Pressure tanks/towers	No		Not applicable
5.3	Booster disinfection (e.g. chlorination)	No		Not applicable
6	**Physical: Distribution System**			
6.1	Pumps	No		Not applicable
6.2	Pump stations	No		Not applicable
	Water System Components	**Applicable**	**Description/Comment**	**Is there an alternative / back-up / redundancy?**
6.3	Pipes	Yes		Yes
6.4	Valves (e.g. pressure reducing valves)	Yes		Yes
6.5	Meters	Yes		Yes
6.6	Hydrants	No		Not applicable
6.7	Water distribution vehicles (e.g. tanker truck)	No		Not applicable
7	**Physical: Sewage System**			
7.1	Gravity sewers	Yes		Yes
7.2	Pumped sewers	No		Not applicable
7.3	Bulk sewers (e.g. service provider)	No		Not applicable
7.4	Sewage collection vehicles (e.g. honeysucker)	No		Not applicable
7.5	Stormwater sewers	Yes		Yes
8	**Physical: Wastewater Pump Stations**			

8.1	Buildings	Yes		Yes
8.2	Pumps	Yes		Yes
8.3	Preliminary treatment	Yes		**No**
8.4	Overflow facility	No		Not applicable
9	**Physical: Wastewater Treatment Works**			
9.1	Buildings/structures	Yes		Yes
9.2	Pumps	Yes		Yes
9.3	Flow measurement	No		Not applicable
9.4	Preliminary treatment (screens, degrit)	Yes		**No**
9.5	Primary treatment (clarifiers)	Yes		Yes
9.6	Biological filters	No		Not applicable
9.7	Activated sludge	Yes		Yes
9.8	Secondary clarification	No		Not applicable
9.9	Disinfection (e.g. chlorination, UV)	Yes		**No**
9.10	Advanced treatment	No		Not applicable
9.11	Discharge/outfall	Yes		Yes
	Water System Components	**Applicable**	**Description/Comment**	**Is there an alternative / back-up / redundancy?**
9.12	Sludge digestion/management	No		Not applicable
9.13	Process control/instrumentation	No		Not applicable
9.14	Treatment chemicals and storage	Yes		Yes
9.15	Laboratory	No		Not applicable
9.16	Laboratory chemicals and storage	No		Not applicable
10	**Physical: Power**			
10.1	Primary power	Yes		**No**
10.2	Auxiliary/back-up power (e.g. generators)	No		Not applicable
11	**Operation and Maintenance Support**			
11.1	Administrative/Procurement	Yes		Yes
11.2	Laboratory	No		Not applicable
11.3	Workshop	Yes		Yes

11.4	Stock/Spares Room	Yes		Yes
11.5	Transportation/work vehicles	Yes		Yes
11.6	Communication tools (e.g. mobile phone, radio)	Yes		Yes
11.7	Data recording and reporting	Yes		Yes
12	**Human Resources**			
12.1	Municipal Manager	Yes		Yes
12.2	Technical Manager	Yes		Yes
12.3	Heads of Department	Yes		Yes
12.4	Supervisors	Yes		Yes
12.5	Water treatment works process controllers	Yes		Yes
12.6	Wastewater treatment works process controllers	Yes		**No**
12.7	Plumbers/field technicians	Yes		Yes
12.8	Mechanical repairs (in-house/appointed external)	Yes		Yes
12.9	Electrical repairs (in-house/appointed external)	Yes		Yes
12.10	Laboratory	Yes		Yes
	Water System Components	**Applicable**	**Description/Comment**	**Is there an alternative / back-up / redundancy?**
13	**IT Systems**	**13**	**IT Systems**	**13**
13.1	Computers	Yes		Yes
13.2	Servers	Yes		**No**
13.3	Electronic Files	Yes		Yes
13.4	Water services related software	Yes		Yes
14	**Institutional Memory**			
14.1	Planning documents (e.g. Master Plan)	Yes		Yes
14.2	Policies and procedures	Yes		Yes
14.3	Asset records (e.g. register, condition)	No		Not applicable
14.4	Drawings (e.g. as-built)	Yes		Yes
14.5	Specifications (e.g. design)	Yes		Yes
14.6	Legal documents (e.g. agreements)	Yes		Yes
14.7	O&M manuals (e.g. waterworks)	Yes		**No**

14.8	Regulatory documents (e.g. licences)	Yes		Yes
14.9	Employee information (e.g. contracts)	Yes		Yes
14.10	Financial records (e.g. budgets)	Yes		Yes
14.11	Customer records	Yes		Yes
15	**Financial Resources and Management**			
15.1	Financial management system	Yes		Yes
15.2	Cash in bank	Yes		Yes
15.3	Access to loans/grants	Yes		Yes
16	**Suppliers and Customers**			
16.1	Suppliers/contractors	Yes		Yes
16.2	Customers	Yes		Yes

*Step 3: Identify (at least) the five most significant overall threats and/or challenges to sustainable water services in your WSA. **NOTE:** The tool allows a maximum of 25 threats and/or challenges to be evaluated for your water systems (using a simple drop down menu - see below).*

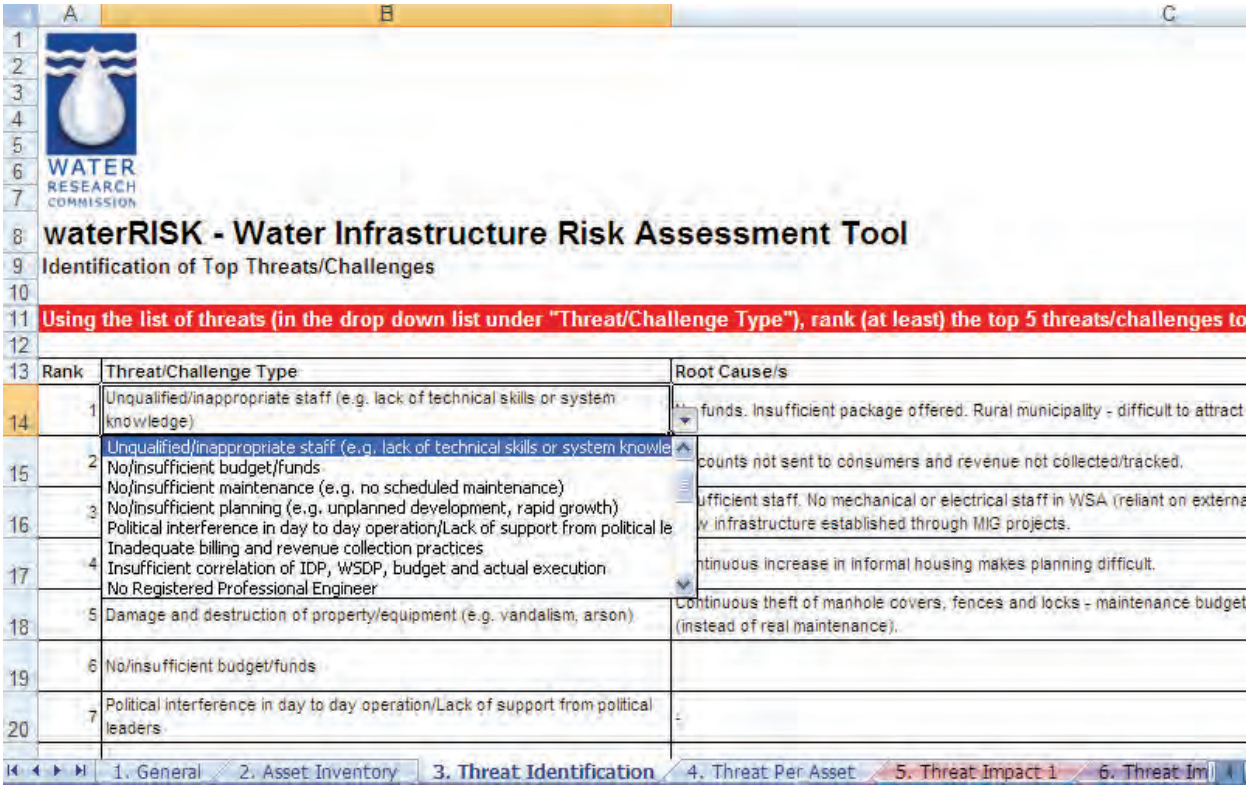


***Figure 9:** Identifying and ranking the top threats/challenges*

In the following example, only 6 threats/challenges have been identified and ranked.

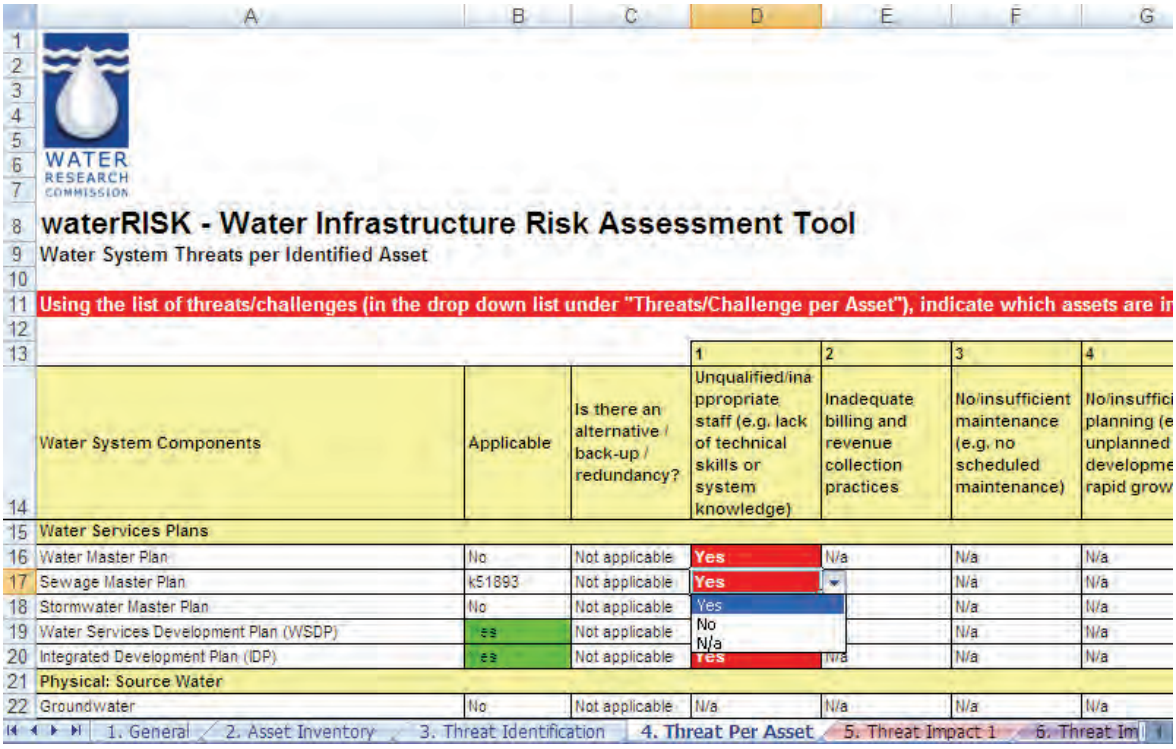
Using the list of threats/challenges (drop down list under "Threat/Challenge Type"), rank (at least) the top 5 threats/challenges to your WSA water services related assets

Rank	Threat/Challenge Type	Root Cause/s
1	No/insufficient staff (e.g. staff numbers)	No funds. Insufficient package offered. Rural municipality – difficult to attract qualified staff.
2	Inadequate billing and revenue collection practices	Accounts not sent to consumers and revenue not collected/tracked.
3	No/insufficient maintenance (e.g. no scheduled maintenance)	Insufficient staff. No mechanical or electrical staff in WSA (reliant on external contractors). Insufficient budget for maintenance of new infrastructure established through MIG projects.
4	No/insufficient planning (e.g. unplanned development, rapid growth)	Continuous increase in informal housing makes planning difficult.
5	Damage and destruction of property/equipment (e.g. vandalism, arson)	Continuous theft of manhole covers, fences and locks – maintenance budget goes towards replacement of such components (instead of real maintenance).
6	Digital information security (e.g. virus protection, hacking)	No strict IT policies or enforcement of protocols. No back-ups of data or information.
7	-	-
8	etc.	etc.

The following 25 threats and challenges facing WSAs in South Africa have been included in the tool:

	Threats and Challenges Facing WSAs in South Africa
1	No/insufficient staff (e.g. staff numbers)
2	Unqualified/inappropriate staff (e.g. lack of technical skills or system knowledge)
3	No/insufficient budget/funds
4	No/insufficient maintenance (e.g. no scheduled maintenance)
5	No/insufficient planning (e.g. unplanned development, rapid growth)
6	Political interference in day to day operation/Lack of support from political leaders
7	Inadequate billing and revenue collection practices
8	Insufficient correlation of IDP, WSDP, budget and actual execution
9	No Registered Professional Engineer
10	Disruption of service (e.g. no water supply, pipe breakage)
11	Contamination (e.g. of water supply)
12	Poor data gathering and management (e.g. routine checks and correction)
13	Poor information management (e.g. no institutional memory, documents copied/destroyed)
14	Digital information security (e.g. virus protection, hacking)
15	Damage and destruction of property/equipment (e.g. vandalism, arson)
16	Theft (e.g. tools, equipment, materials, chemicals)
17	Unauthorized entry (e.g. site or system access)
18	Staff injury (e.g. from lack of proper safety)
19	Assault (e.g. attacking an employee)
20	Fire
21	Flood
22	Storm
23	Drought
24	Chemical or hazardous materials emergencies
25	Explosive device (e.g. bomb, flammable material)

Step 4: Considering the likely threats and/or challenges, allocate a threat and/or challenge for each identified asset component (i.e. match threats and/or challenges to assets).



WATER RESEARCH COMMISSION

waterRISK - Water Infrastructure Risk Assessment Tool

Water System Threats per Identified Asset

Using the list of threats/challenges (in the drop down list under "Threats/Challenge per Asset"), indicate which assets are in

	Water System Components	Applicable	Is there an alternative / back-up / redundancy?	1 Unqualified/inappropriate staff (e.g. lack of technical skills or system knowledge)	2 Inadequate billing and revenue collection practices	3 No/insufficient maintenance (e.g. no scheduled maintenance)	4 No/insufficient planning (e unplanned developme rapid grow
15	Water Services Plans						
16	Water Master Plan	No	Not applicable	Yes	N/a	N/a	N/a
17	Sewage Master Plan	k51893	Not applicable	Yes		N/a	N/a
18	Stormwater Master Plan	No	Not applicable	Yes		N/a	N/a
19	Water Services Development Plan (WSDP)	es	Not applicable	No		N/a	N/a
20	Integrated Development Plan (IDP)	es	Not applicable	N/a		N/a	N/a
21	Physical: Source Water						
22	Groundwater	No	Not applicable	N/a	N/a	N/a	N/a

1. General | 2. Asset Inventory | 3. Threat Identification | 4. Threat Per Asset | 5. Threat Impact 1 | 6. Threat Im

Figure 10: *Assigning specific identified threats to assets (only assets with a "Yes" need to be completed)*

Step 5: Consider the impact on the asset if the threat and/or challenge is realised (i.e. determine the consequence).

This is performed for each asset category in order, including:

- Water Services Planning
- Physical (combined assessment for water source, water treatment works, storage/reservoirs, water distribution, sewage system and wastewater treatment works, power)
- Operations and Maintenance Support
- Human Resources
- IT Systems
- Institutional Memory
- Financial Resources and Management
- Suppliers and Customers

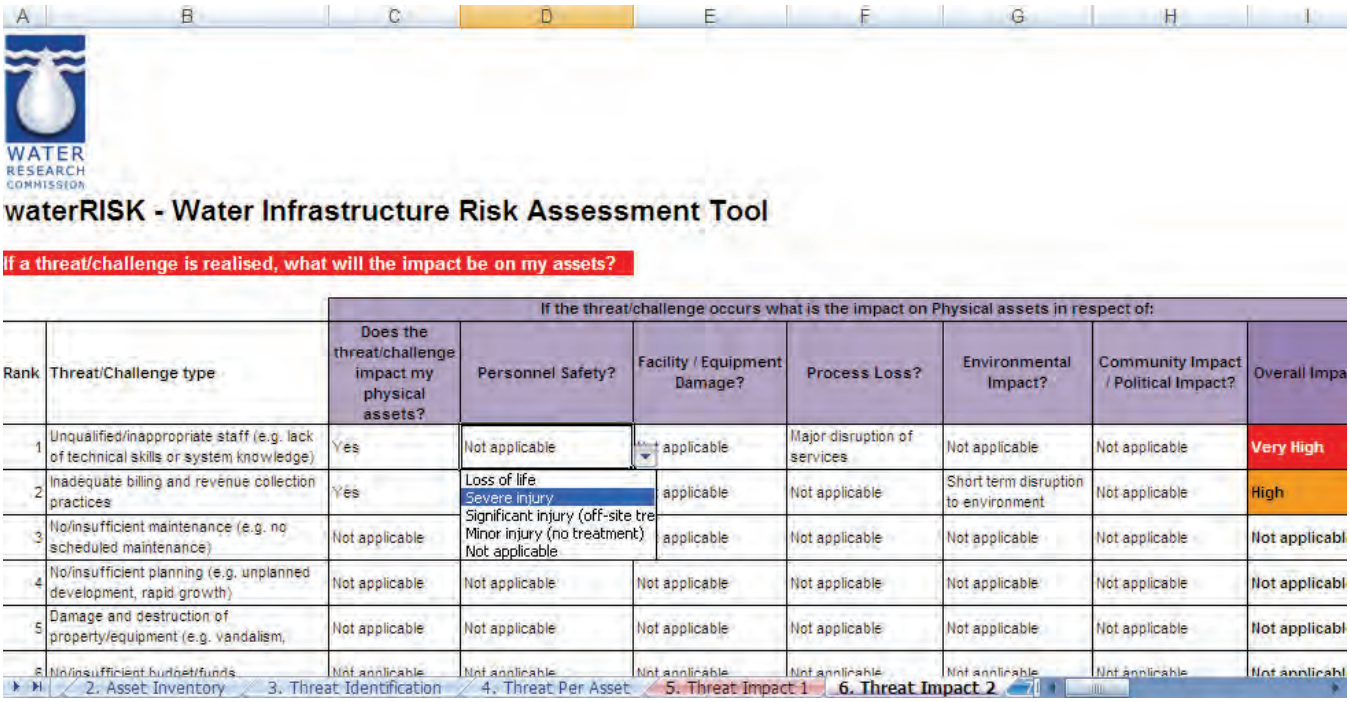


Figure 11: *Determining the impact or consequence of a threat materialising*

The impacts/consequences are considered for the following asset categories:

1. Water Services Planning					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Significant proportion of all planning assets	Complete loss of asset	Loss expected to last for several weeks	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	Significant proportion of 1-2 planning assets	Complete loss of asset but can replace	Loss expected to last for 7-10 days	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	One major planning asset	Loss of asset but can replace	Loss possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	One minor component of a planning asset	Minor / no loss of asset	Loss resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

2. Physical					
	Personnel Safety	**Facility / Equipment Damage**	**Process Loss**	**Environmental Impact**	**Community Impact / Political Impact**
Very High	Loss of life	Widespread loss of assets	Major disruption of services	Long term and serious disruption to environment	Widespread disruption to community
High	Severe injury	Partial loss of, or irreparable damage to assets	Significant impairment of services	Short term disruption to environment	Localized/some disruption to community
Medium	Significant injury (off-site treatment)	Reparable or minor damage to assets	Minor disruption of services	Minor disruption to environment	Nuisance / inconvenience
Low	Minor injury (no treatment)	Little / no damage to assets	Minimal disruption of services	Localized/minimal impact to	Little / no community impact

2. Physical					
	Personnel Safety	**Facility / Equipment Damage**	**Process Loss**	**Environmental Impact**	**Community Impact / Political Impact**
				environment	
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

3. O&M Support					
	Personnel Safety	**Facility / Equipment Damage**	**Process Loss**	**Environmental Impact**	**Community Impact / Political Impact**
Very High	Loss of life	Widespread loss of assets	Significant impairment of services	Long term disruption to environment	Widespread disruption to community
High	Severe injury	Partial loss of assets	Major disruption of services	Short term disruption to environment	Localized disruption to community
Medium	Minor injury (off-site treatment)	Damage to assets	Minor disruption of services	Minimal disruption to environment	Nuisance / inconvenience
Low	Minor injury (no treatment)	Little/no damage to assets	Minimal disruption of services	Localized impact to environment	Little/no community impact
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

4. Human Resources					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Significant number	Loss of life	Sustained threat to employees	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	A few	Severe injury	Threat expected to last less than 1 week	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	Possibly one	Minor injury (off-site treatment)	Threat possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	None	Minor injury (no treatment)	Threat resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

5. IT Systems					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Significant proportion of all IT systems	Complete loss of IT systems	Loss expected to last for several weeks	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	Significant proportion of IT sub-systems	Complete loss of IT sub-system	Loss expected to last for 7-10 days	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	One major component of IT sub-system	Loss of IT sub-system but can repair / replace	Loss possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	One minor component of IT sub-system	Minor / no loss of IT sub-system	Loss resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

6. Institutional Memory					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Significant proportion of all knowledge assets	Complete loss of asset	Loss expected to last for several weeks	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	Significant proportion of 1-2 knowledge assets	Complete loss of asset but can repair / replace	Loss expected to last for 7-10 days	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	One major knowledge asset	Loss of asset but can repair / replace	Loss possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	One minor component of a knowledge asset	Minor / no loss of asset	Loss resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

7. Financial Resources					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Widespread parties affected	Complete loss of service	Loss expected to last for several weeks	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	Significant number of parties affected	Loss of service	Loss expected to last for 7-10 days	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	Small number of parties affected	Reduction in service quality / quantity	Loss possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	Isolated parties affected	Minor / no loss of service	Loss resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

8. Suppliers & Customers					
	Extent	**Severity**	**Temporal Effects**	**Recoverability**	**Collateral Damages**
Very High	Widespread parties affected	Complete loss of service	Loss expected to last for several weeks	Unable to recover soon (irrespective of cost)	Widespread, serious effects on people / property
High	Significant number of parties affected	Loss of service	Loss expected to last for 7-10 days	Able to recover but at significant cost	Localized, serious effects on people / property
Medium	Small number of parties affected	Reduction in service quality / quantity	Loss possibly lasting 1-2 days	Able to recover at moderate cost	Localized, limited effects on people / property
Low	Isolated parties affected	Minor / no loss of service	Loss resolved in less than 1 day	Able to immediately recover at no / little cost	Minor/no effects on people / property
N/a	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

The forms are completed for each asset category (i.e. 8 forms to be completed, assessment of physical assets has been combined into one form).

A summarised form showing impact levels is available for incorporation into a report (see below).

		Overall Impact							
Rank	Threat/Challenge type	1. Planning assets?	2. Physical assets?	3. O&M support services assets?	4. Human resources assets?	5. IT assets?	6. Institutional memory assets?	7. Financial resources assets?	8. Suppliers / customers assets?
1	No/insufficient budget/funds	Low	Very High	High	Very High	Very High	Very High	High	High
2	Inadequate billing and revenue collection practices	High	High	Very High	High	High	Very High	Very High	Very High
3	No/insufficient maintenance (e.g. no scheduled maintenance)	Very High	High	High	Very High	Medium	Medium	Medium	Medium
4	No/insufficient planning (e.g. unplanned development, rapid growth)	Very High	Very High	Very High	Low	Low	Very High	Low	High
5	Damage and destruction of property/equipment (e.g. vandalism, arson)	Very High	Very High	High	Very High	Not applicable	High	Not applicable	Not applicable
6	Digital information security (e.g. virus protection, hacking)	Very High	Not applicable	Not applicable	Very High	Very High	Very High	Medium	High
7	-	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
8	-	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
9	-	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
10	-	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	Not applicable

Step 6: Identify existing control/intervention measures (see below).

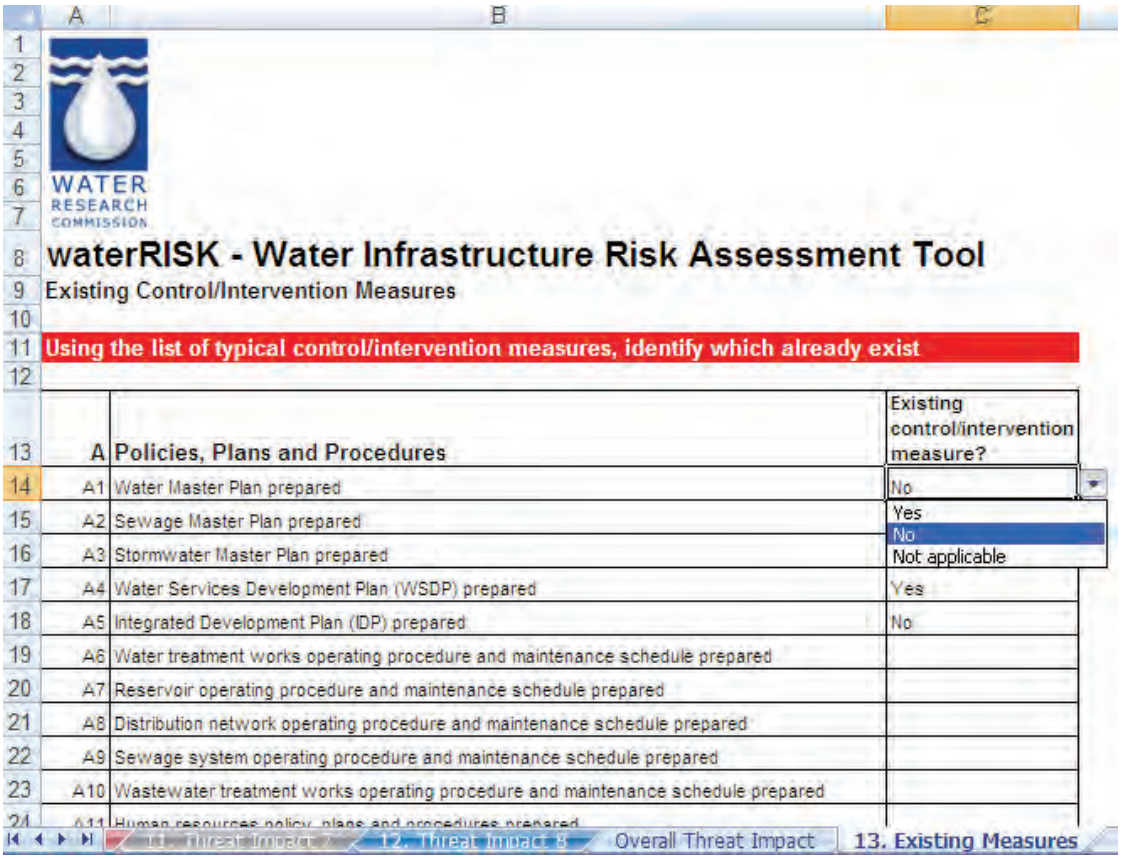


Figure 12: *Identifying existing control measures*

Consolidated list of possible control/intervention 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
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)
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)
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
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)

Step 7: Consider the actual likelihood that a threat will materialise by considering system control/intervention measures, redudancy, alternatives, back-ups and the probability of such an event (e.g. has it happened in the past).

This determines the vulnerability of the asset.

NOTE: Vulnerability assessments are subjective, and therefore need (a) to be completed by a competent individual and (b) careful consideration. It is therefore best to include comments as far as possible to indicate how a decision was made.

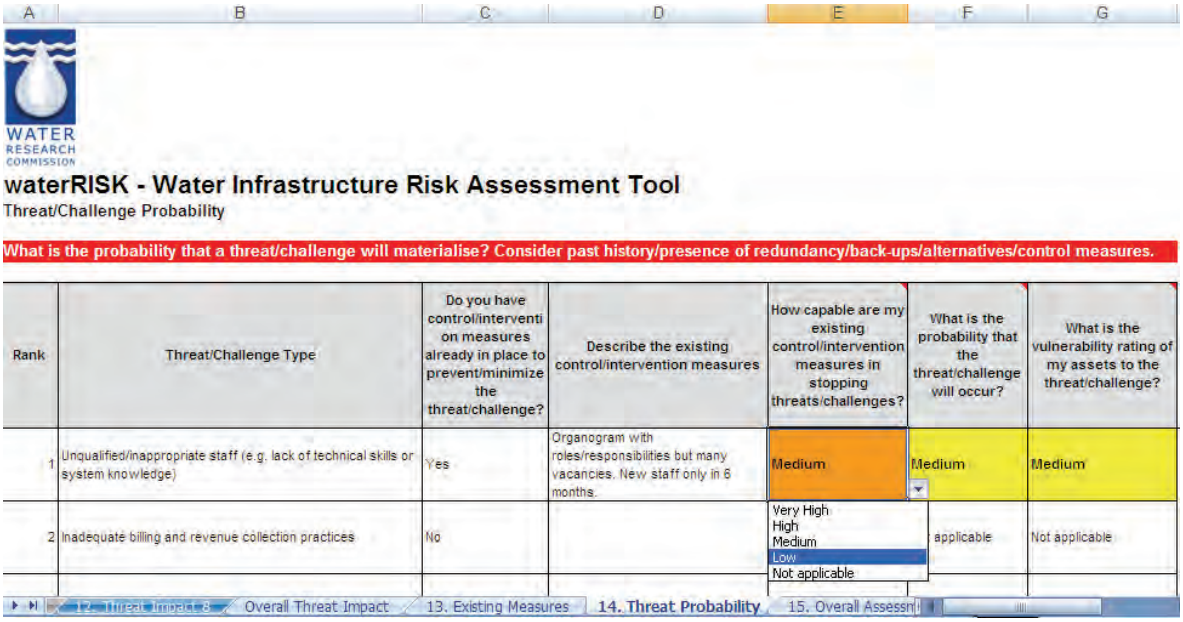
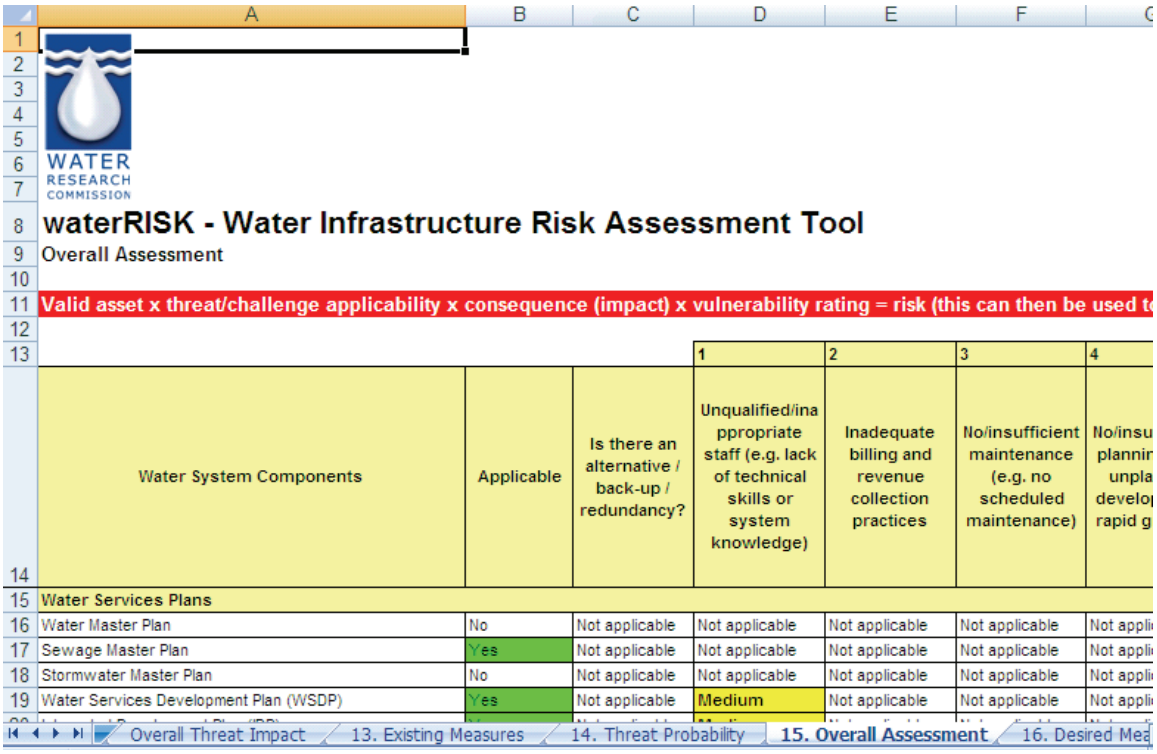


Figure 13: *Determining the probability/likelihood that a threat will materialize (vulnerability rating)*

Step 8: Considering the vulnerability and the consequence, a risk is automatically calculated.

Rank and prioritize the risks from Very High → High → Medium → Low. Depending on WSA capacity (e.g. funds), the WSA could, for example, decide to initially only focus on "Very High" risk items.



waterRISK - Water Infrastructure Risk Assessment Tool

Overall Assessment

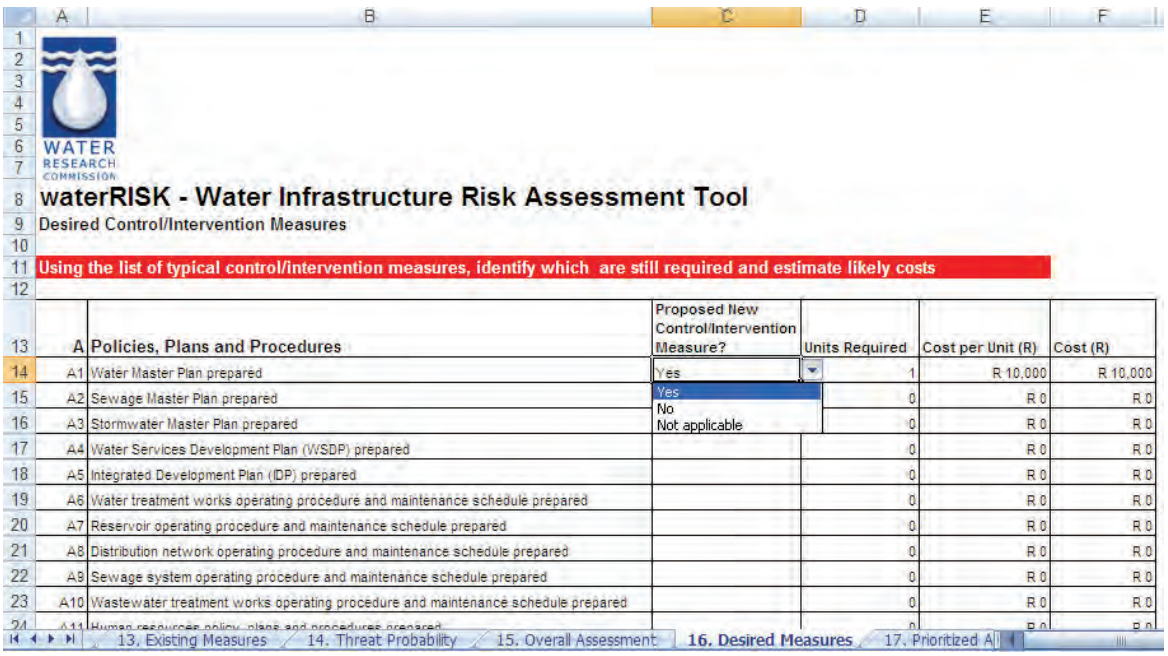
Valid asset x threat/challenge applicability x consequence (impact) x vulnerability rating = risk (this can then be used t

	Water System Components	Applicable	Is there an alternative / back-up / redundancy?	1 Unqualified/inappropriate staff (e.g. lack of technical skills or system knowledge)	2 Inadequate billing and revenue collection practices	3 No/insufficient maintenance (e.g. no scheduled maintenance)	4 No/insu planni unpla develo rapid g
Water Services Plans							
	Water Master Plan	No	Not applicable	Not applicable	Not applicable	Not applicable	Not appli
	Sewage Master Plan	Yes	Not applicable	Not applicable	Not applicable	Not applicable	Not appli
	Stormwater Master Plan	No	Not applicable	Not applicable	Not applicable	Not applicable	Not appli
	Water Services Development Plan (WSDP)	Yes	Not applicable	Medium	Not applicable	Not applicable	Not appli

Overall Threat Impact | 13. Existing Measures | 14. Threat Probability | 15. Overall Assessment | 16. Desired Mea

Figure 14: *Calculated overall vulnerability assessment with areas of highest risk clearly identified*

Step 9: Identify desired control/intervention measures and assign budgets, roles and responsibilities, time frames, etc for proposed improvements.



waterRISK - Water Infrastructure Risk Assessment Tool

Desired Control/Intervention Measures

Using the list of typical control/intervention measures, identify which are still required and estimate likely costs

	A	Policies, Plans and Procedures	Proposed New Control/Intervention Measure?	Units Required	Cost per Unit (R)	Cost (R)
	A1	Water Master Plan prepared	Yes	1	R 10,000	R 10,000
	A2	Sewage Master Plan prepared	Yes / No / Not applicable	0	R 0	R 0
	A3	Stormwater Master Plan prepared		0	R 0	R 0
	A4	Water Services Development Plan (WSDP) prepared		0	R 0	R 0
	A5	Integrated Development Plan (IDP) prepared		0	R 0	R 0
	A6	Water treatment works operating procedure and maintenance schedule prepared		0	R 0	R 0
	A7	Reservoir operating procedure and maintenance schedule prepared		0	R 0	R 0
	A8	Distribution network operating procedure and maintenance schedule prepared		0	R 0	R 0
	A9	Sewage system operating procedure and maintenance schedule prepared		0	R 0	R 0
	A10	Wastewater treatment works operating procedure and maintenance schedule prepared		0	R 0	R 0
	A11	Human resources policy, plans and procedures prepared		0	R 0	R 0

13. Existing Measures | 14. Threat Probability | 15. Overall Assessment | 16. Desired Measures | 17. Prioritized A

Figure 15: *Identifying desired control/intervention measures (to improve the current status)*

Step 10: Considering the findings from the assessment, and the desired control/intervention measures, create a prioritized plan of items that will be adressed.

It is suggested that this be limited to 10 items, and have a short term action period (e.g. 3 months). It is essential that appropriate budget and responsibilities are assigned to address the top 10 identified items. Progress and outstanding issues could then be tracked and reviewed on a quarterly basis.

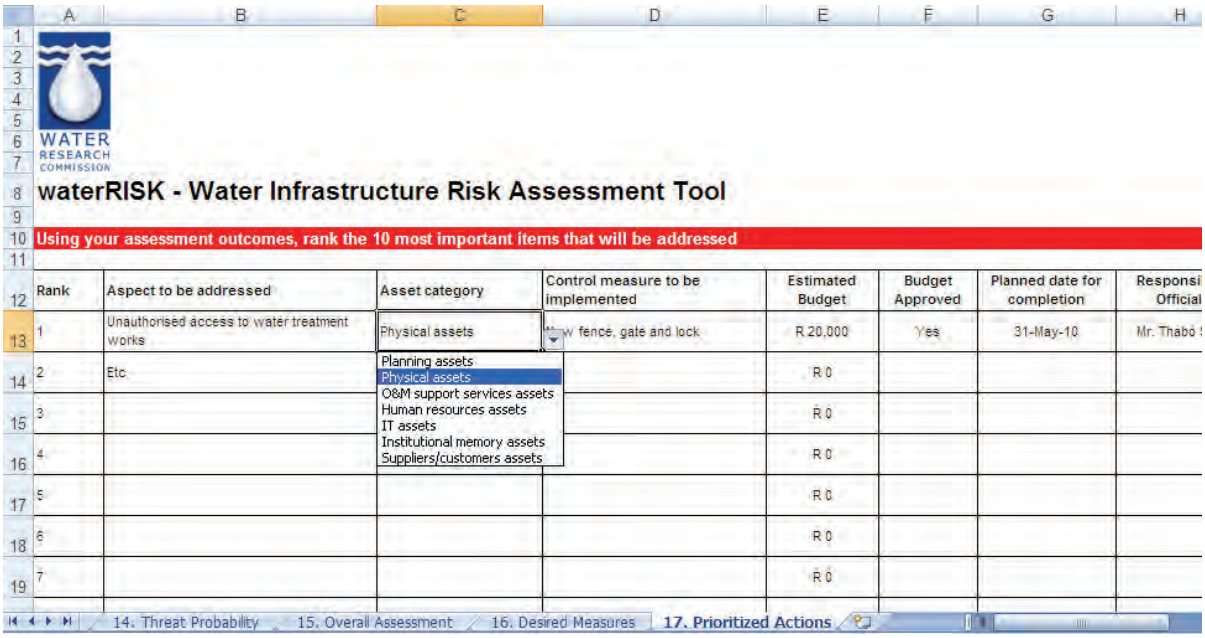


Figure 16: *Develop a prioritized list of items that will be addressed (to improve the current status)*

Step 11: Copy and paste outputs from the completed Microsoft Excel spreadsheet into the Vulnerability and Risk Assessment Report Template (see below).

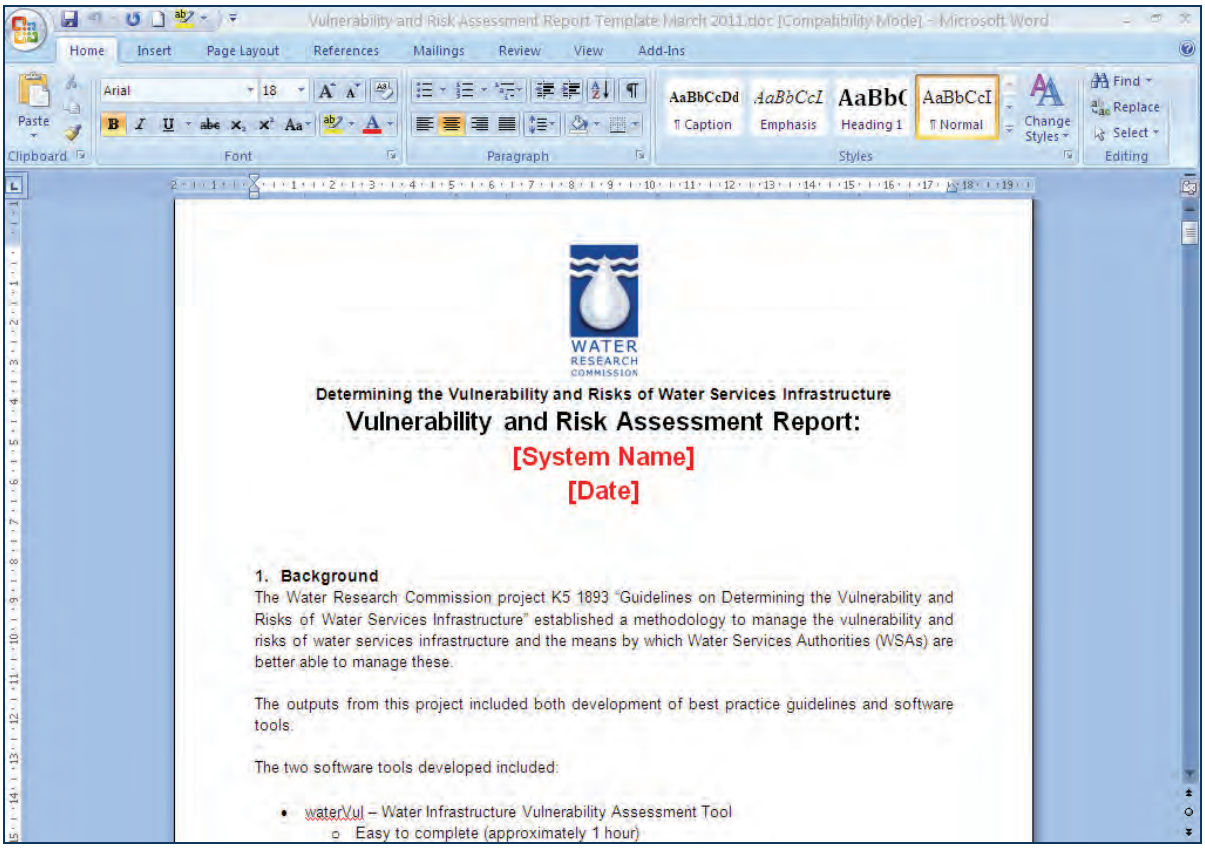


Figure 17: *Report template which can be used to insert completed worksheets (copy/paste)*

Step 12: Implement your plan, review the effectiveness of actions implemented and budget spent, etc.

This last step is crucial to the successful reduction in water services related vulnerabilities and risks within the WSA.

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